

Doing

Field

Research

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EU ACP Science and Technology Program

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# Field Research with a farmer focus

## Introduction

**Doing field research. Three words that carry lots of meaning.**

Doing refers to the actions- the learning that happens as effective research occurs. It also refers to the process of learning linked to our use of this manual. There’s lots of doing involved in the training program.

Field is about things we do together- mostly outside. This is a very practical learning process.

Research. Some research is focussed on the needs and interests of the researcher. *We are focussed on farming families and their needs and wishes.*

With a farmer focussed approach we pursue a process often referred to as Agricultural Research for Development.

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| A positive impact on farming families- that is what this is all about. |

The ARDSF project has a range of readings directly relating to this topic. The process starts with farmers needs- men and women are listened to and we seek, in research, to answer clear questions that they have helped to state. It is a discussion, a process, that engages men and women in the farming community with researchers and where available, extension officers, NGO’s and other stakeholders.

Our learning in this manual is focussed on the tools we need to answer the problems that farmers experience. Sometimes people argue or assume that all we need now is better extension processes- as if all the research has been completed. Others would propose a better market chain. Make no mistake- there is a need for effective and appropriate field research that assists farmers in answering the problems and questions they face. Climate change, insect and disease problems and the challenges of increased pressure on land and farming systems all raise new questions that require effective and appropriate (field) research.

Trials must be managed well to ensure that results and conclusions are valid or true. In your busyness, don’t forget the reason for your research. It is people. They are the cause of the experiment and particularly if you have some of the research happening directly with farmers, you must keep in touch with them. This may mean doing some of the work with them- not just men or just women- but involving people, working together as much as you can. When their involvement is really strong, your research results are likely to be more appropriate and they are likely to have a much larger impact on their lives and those of others. Impact on farming families- that is our focus.

This manual starts with the skills and knowledge needed to be effective field researchers. Our planned learning programme starts with practical skills and will teach theory from the base of practical outdoor and lab tasks. There is much to learn and each chapter seeks to develop a different topic.

There is much to think about before you start your research. Remember that farming families are crucial to the success of the research. This success will only happen as you involve them at each stage of the research.

Rest assured. We will not lose sight of the needs of the farming/gardening men and women who are the focus of our research.

## Working together in teams

There is much that could be said about the importance of team work. It is too big and too important to deal with in just a short section of this manual. However, we have provided a number of resources at [www.cdwi.net](http://www.cdwi.net). Please refer to those as background.

We will discuss the issues as we work as teams in our four week training program.

# Gender and Agricultural Research[[1]](#footnote-1)

Mandy Cahn, Canterbury, New Zealand

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| Gender awareness and analysis makes a difference to research  A researcher who is evaluating new African yam varieties conducts a participatory matrix ranking exercise with a group of men and then women. The exercise explores the characteristics and qualities of yam varieties that are most important .  Men see the most important characteristics as high yield, resistance to pests, and ability to grow well in a range of soil type.  Women are also interested in yam varieties that cook and store well. From this gender analysis researchers can ensure that their research is equitable (fair to both men and women) and varieties that they select are beneficial for both. |

## Introduction

Gender awareness makes a vast difference to research and extension in agriculture. Understanding the different roles and responsibilities of women and men farmers has a positive impact on:

What knowledge is generated,

The way knowledge is generated,

How farmers (men and women) come to develop new ideas and assess these options,

Whether or not farmers (men and women) make decisions to use new ideas in their farming practice.

This chapter explains:

**Why** gender awareness makes a positive difference to agricultural research and extension,

**How** those involved in agricultural research and extension can make that difference by carrying out gender analysis (research on gender issues), and using the gender analysis to plan and conduct agricultural research that is gender aware.

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| ‘Gender’ means the social differences between men and women and is different from physical differences. Gender focuses on social relationships between men and women |

**Gender does not mean women or women’s issues. Gender is the social differences and relationships between men and women and is very different from the physical differences between men and women. Gender refers to socially constructed roles of women, men, girls and boys in a society. These gender roles differ between cultures and can change over time.**

This means that men and women see problems and opportunities differently. They have different access to resources and services. They work differently in groups and makde decisions differently. Do you agree?

## How can gender awareness make a positive difference?

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| Researchers in PNG have shown that women spend more time, compared to men, in producing food, they use more energy, and produce much of the food that is consumed. However, men’s work in clearing and preparing the land, building, fishing and hunting is perceived as culturally more important. (Brouwer et al, 1998.). In 1985 a study in the Southern Highlands showed that Wola women worked between four and six times more in agricultural activities than men (Sillitoe, 1985 cited in Brouwer, 1998 |

In Melanesia, women have not been equal partners in agricultural development despite their extremely important roles. They are farmers producing food for home consumption and also sale to provide cash for clothes, school fees, store food and other daily necessities. They are of course, much more than this, in the same way that a male farmer is much more than a farmer.

Much of the agricultural research and extension has been designed and completed without consideration of gender issues. Because most of those making decisions in agriculture are men, the direction of agricultural development has been conducted from a male perspective and women’s needs have often been forgotten or misunderstood. This process can be referred to as marginalisation.

We are going to assume agreement on the following bold assertion- Women have not been equal partners in agricultural development, despite many women having educational qualifications in Agriculture. Changes are needed. Understanding and awareness in agricultural research is important, so that more meaningful and valuable research is conducted. Let’s dig a little deeper. The table below lists a number of issues, shows how women have been disadvantaged and offers thoughts for change. What do you think?

**Table1: Marginalisation of women in agriculture**

| **Issue** | **How women have been disadvantaged** | **Opportunity for change** |
| --- | --- | --- |
| **Research** | Agricultural research is often based on individual single commodities (ie. individual crops or livestock). | Consider farming systems so that women are included. (Farming and gardening are used interchangeably within this manual, reflecting the ways in which the terms are used interchangeably in Melanesia) |
| Research concentrates on commercial crops that are mainly ‘men’s’ crops. | Use gender analysis to include food crops and commercial crops that women grow. |
| **Agricultural Technology** | Improved tools or mechanisation normally focus on men’s needs. | Develop appropriate technology for women and ensure they have access to the technology and training required. |
| **Agricultural Extension** | Most agricultural extension is directed at men. Women rarely receive extension first hand. | Consider women as equal partners in farming systems and direct extension at both men and women. |
| **Training** | Training and demonstration of farming techniques often target male farmers. | Target both men and women for training as appropriate. |
| **Women’s capabilities** | Women’s capabilities are regarded with suspicion. For example, people assume that women who are in positions of responsibility are the ‘token’ woman or that they are standing in for their husband.  Women’s groups are thought to be only interested in sewing and cooking… | Give men and women equal respect. Make sure women do not have to ‘prove’ themselves before being accepted and given access to resources, training and information. |
| **Women’s responsibilities** | Women normally have responsibilities caring for the family as well as in agriculture that limits their access to resources or services. | Use gender analysis to find out peoples roles and responsibilities and consider this when planning meetings or extra work for farmers.  Consider time and labour implications. |
| **Statistics** | Statistics are seldom ‘disaggregated’ to show data for men and women separately. Women’s unpaid work in growing food for the family is often not shown. Statistics on crops that are grown for handicrafts are seldom available. | Always disaggregate statistics to show the differences between men’s and women’s output and attendance at training, visits etc. Give value to the importance of both men’s and women’s work, whether it is paid or unpaid. |
| **Resources** | Women often find it more difficult to obtain resources and have less control over land and income. | Consider women’s access to resources in gender analysis and ensure that research is designed around the resources that are available - or that could be made available. |
| **Projects** | In many cases agricultural projects are for women only when they relate to household needs . While such projects can be very successful, they are often given less status (or money!) than mainstream projects which may have an economic or larger market focus. | Women must be included as equal partners in ALL agricultural development projects. This is called ‘gender mainstreaming’ and is fundamental to the success of agricultural research and extension.  Projects should therefore all reflect socio-cultural and economic issues at household, community and national levels. |

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| **👪** | Time for discussion  * Women rarely receive extension first hand. This is a bold and important assertion. Do you agree? What should we do about this? * In your group discussion did you find yourself carefully listening for a women’s and a men’s perspective? Did you find any interesting differences? |

The 1993 Women in Development sector review by UNDP identified the following key areas for gender sensitisation in the Department of Agriculture and Livestock (DAL - PNG).

* Development of sex disaggregated and gender specific data in agriculture.
* Recruitment planning for women.
* Support for non-government women’s associations involved in agriculture.
* Inclusion of a gender sensitive approach to curriculum development for in-service training courses.
* Strengthening of agricultural extension programmes for women.
* Involvement of women’s groups in small holder projects.
* Increased training for women and distribution of livestock.

**This list from many years ago, raises an interesting question for all of us in Melanesia- How much progress has been made and how would we measure it?**

### Efficiency and equity in agriculture

Agricultural research and extension aims to improve agricultural production in a sustainable way. This will improve the well being of farmers (men and women) and their families, and ultimately improve the economic situation of the country as a whole based on a healthy agricultural sector.

Good agricultural research and extension will only occur if every available resource is used as **efficiently** as possible. ‘Gender blind’ research and extension, which ignores, or regards as less important, the needs, the capabilities, the knowledge and/or the potential of women excludes some of the most important resources in agriculture.

Only when women are included as equal partners in agricultural development will efficient research and extension occur, and family nutrition and well being improve. Equality does not mean that men and women must carry out the same tasks. Rather, that the importance of men’s and women’s tasks have equal recognition and women have equal opportunities for improving their role in agriculture.

In the Western Province sago is a staple food and cash crops are of less importance. The contribution of men and women to agriculture is quite similar in terms of overall activity but their activities are different. In the Kubo area of Nomad, men spent 49% of their total activity time and women 58% of theirs in subsistence activities. Men spent the majority of this time in fishing, hunting and collecting, whereas women spent the majority of their time in agriculture in sago making, fishing and gathering. Both men and women spent a lesser amount of time in horticulture. (Dwyer, 1994, cited in Brouwer, 1998

The results are a good example of how gender awareness can help in understanding roles and responsibilities.

Gender **equity** in agriculture is a matter of human rights. In the past, women have often not benefited from research and development to the same extent as men. In some cases the impact of agricultural development has actually disadvantaged women. Is this fair? Women have the right to the same opportunities, involvement and benefits in agricultural development. Only if everyone is included equally will the aims of agricultural research and extension be achieved.

***Improving opportunities in agriculture for women is therefore not only a matter of gender equity and human justice, but also a way of ensuring efficient and sustainable agricultural development.***

## Ensuring research and extension are gender aware

### A gender aware approach

In research and extension it is important to consider all the aspects of the farming system in an holistic way. This includes social aspects as well as scientific, environmental, technical and economic aspects. There is a social aspect to all research – it can’t be ignored if the research is to be useful to people. The social aspect includes the needs, capabilities, roles, resources available to and impacts of the research and extension on men, women, boys and girls.

‘Gender aware’ agricultural research and extension recognises the social differences between men and women farmers. On the other hand, ‘gender blind’ research and extension wrongly assumes that research and extension affects men and women in the same way

‘Gender aware’ research and extension recognises that social aspects are different for men and women. On the other hand, ‘gender blind’ research and extension **wrongly** assumes that research and extension affects men and women in the same way. It might also assume that men will pass on the extension messages to women in an effective manner. What do you think? The result of gender blind research and extension is that it is directed at men’s needs and men’s way of thinking and as such is neither as efficient as it could be, nor equitable. In a worst case scenario, research may be useless if there is conflict between men and women farmers in the way the research can be used or implemented. This has happened in the past.

### Gender analysis

How do we ensure that agricultural research and extension is gender aware?

How do we 🡪

learn about the gender differences between men and women farmers?

make sure that we have gathered accurate and reliable information from and about both men and women?

**Gender analysis** is inquiry that helps us to understand cultural differences and different needs of men and women. Experts in gender issues have developed many frameworks for gender analysis. For example the 🡪

‘Harvard’ method of gender analysis is very structured and uses tables and forms such as those provided in this chapter (following, from Poats et al., 1988).

Moser’s approach to gender analysis is more descriptive and concentrates on women’s roles (eg reproduction, production, community), women’s access to and control of resources and women’s needs (Moser, 1993).

Longwe’s approach to gender analysis is to consider a range of issues where men and women’s roles are significantly different (Longwe, 1992).

The approach to Gender analysis described in this chapter is influenced by these three approaches and is designed so that researchers can answer the questions below of the communities they are working with 🡪

Who does what, where and when? (Don’t forget planning and decision making roles)

Who has access and control over what resources?

Who benefits from, and what are the impacts of research and/or extension?

What are the needs of men and women?

What are the ‘gaps’ between men and women – are women disadvantaged in any way?

Knowing the answer to these questions helps those in research and extension to ensure their work is appropriate, needed, useful, directed at the right people, has the required resources available and is thus efficient and equitable.

New ideas that have been generated and researched in a gender aware, participatory way are much more likely to be adopted and used by farming families and therefore meet the aims of agricultural research and extension.

**Gender analysis is the process whereby those involved in agricultural research and extension can find accurate and reliable information about farming families: the ways in which men and women work together and/or independently. It should assist researchers and planners in developing more balanced research protocols- ways of doing research. Gender analysis is essential for researchers to understand the social environment in which they are working.**

### The household

One of the reasons that women farmers do not actively participate in decisions about agricultural research and extension is the common misconceptions about households.

Farm households are often used as the basic social and economic unit on which information is collected and used in agricultural policies. It is often assumed that🡪

The household consists of a family unit of which the basis is husband and wife, and that households are headed by men. However, often women head the household for a number of reasons. Men may be away temporarily working in the mines, truck driving, or in forestry. Men may be training overseas or in PNG. Women may be divorced or widowed.

The household is a unit with just one farming system. However, in many families men and women have independent responsibilities for farming systems as well as shared responsibilities.

Wrong assumptions lead to wrong information. For example🡪

Men are often asked to answer questions on behalf of the household for data collection, but men are rarely knowledgeable about all of the things women do.

The economic status of the male is often used as a generalisation about the economic status of the household regardless of what other family members may be doing, but in some households there is no (adult) male so women have complete economic responsibility.

In the case of farming, it is often assumed that the man is the only farmer, but often women are active farmers either in partnership with a man or independently, and their information is also important.

It is often assumed that everyone has similar goals, expectations and needs but🡪

people have self interest - some have more self interest than others,

households are not equitable - sometimes members of the household receive fewer benefits or work longer hours.

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| **One of the reasons why women are excluded in agricultural development is that the household is traditionally considered as a single unit that is headed by a male who can speak on behalf of the entire household. Rather the household should be considered as a complex and diverse unit where individual members have differing roles, goals, expectations and needs.**  **What do you think? Is this raising gender issues a western intrusion in traditional Melanesian societies? Which components make good sense, and which should be ‘left out’? Discuss together…** |

Furthermore women often have less access to cash. Household incomes are not necessarily pooled. Culturally there are different patterns and individually there are different ways of using household money.

While women may be considered helpers, they are often experts in their specialised tasks, and as such farmers in their own right. Women may need permission to get money. This can impact on the potential for women to engage in their own agricultural production.

The way households within a community relate to each other is also important to understand as it will have an impact on the organisation of groups within the community and the co-operation within the community.

## Gender analysis techniques

### Gathering information on gender

How can you gather information on gender in agricultural systems in a sensitive way so that you can be sure that the information is true and reliable? Participatory methods are ideal for gender analysis because, among other things, they🡪

involve as many people as possible including both men and women, rich and poor, powerful and those with less power,

place emphasis on local knowledge,

usually separate men and women so that ideas can be expressed freely,

encourage a relaxed and informal atmosphere,

empower local people and encourage ownership of decisions and future actions.

Always remember to avoid bias in gathering information. Bias can be caused by🡪

cultural considerations –it may be customary to talk with certain men in a community,

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| **My first experience of this was in West Papuan highlands many years ago. We set up a field day for women, with discussion in the local church. Listening to their perspective and needs was a great way to start learning about their needs and wishes. The women loved the emphasis placed on listening to them.**  **We ran a ‘special’ field walk for the men at the same time, so that they were also offered the ability to learn and engage with the training and joint learning program.**  **Making that separation – men and women-was greatly valued by the women.**  **Dave Askin, 1989, Makki, West Papua.** |

the make up of research/extension team –if the team is mainly men it is more difficult to include women farmers in the information gathering,

men interviewing women –women are sometimes intimidated by male interviewers and may not tell the full story so try to make sure that women interview women, and men interview men,

use of interpreters and other counterparts such as extension agents, progressive farmers etc. Talking to progressive farmers and/or extension agents may give a wrong impression of women’s interests, interpreters can unknowingly put their own interpretation on information, especially if, for example, a man interprets a woman’s conversation or vice versa – working in the local language is always best,

logistical constraints -women may not be able to attend meetings at certain times of the day because of household duties, caring for children etc. It may not be possible to gather some groups of people unless key decision makers are present,

preconceptions that the male is the head of the household and the most important farmer in the family or that one community will be the same as another can bias information,

sexist language –calling all farmers ‘he’ immediately reduces the status of women farmers. (Learn to listen to your own use of language, when talking with a group of farmers).

**Use your imagination in your gender analysis.** Use innovative methods that suit the community or farmers that you are working with. Adapt the techniques described in the following sections to suit your situation and the project you are working on.

**Participatory methods are ideal for gender analysis. Be wary of gender biases and preconceived ideas that may occur when gathering information. Use your imagination and adapt standard techniques.**

### Who does what?

It is important to understand gender roles – who does what tasks, where and when so that you understand the different farming systems within the community and/or household and can anticipate both opportunities and difficulties. Women’s tasks are often divided into three types of work🡪

productive work – work that generates food or income eg. paid work, farming for food or cash, marketing or selling for cash, generating income,

reproductive work – work related to caring for household and/or the family eg. cooking, washing clothes, housework, caring for children,

community work – caring for others in the community, meetings, work with community groups.

It is important to recognise the difference between these types of work because women are constantly ‘juggling’ productive, reproductive and community tasks whereas men’s time is more often spent in productive and community work. Girls and boys will also have tasks within farming systems.

You can use participatory methods to summarise who does what, where and when on charts that look like Table 2(a) and Table 2(b). It is useful to separate activities into productive, reproductive and perhaps even community.

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| **Looking and Seeing**  **Next time you walk past a garden, walk around a market, travel on a road-**  **take a look and without writing anything down, simply look through the eyes of someone who is gender aware**  **Who is doing what?**  **Who is taking time out?**  **What ages are represented?**  **Can you make any generalisations?**  **Look and see!** |

Table 1 Activity Profile – Productive Tasks

Note: This is an example only and does not apply to any particular situation. Make blanks to suit your own needs.

| **Productive activities** | **Male** | **Female** | **Time** | **Place** | **Implications for project activity** |
| --- | --- | --- | --- | --- | --- |
| Cash crops: |  |  |  |  |  |
| Land clearance | XX |  | Occasional | Family plots |  |
| Land preparation | XX | X | Occasional |  |  |
| Planting | X | XX | Every 3 months |  |  |
| Tending[[2]](#footnote-2) | X | XX | Daily |  |  |
| Fertilising | XX |  | Monthly |  |  |
| Irrigation | XX |  | Occasional |  |  |
| Weeding |  | XXC | Weekly |  |  |
| Bird scaring | XXC |  | Daily |  |  |
| Carrying crops[[3]](#footnote-3) | X | XX | Weekly |  |  |
| Sorting/ grading | XX | X | Weekly |  |  |
| Seed selection |  | XX | Monthly |  |  |
| Storage |  | XX | Occasional |  |  |
| Marketing | XX | X | Weekly |  |  |
| Waste disposal | X | XX | Weekly |  |  |

X Helps out XX Primary responsibility C Children

Refer over leaf for the food crops part of this table.

| **Productive activities** | **Male** | **Female** | **Time** | **Place** | **Implications for project activity** |
| --- | --- | --- | --- | --- | --- |
| **Food Crops**  Land clearance | XX | X | Occasional | Gardens |  |
| Land preparation | XX | X | Occasional |  |  |
| Planting |  | XX | Every 3 months |  |  |
| Tending |  | XX | Daily |  |  |
| Fertilising | X | XX | Occasional |  |  |
| Irrigation |  | XX | Occasional |  |  |
| Weeding | XC | XXC | Daily |  |  |
| Bird scaring | XXC |  | Daily[[4]](#footnote-4) |  |  |
| Harvesting | X | XX | Daily |  |  |
| Carrying crops | X | XX | Daily |  |  |
| Sorting grading |  | XX | Monthly |  |  |
| Seed selection |  | XX | Occasional |  |  |
| Storage |  | XX | Occasional |  |  |
| **Animals** |  |  |  |  |  |
| Put in the categories you think are needed under animals- there may be considerable differences to consider. |  |  |  |  |  |

X Helps out XX Primary responsibility C Children

Table 2(b) Activity Profile – Reproductive tasks

| **Reproductive activities** | **Male** | **Female** | **When** | **Where** | **Implications for project activity** |
| --- | --- | --- | --- | --- | --- |
| Food processing[[5]](#footnote-5) | X | XX | Post harvest | House |  |
| Food preparation |  | XX | Daily |  |  |
| Child rearing | X | XX | Daily |  |  |
| Clothing provision | X | X | Occasional |  |  |
| Household cleaning |  | XXC | Daily |  |  |
| Washing clothes |  | XXC | Daily |  |  |
| Water carrying | XC | XXC | Daily | Village well |  |
| Building construction | XX |  | Occasional |  |  |
| Building maintenance | XXC |  | Occasional |  |  |
| Fuel gathering | XC | XXC | Daily | Village gardens |  |

X Helps out XX Primary responsibility C Children

Do we need a table for community related tasks and the gender differences in these?

### Who has access and control over what resources?

Many farming decisions and requirements are determined by who has access and control over resources such as land, labour (one’s own, family, children’s, other), money, training, knowledge, machinery, materials (eg fertilisers, sprays, livestock feed) and/or access to markets. Any research or extension planning needs to take account of the access and control that men and women have over resources.

There is a difference between access and control. Access means that a person is able to use a resource, control means the power to decide how that resource is used, who will use it and how it is to be allocated. For example, often women have access to land but may not have complete control over it. Thus, if their husband or some other family member decides it is to be used for a different purpose, the woman may lose access to it.

|  |
| --- |
| In most areas of PNG men control land and make decisions about it. However, in some Milne Bay communities women are deemed to own the land and make decisions about garden sites. In some New Ireland communities men have sole authority over land, in other matrilineal communities land is held jointly by women with their brothers. The systems of land village courts established during Australian rule excluded women from public decision making about land. Women have been disadvantaged in most cases where land has been registered or privatised (Brouwer et al, 1998). This has severely restricted the access that women have to credit from banks as they rarely have land to use as collateral. |

A resource profile such as the example in the table below will give some idea of the resource constraints that men and women farmers face in practice and will assist those in research and extension to understand the gender aspects of the farming systems.

Table 3 Resource Profile

Note: this is an example only and does not apply to any particular situation

| **Resource** | **Access** | **Control** | **Notes** | **Implications for project activity** |
| --- | --- | --- | --- | --- |
| Land | MF | M | Men decide the use |  |
| Water | MFfm | MF | Readily available |  |
| Credit | M | M | Rarely available to women |  |
| Tractor or other technology | M | M | Hired by men |  |
| Fertiliser and sprays | M | M | Only occasionally used by women |  |
| Income | MF | M | Men usually decide what the money will be used for |  |
| Labour- Own | MF | MF | Men can hire labour as they have control over money |  |
| Labour Family | MFfm | M |  |  |
| Labour Hired | M | M |  |  |
| Access to local markets | MFf | F | Women take the crops to the local market |  |
| Contact with extension officers | M | M | Only male extension officers visit and talk with men  Both men and women have important indigenous knowledge. |  |
| Local knowledge | MF | MF |  |  |

F Adult female M Adult male m Boy [[6]](#footnote-6) f Girl

### Who benefits? What incentives do people have?

It is important to know who (men or women) **benefits** from farming activities and thus who will benefit from any research or extension projects. Because people usually have self interest, they are more likely to be motivated to be involved in, or to allocate some of their resources (such as land, labour or money) to farming activities that will have some benefit to them. For example it is unrealistic to expect women to devote a lot of time and labour to a cash activity if they do not have control over the financial benefits of that activity.

It is also important to understand the incentives that men and women have to continue or change farming activities. Incentives may be the end uses of a crop, eg. sale, home consumption, or perhaps reduced risk, increased prestige, increased yield, improved nutrition (or access to nutritious food), timing of operations, fodder or building materials. Knowing the gender aspects of the incentives will help understand what motivates people and what research will be useful to them. A benefits and incentives analysis can be summarised as in the table below.

‘Income from cash crops, such as coffee, copra or cocoa, is managed by men in the majority of societies, although there are many communities where this is not so. Local sales of garden produce at markets or roadside stalls are generally the preserve of women. In some cases, especially matrilinear societies where women have continuous rights in their clan land, cash is perceived as belonging to the person who produced the goods for sale. In these areas the women retain control over the money they earn. …. It is clear, however, that few women control household income.’ (Brouwer et al, 1998).

Table 4 Benefits and Incentives

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Outputs** | **Access to outputs** | **Control over outputs** | **\*Incentives** | **Implications for project activities** |
| Crop Production | | | | |
| Cocoa | M | M | a |  |
| Kaukau | MF | MF | a,b,e |  |
| Tomatoes | MF | MF | a,b |  |
| Banana | MF | MF | a,b,e |  |
| Coconut | MF | M | a,b,e |  |
| Livestock production | | | | |
| Chickens | MF | M | a,b |  |
| Eggs | MF | F | ab |  |
| Pigs | MF | M | a |  |
| **Off farm activities** |  |  |  |  |

\* ie. uses and desirable characteristics of the product or output (Note: use a key such as a=cash, b=home consumption, c=fodder, d=building material, e=low risk crop, etc.) Note these may also have a male/female issue to consider.

F Adult female M Adult male m Boy f Girl

### The differing needs of men and women

Men and women have different needs relating to land use and agricultural production. For efficient and equitable research and extension it is important that everyone’s needs are recognised. Needs fall into two categories🡪

1. Practical needs. These are needs that are usually obvious and immediate such as the need for food, the need for more cash or the need for materials such as fertilisers.
2. Strategic needs. Satisfying these needs will increase a person’s position in the family or community, or reduce subordination (especially important for women). The need for education, training, involvement in decision making and research, changes in land ownership laws to allow women control over land, changes in the rules for obtaining bank credit to allow women to obtain credit are examples of strategic needs in agriculture. These needs are often more difficult to identify and when asked, some women may hesitate in suggesting strategic needs. Sometimes these needs are seen as ‘feminist’ or may be deliberately ignored. However, it is important to remember that these needs exist and are very important if research and extension is to be equitable and efficient and play an important role in PNG agriculture.

A needs analysis asks people about their needs and uses the information when formulating research and extension plans.

|  |  |
| --- | --- |
| **👪** | Time for discussion  * Think about savings and credit. Are there gender related issues to consider? How would you set up research to consider this topic, in a way that helped understanding relating to crucial limitations that men and women face? |

### What are the gaps between men and women?

Women are not normally equal partners in commercial or household agricultural development. What are the gaps between the opportunities, benefits and status of men and women in agriculture both at the local community level and the professional level? Your gender analysis will already have identified gaps in work loads, access and control of resources and benefits and needs. Can you close these gaps in your research and/or extension work?

How might research planners and donors act to encourage a greater gender awareness and sensitivity that will lead to improved outcomes for village families?

## Using the information from gender analysis

From your gender analysis you will have identified a number of differences between men and women. Use this data when planning and conducting your research🡪

Interpret the data and discuss with your fellow researchers the implications that the data may have on your research proposal.

Decide which of the differences you have identified will impact most on your research. (Remember this research isn’t really your ‘own’. Good research is community owned and input from the community will greatly enhance positive outcomes).

Identify any contradictions or areas that need clarification.

Adapt and revise research methods to further investigate any issues that need clarification.

Identify any other people that need to be consulted.

Identify appropriate partners to ensure accountability to key groups.

Check your research proposal and the methods you intend to use and ask yourself these questions🡪

Who has designed the research question? Is the research relevant to men and women in different ways? Have both men and women been involved in the design? Was there a participatory process at the heart of this research?

Does the proposal refer specifically to men and women or have you used broad terms like ‘the community’ or ‘poor farmers’? Use your data to be more specific.

Have you outlined how the proposed research will impact on different sectors of the community? Will men and women benefit equally? Use your data to identify impacts on men and women.

Have you considered whether the results of your research will be useful – do men and women have the resources available to use the results of the research? Use your data to think about access and control of resources.

Have you considered how men and women in the community will interact with you during your[[7]](#footnote-7) research? Will men and women have equal opportunities? Use your data to outline specifically how men and women will be involved and at what time of the day.

Have you considered who will be consulted over the proposed research and the results? Use your data to decide who is the most appropriate person or group to consult.

Have you proposed how people will both work with you during the research and get to know about your research – demonstrations and training? Use the results of the gender analysis to discuss who will be invited to demonstrations and be provided with training. Make sure the people who will be using the information are targeted.

Is your research helping to close the gaps between men and women? Or is your research targeted at men?

What criteria or indicators will be needed to evaluate the success of the research project in meeting its objectives in a gender sensitive way?

With these points above considered well, you are actually answering critical planning questions🡪

What is the problem?

Why is the problem important- get to the root causes. (Problem trees, refer project cycle management training notes).

Where is the problem located and who is affected- this of course has a gender perspective.

Is it appropriate for your organisation to expend resources in solving this problem?

Who else may be involved?

Are their ways of involving others so that the positive impact of the research is widely felt?

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### Web based resources:-

IDRC: Social Development. The ASPR initiative for gender equitable research. Available: <http://www.idrc.ca/socdev/research/gender.html> 17.10.00

IDRC: Research Programs: Sustainable use of biodiversity. Available: <http://www.idrc.ca/biodiversity/tools/gender2_e.cfm> 17.10.00

# Encouraging farmers to do their own experiments

## Introduction

Highlanders of the Baiyer valley were taught how to tan rabbit skins. Some of the farmers realised that if they killed the rabbit and dipped it in hot water they could then pluck the fur for bilums and eat the remaining animal, rather than having to rely on chemicals to tan the skins.

→Outsiders brought to locals a new animal, but insiders, villagers, took that animal and adapted it to fit within their own culture.

Farmer learning in action. Well done.

International literature refers to farmers doing their own experiments as ‘Participatory Technology Development[[9]](#footnote-9) (PTD). What a mouthful! This chapter is about working with farmers to do simple experiments on their land. A local research organisation offers its formal-scientific knowledge, training and experience; its ideas; and some resources. Farming families offer their indigenous knowledge and experience; their imagination and ideas; and some resources. Working together, listening to each other- keeping men and women involved – this is all part of farmers doing their own research, supported by you the officer from a research and/or extension agency.

Because this process encourages farmers to do their own experiments the farmers themselves are the source of innovations, and research institutes work to support and complement farmer[[10]](#footnote-10) experiments with simple scientific procedures.

This is well worthwhile. Let’s look in more detail at what we aim to achieve.

### What are we seeking to achieve?

We aim to 🡪

* Strengthen farmer and rural communities’ ability to respond positively to changes in their circumstances by developing their own innovations and solutions to problems.
* Foster self-respect and self-confidence in farmers (men and women, young and old) and therefore rural communities by encouraging them to take responsibility for their situation.
* Encourage farmers to conduct simple experiments.
* Recognize and respect the indigenous knowledge of men and women.
* Develop sustainable agricultural practices that conserve and enhance natural resources (rather than degrade and deplete them) so the land can still be used by future generations.
* Encourage farmers to share the knowledge and understanding they have gained with other farmers. This may be through songs, proverbs, poems, traditional singsongs, farmer meeting groups or farmers simply talking with other farmers.
* As much as possible we want the questions and answers to be earthed in a home grown, local is great way of doing things.

### What might a farmer’s experiment look like?

This chapter is written primarily for those who assist and work with farmers. So here are some suggestions🡪

* At the outset, encourage the farmer to bring / allow others to participate in the learning that will happen in this experiment.
* Keep it simple.
* Encourage ‘with’ and ‘without’ experiments initially.
* Don’t get too bothered about replication. (We’ll talk about replicates later). For example, if mulch is being considered… grow some plants with mulch and some without. If it is chicken manure- grow some with and some without.
* Record carefully what you did. How much of this was used. How many plants received the ‘with’ treatment?
* Take photos.

|  |  |
| --- | --- |
| manure rabbit chinese cabbage | Askin, first farmer experiment- Highlands of West Papua, 1989, with and without rabbit manure. It can be as simple as this! |

* Measure results in ways that are meaningful to farmers.
* Involve a number of farmers so the overall value of the new technology is seen by all.
* Visit regularly.
* Discuss and encourage as much learning as possible from the experiment.

I hope you are getting the picture. Farmers can and should be involved in experiments on their land. Don’t forget to encourage husband and wife involvement in what is happening. Children can be involved- encourage their curiosity. We are encouraging humility. We as outsiders don’t know it all. We can learn together- scientist/extensionist with the farmers. That is a key reason for farmer experiments. The other of course is to see farmers growing more profitably and sustainably. We are all asking- what happens if we do this? That means we are learning together.

[www.wetarcomdev.org](http://www.wetarcomdev.org) has a number of examples of simple field experiments we are running with farmers in Indonesia. For example six water melon plants are grown without any additional mulch, another 6 are planted into holes that had mulch and chicken manure added about 4 weeks ago. Farmers assess the different growth and yield of the two treatments.

As research staff we need to help farmers to recognize the value of their own experiments. Our formal scientific training does not make the traditional ways the farmers may use in their experiments any less valuable. In fact, by sharing our formal science with their informal science we can obtain a much more workable and useful result.

### Discovering the local ‘experimenters’

Observe –by walking around your local area you may notice unusual things, -chances are it may be a local farmer experimenting

Ask – Local people generally know who the innovative, creative farmers are in their area. Visit these people and discuss their experiments with them. They may also be able to suggest other people you could talk to.

Ask local farmers who the key people were in introducing, adapting and adopting new innovations in the past. Don’t forget that because extension services have collapsed in some areas it is the women particularly who have been experimental in their approach.

### Advantages of farmer lead experiments and extension

The farmer leader is familiar with the local characteristics, problems and history.

They speak the language of the other farmers and understand them.

They know crucial issues of how to motivate neighbours.

They have contacts within the community.

People tend to trust someone from the same group who is actually delivering or initiating the technology themselves.

They are used to manual work and walking long distances.

The costs of maintaining farmers as demonstrators and leaders are much lower compared with those of outsiders.

Farmers who can show others what they have accomplished on their own farm is of course more relevant than something that has happened on a distant research station. Farmers are wise to be careful. Sometimes labour is paid by government salaries and isn’t considered in the advice the extension officer provides.

Sometimes the advice from a research station is based on unobtainable machinery, and so is not relevant to the farmers. Keep it relevant!

### Disadvantages of farmer lead experiments and extension

Male farmers may be quite unaware of how gender insensitive they are. This needs considering right at the start.

The farmers may neglect the management of their experiment and/or extension work, as they live where they work and have many other responsibilities.

Some other farmers may be reluctant to learn from a local person.

Farmers may require considerable support and extra training.

Frequent trips outside the area may cause family problems.

Farmer researchers may have difficulties in preparing reports and other paperwork.

They may not fully understand the principles and if not supported well, their credibility may be reduced through some failures.

They may not have open minds- this is critical! A willingness to learn and try things is the primary starting point.

## Planning - the key to a good outcome

We have all heard about what happens if we don’t plan ahead. This warning is particularly important with farmer led experiments. It takes time in careful discussion, before anything happens in the field (plants or animals), to do it well.

Here are some issues to consider🡪

|  |  |
| --- | --- |
| **Regarding the farmers- who should be involved?** | Everyone who wants to? A few to start with? Only women? Both women and men? The poor? Those with the resources? Maybe just those who live near the road so we can drive to their field…!? |
| **When?** | Should all experiments start at the same time? Are all inputs available at that time? Is it an appropriate time to sow? How long till harvest/ maturity? |
| **Do the farmers need to be paid?** | Gifts or payments for time invested are inappropriate. Experimenting farmers should be taking part because they want to improve their situation, not because they want to be paid or rewarded by you! |
| **Monitoring, maintenance and evaluation?** | What information do you need to collect? How will you go about collecting it? Who will do what, and when? Do you have agreement with the key people? If you forget to include women, beware- they just may harvest the experiment inappropriately because they were not involved in planning. |
| **How will contact with the research station be maintained?** | When will visits happen, and what process will be used for communicating any need?  Issues surrounding measurement of harvest are particularly important. Get this wrong, and you don’t have an experiment- you have annoyance. |
| **Risks?** | Be flexible, and allow for adaptation mid-way through the experiment if necessary. –be aware that some farmers may drop out and make sure that enough farmers are taking part that this won’t destroy the experiment. Discuss with farmers before experimentation begins, the risks involved so they know what they are getting into |
| **Complexity?** | Making sure the experiment design is easy for the farmers to understand and manage.  At least at first, limit the variables to areas that can be easily manipulated within the farmers existing farming system. Don’t expect farmers to change their whole system to fit the experiment |

### Farmer discussion groups

It may be beneficial for farmers to get together as ‘farmer-experimenter groups’ to discuss farming issues and their experiments. It’s best to support these groups with an effective and experienced extension or research officer- someone who really knows practically what they are sharing with the farmer group.

Sometimes these groups can grow out of existing groups. For example many churches have vibrant women’s groups, that will also be very interested in learning new things to do on their land.

Ongoing communication will provide the opportunity for farmers to support each other and will improve the chances of success. These groups shouldn’t be restricted just to those participating in the experiment, but should also include other interested farmers who may not be able to participate at this stage, but still wish to be involved. In particular, the group should include poorer farmers who may not be able to afford the risk of experimenting, but who would also benefit from new innovations and would like to be involved.

Usually the easiest way to get groups under way is to have a workshop(s) with interested farmers. Keep in mind who you are aiming the workshop at when planning this, (look back at the gender module for ideas on including different groups).

Use the workshop to discuss various case studies (preferably ones the farmers are familiar with), including how they did the experiment and why they did it that way. Workshops are also a good place to provide training in simple experimental design.

### Deciding what experiments to do

An effective and capable researcher/extension officer should be able to see opportunities for a farming family to engage in simple experiments on their land. These ideas can be discussed in the field, but it is probably best to engage others in the discussion, to explain more fully what is being suggested. That way, a group of farmers are strengthened in their group dynamics and you can have a number of famers all engaging in very similar experiments.

Workshops are also useful to allow farmers to discuss possible experiments.

Start by asking the whole group what is the biggest problem they face on their farms. Record the ideas on a large piece of paper so that everyone can see their idea being written up (or better still, get one of the farmers to record the ideas). Next, together assess which of these problems might be solvable, and cross out any that are unsolvable. By the time you reach this point the group should only have a few ideas for experimentation left. PRAP[[11]](#footnote-11) manuals have useful suggestions for helping farmers decide on which problems are most solvable.

### Appropriate design of experiments is important

Experiments should🡪

Have a clear objective –in other words, everyone involved should know what is what you are trying to find out and how things like fertiliser, water and harvest are to be done. You don’t want the harvest to start before you can measure the yields. This is not an unusual problem, especially with a crop that is harvested over a long period.

For example, a farmer suspects that adding chicken manure to her taro will increase the size of the taro and reduce taro beetle damage. This can become her hypothesis and we can test this on her land and some gardens of her neighbours. Remember the goal is clarity about the usefulness of chicken manure in controlling taro beetle. The more people involved on their land, the more reliable the results will be.

Give clear and significant results. For example, if a farmer tries a new fertilizer and a new seed variety in the same plot, how will they be able to tell if the improved yield is from the application of fertilizer or the new seed variety?! It would be better for them to test them both separately, -either at the same time on different plots, or at different times. More complicated designs are available to test both things at once, but these are best managed on a research station- more on these to come in this manual.

Be able to be replicated–it should be clear to everyone (researchers and farmers) how the experiment was carried out and under what conditions. This will include keeping a note of the time of year it was undertaken; the quantities of fertiliser, water etc used. Farmers should be able to explain to other farmers how they reached their conclusion and how to copy their experiment. Replication is normally managed best by having four or five or more farmers doing a simple with and without experiment- each farmer having just two plots- one with, and one without. That keeps it simple, and they can look at the big picture in a field day style gathering. That gathering will need input from someone who is recording and collating information from all farmer plots.

Have the same, or at least similar, conditions in the plots to be compared –for example, a farmer in Mali compared two varieties of millet, one on a plot previously planted with millet, the other on a plot previously planted with beans. When the latter gave higher yields, he concluded that this variety was superior, whereas the beans may have improved the soil.

Have border effects eliminated –for example, when harvesting the experimental plot, exclude the outermost 0.5m (because this area will be affected by other factors such as wind, extra sunlight, less competition).

Know your plot boundaries, by making a good diagram (trial plan) and using solid pegs at the corners of plots.

Allow for a control –A control is simply a plot that has been left untreated. So, for example, when you applied your chicken manure to your chicken plot you would leave a plot without any manure (the control) so that you can compare productivity between those plots with manure and those without.

Ensure both the household and the community understand that the experiment is necessary to work out their problem, and that theft, “short cuts”, or any change in conditions will affect the experiment and limit its benefits.

### Recording and assessing experiments

Some farmers are very good at keeping records and can recall details of their experiments, however, many farmers keep very few, if any, useful records and often can’t remember details such as dates and quantities applied. This makes it very difficult to interpret the results.

Careful planning and discussion will help with recording what is important. The extension officer needs to ask to see records.

In your experiments use materials and ideas that are familiar to local people. For example, use tin fish cans to measure things like fertiliser. Remember in formal publications to give metric equivalents.

For research and extension staff, one of their roles in farmer experiments may be to raise the following issues in ways that make sense to local people🡪

* What criteria should be used to assess an experiment with this objective? e.g: productivity, labor requirements, taste, colour, storability, cooking characteristics, profits?
* What indicators will show whether these criteria have been met? Will it be a reduction in time of weeding (hours per plot (hours plot-1) of a given size) or yield in kg plot-1?
* What do we record or measure to find the indicator? ie: what essential information do we need to collect? Remember the issues relating to men and women directly, like time spent doing something may be more important than the more animal or plant related parameters of yield or growth rate.
* How do we measure these? ie: what techniques of observation and measurement will we use? What equipment do we need? Who will do this? When will we do it? e.g: at sowing farmers will measure the total amount of corn seed sown, using tin fish cans. (Research staff will later convert this to kg and relate this to the plot area that was planted).
* How do we record data? E.g.: notebooks, recording forms, farmers’ memories…

Data collection and recording should be cheap and easy. There is no point collecting lots and lots of information and making it complicated if there is no need to. It is also vitally important that the farmers understand the information they are collecting and why they are collecting it. –Don’t expect her to collect information that will be of benefit to the researchers but not to herself or her family.

Be aware of the level of accuracy that is needed for a particular experiment.

Use your imagination when it comes to designing ways to record data. Some commonly used ways are:

* Farmer record sheets or notebooks – farmer observations,
* Photos,
* Maps –for example, to record the spread of a pest
* Wall sheets (similar to record sheets but hung on a wall so more than one person can fill them in).

Some of your experience with PRAP may lead to your thinking of other ways.

### Analysing the data

Keep it simple!

Simple tables can be an effective way of presenting data. Refer below.

Table 5 Summary of results of farmer experiments on yield of sweet potato after drought



There’s much to discuss about these results. Here’s some questions🡪

Were cultivars A, B and C the same for each farmer?

Were they planted at same time?

Were the mounds the same size?

Were the scales used accurate enough? Why not record 1.4 kg instead of just 1 kg or 2?

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| **👪** | Time for Questions  * What are the other issues you can think of (that relate to this simple experiment regarding three cultivars of sweet potato? * Make a long list – one issue to one piece of card. * Now rank the issues- 1 not important through to 3 really important. |

It is important for farmers to identify any special circumstances that may have ‘distorted’ the trials and need to be taken into account when assessing the results. This is not only important when the results are not what you would have expected, but also when results confirm your expectations. The two main areas of concern are:

* Are the differences in results between farms because of differences in the ways the farmers each implemented the trial?
* Other ‘special conditions’ such as an extremely dry year or unusually high market prices or if you are measuring people related items, perhaps sickness or a wedding/funeral has severely affected results. Perhaps the experiment needs repeating- hopefully in more representative circumstances.

### Incorporating results into farming systems:

Farmers and researchers need to consider🡪

* Is there going to be a demand for the final product? (“Can I sell it, and will it make a profit?!”)
* Will it benefit us? –will it be more expensive or demanding of labour than the old way? Will there be more risk involved?
* Does it fit into what I know and can do with my present resources? What new things will I have to learn? Will it require more fertilizer and water to be profitable?
* Is it available? –Can I get the seed of the new variety? Can seed be stored until next season? Will I be able to get the credit to get the inputs (seed, fertilizer, etc) I need on time, to use this new practice effectively? Can I use compost, or must I buy expensive inputs?
* Will the benefits be ongoing, or just temporary?
* Will this innovation improve my family’s life too? Or will it have a negative effect on them (especially if there is no market demand!)?

## Spreading new innovations and experiences (Farmer-based extension)

When farmers are happy with the results they obtained from their experimentation they will usually pass that information onto other farmers. This will mostly occur informally as farmers talk to each other. Unfortunately this sort of information exchange only reaches a few people, and often the ones that need it most miss out.

Farmers ideas also may not be taken seriously as local people may have learnt to rely on extension agents. It is important therefore that some ‘formal’ information transfer takes place, with the support of research and extension staff. Be creative at this stage.

## Why should our research station encourage farmer experimentation?

In the past research institutions have been the primary focus for developing new technologies and ways of doing things in farmer’s land. These new ideas were transferred as packages to waiting farmers – often men- through extension officers. So why is farmer experimentation an important part of this process?

* Farming families know all about the day-to-day issues of running their farms. Wouldn’t it make sense then for farmers to be involved in research which aims to benefit them?!
* Farming households (men and women- are we talking with both?) see a wider picture of constraints and opportunities than a visiting scientist.
* The combined knowledge of groups such as government departments, NGO’s, churches, businesses, farmer associations and farmers can save a lot of research time, money and stress.
* Sometimes extension officers have little practical farming experience. When farmers are part of the whole development process the resulting technologies are more relevant and appropriate.
* Farmers gain the confidence and courage they need to try new things (and keep trying new things!).
* This approach allows differences between men and women to be fully recognised and integrated into the research.
* This process gives increased control to people to shape their own lives (because after all, it is their life, right?)

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| **👪** | Time for discussion  * Sometimes extension officers have little practical farming experience? * What do you make of this statement? How do you react personally to this? * If true, what should we do about it? |

### Selecting a trial site – on station or on farm?

One of the first issues to resolve is whether the site will be on a research station or on farmer’s land. The site must always be appropriate for the experiment. Make sure that the site is typical of the area where the problem to be researched has arisen.

The table below gives some advantages and disadvantages of doing research on research stations or farmer’s land.

Table 1 Advantages and disadvantages of conducting research on-station or on-farm.

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| **Advantages of research conducted on the research station** | **Advantages of using farmer’s land** |
| Greater control over the crop or animals | Farmer involvement in the research process dramatically increases. This partnership between researcher and farming community is very important as results of research need to be conveyed to farmers and if they have been intimately involved in planning and conducting research, then the linkage between farmer and researcher is strong and healthy. |
| Can take risks that a farmer would not contemplate | Greater chance that our research is truly responding to the needs of farmers |
| Knowledge of past history of the field. | Farmers are asking questions all the time- they naturally fit well within a research framework. |
| May be lower cost | Research developed with farmers is likely to be adopted much faster than the same good idea developed in isolation in research stations. |
| If you need the site for longer than expected it is likely that you can negotiate for a longer time frame. | Farmer groups working in different areas give a robust form of replication which can help to develop credible/useful advice for farmers. (ie a simple experiment of just a standard way of doing something compared with a different way of doing that thing, repeated by many farmers is replicated in ways that makes our conclusions stronger and more valid. |
| Farmers, just doing their work of weeding or pruning, will be able to do some of the work of research, keeping costs down. Farmers can also help each other, even if researchers are not present. |
| Research will be done under realistic conditions, using the equipment available to the farmers. |

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| Disadvantages of research conducted on the research station | **Possible disadvantages of using farmer’s land** |
| Sometimes the inputs we use are beyond the means of the farmers we are seeking to serve and therefore the results are simply unrealistic and maybe unhelpful. | Farmers sometimes do things that cause problems for the researcher- perhaps harvest part of the experiment before measurements have been made. They must be part of the process of doing the research. |
| We may have little interaction with the people the trial is designed for | Neighbours may spray in a wind- and this can destroy your trial. This can also happen on a research station- beware. Make sure as many people as possible know about the research you are planning- and who to contact with comments or questions. |

Even where the research is done on a research station, remember that the research is being done for farmers. Involve them as much as possible. Farmers are natural researchers who can help you choose treatments and especially help you understand what are the important variables. Sometimes their choices may surprise you. Remember that work load or cost of inputs or risk may be more important to them than yield. If the manure experiment is only presented in terms of yield we are missing the important issue of cost of manure and the transport needed to get the manure to the farmer’s field.

### Important points for national organisations in relation to research

* It is important staff understand why local participation is not just important but necessary to achieve sustainable development. Our training may have unintentionally taught us to have a poor regard for farmers. It is only when we take a real interest and make an effort to understand the day to day struggle that farming families face that we can begin to respect how farmers manage to make the best of often extremely difficult situations. If we don’t really respect and admire the knowledge and understanding that farmers have, then our development programs will probably be ineffective and fail.
* Staff need to get their hands dirty in amongst the whole process of PTD. Farmers distrust advice from someone who lacks practical experience. Learn together. Get amongst the action. Show willingness to learn from farmers in the practical skills they have. Try these new ideas out on your own garden, with your own family. Theory alone is not good enough for top quality research teams.
* Farming families have to base their decisions on more than just economics. So where a scientist may be primarily interested in increasing productivity, a farmer may be more concerned with better taste, resistance to pests, or reducing the amount of labour. Farming families will also have to take into account issues other than their farms.
* A ‘farmers can experiment’ program will normally grow out of a PRAP (Participatory Rural Appraisal and Planning) process. It does not start with the researchers ideas, but, if your research agency is to be useful for farmers its staff will need to keep up to date with new technologies and ideas, as farmers will look to your research team for suggestions for new innovations worth testing.
* Your station will need to have the flexibility to respond to a variety of problems and issues raised by different categories of farmers. In areas that your research station is not specialised in, or doesn’t have the resources to deal with, it must have links with other organisations that can help or take over. Don’t be afraid to let villagers know that this problem is outside your priorities. You don’t have the resources to work on all problems farmers face.
* Farmers doing experiments should not just involve interactions between fieldworkers and farming families, but should also be a part of your organisational structure. Meetings between field staff and higher levels of management should provide opportunities to discuss problems encountered in the field, and develop solutions together. Management should be approachable by fieldworkers and the fieldworkers involved on a day-to-day basis in the running of the program should also be involved in the planning and prioritising of research.
* The research station will need to do ongoing evaluations of how effective their farmer’s doing research program is, including who is involved in it (men and women, wealth classes, ethnic groups) and whether the results have been useful for farming families.
* Remember always, to make your training ‘gender sensitive’. Just because you’ve already completed the gender module doesn’t mean you can just forget about it! Women and men farmers have different things to contribute. Don’t forget women in your work especially.
* Keep in mind that although you may be very comfortable with the formal scientific procedures you’ve been taught to use, they will seem very foreign and confusing to your local farmers. Respect that your ‘formal science’ way isn’t the only way! –Think outside the square! Use your imagination!
* Allow yourself to wonder & be amazed at the clever ways local farming families have coped with their circumstances. The knowledge they have accumulated has enabled them to survive this far, -respect that! Better still, record it so that they see you acknowledging their skills and knowledge.
* Farmer’s doing research may be ‘messier’ than the experimental methods that you have traditionally used, but the benefits should warrant some initial confusion! Remember that if you are only measuring plant and animal things you have probably missed the most important things to measure- relating to the way the people interact with the technology. Time is important in farming families. Who does what and how long it takes etc.
* Be creative! This is real life, on the edge, exciting stuff! You are being given an opportunity to improve the quality of life of fellow villagers. Go for it!

### Obstacles to Participation

* ‘Well-meaning’ people (fellow researchers, government agencies, wealthy farmers…) may try to take over and ‘run the show’. To prevent this you may simply need to explain to these people what you are doing and why farmer participation (and control of the experiment) is so important.
* Professional agronomists and development workers may find it hard to accept that rural people have anything worthwhile to contribute to technology development. This is often because throughout their formal education, they have been led to believe that scientific knowledge is superior to traditional or local knowledge. This prejudice can be very difficult to overcome! We need to be effective role models.
* Some farmers, especially women farmers, may face obstacles that prevent them from participating. For example, cultural restrictions may restrict them speaking at, or even going to, agricultural meetings.
* In some circumstances farming families are already so disillusioned with development projects that they will refuse to participate. Probably the best way to overcome this is to work initially with a small group of willing participants. As long as the project is run well and is relatively successful other farming families will probably overcome their doubts and join in too. Did you note how this statement is very focussed on the researcher coming to the village with their own ideas? How can you be part of changing the focus towards farmer involvement from the outset?

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| **👪** | Time for reading – Two ears of corn- Roland Bunch  * When I started out in West Papua this book was my development ‘Bible’. It is old now, but still good. * Roland said- ‘Start simply, start successfully’. Great advice. |

* Small-scale farmers live a precarious existence and there is always a chance that farmer experimentation may risk their existing livelihoods (eg: through the failure of the experimental crop). You will need to discuss this with the farmers and devise ways of avoiding it (for example, not planting the whole farm in an experimental crop, but just using a small plot at first). Remember that planting the whole garden in a new crop isn’t an experiment- rather it is folly! An experiment always needs something(s) to compare with others- a new with some of the old types for example.
* Scientists need to be creative in the way they manage this process. Public transport may need to be used to get to farmer fields if the research station 4WD is unavailable or short of fuel. Staying with the villagers overnight is always a good way of getting to know people and develop trust. Without the personal relationships working well, we can forget about developing effective partnerships in research with farmers.

### Roles of field research staff

Sometimes the best way that we can support farmer’s experiments is by learning from it, documenting it, and sharing and spreading its results to farmers in other villages. We can also help by teaching farming families about the options available to them and the basic principles behind various innovations. For example, rather than just telling farmers how much fertilizer to apply, describe how the fertiliser will affect soil life, fertility, economics[[12]](#footnote-12) etc. This allows them to make their own decisions based on an understanding of the issues. A third way to support farmers is by showing them how to make their experiments more systematic, ie: taking into consideration issues such as controls, replication, border effects and history of the site.

## References for farmers doing their own experiments

Considerable use has been made of Van Veldhuizen, L. , Waters-Bayer, A. and de Zeeuw, H. (1997) Developing Technology with Farmers: A trainers guide for participatory learning. Zed Books Ltd. London.

# Doing Field Research – getting the basics right

## Introduction

There is much to consider that relates to your own personal management (some call this personal viability) and your management of staff that work for you. There is supervision and delegation, the seven habits of highly effective people and more. In this section we concentrate on skills, attitudes and knowledge that will ensure you are more effective as a field researcher.

## Teams – research scientists, technicians and field labouring staff

Life is too short and the problems too serious to work alone or in ways that reduce the input from those who are farmers or labourers. Scientists particularly need to encourage the ideas and input and develop the skills of their field staff. Technicians need to see ways of sharing their learning with other ancillary staff/labourers. Outputs in terms of better advice developed will increase as we work together, valuing each others input, but also seeking to share the learning that we are each involved in.

Research is not a competitive business- it is one characterised by sharing knowledge so that as you do better in your work, this reflects well on everyone, contributing to real development.

The following goes some way towards a checklist for you to keep in mind regarding the way in which you work with field staff. Can you provide other suggestions?

* Be sure you are able to do the tasks you ask a technician/field labourer to do.
* Work with your field staff to ensure they know and understand fully the work they are to do. This can’t be stressed enough. They need a trial plan that is clear and explained. They need to see how something is done correctly. They need to work with you to achieve the right result. Then…
* Be appreciative of what they do.
* Listen to them, offering space for them to provide you with their ideas and suggestions.

If you as a research scientist simply hand tasks on and don’t really engage in the process of achieving the research – don’t expect quality results. It takes a lot more than telling someone to achieve a quality result.

If you are interested in more information on teams- supervision, delegation and mentoring – there is a separate manual to assist. It also covers personal effectiveness and efficiency issues- refer www.cdwi.net.

## Keeping a Field Notebook

Keeping track of what you have done in a simple notebook is not an optional extra. It is a must. Actually, a field notebook should be backed up by a computer based file- probably a LibreOffice or Microsoft Office file. Record-

1. The basics of what is happening- How? What? Where? When? Who? Why? How many? How much?
2. You may have to leave this task and your notebook will help others pick-up where you left off.
3. Write down your plans, decisions, and discussions with others, addresses and contact details, observations and don’t forget to write down the unexpected.
4. Keep it neat and tidy.
5. Glue loose sheets of paper into the notebook.
6. Your supervisor must see your notebook- at least monthly.
7. Finally, your name and contact details must be clearly marked.
8. Backup key information to your computer and to the internet as a way of backing information up- use something like a gmail account- refer below.

A good field notebook will make writing up the experiment so much easier.

That computer file… must be backed up. You don’t want theft, fire or (I’m based near Christchurch) earthquake to destroy your hard work.

## Backing up information

Backing up your information is crucial. It is not an optional extra.

1. Backup starts long before the harvests begin in an experiment. Field notebooks and discussions need to be backed up. Keep a hand-written field diary/notebook and get into the habit of recording key information into a file on your computer.
2. At least weekly make a copy of this computer file and store it somewhere else- in a different building and in a low humidity environment. Air-conditioned rooms are best for these backups.
3. If your office burns down tonight, how much will you lose that could have been stored on a memory stick or CD/DVD? Don’t let fire or theft or a computer crash ruin your research. It is too important for that.
4. Portable hard drives have become increasingly cost effective. Always budget for one, when applying for research funding. Storing your research on that drive is a ‘must do’ activity, but don’t leave that drive in the office where you normally work. Remember that fire issue.
5. As more of us have access to the internet, make use of opportunities for free storage. Opening a gmail account is very simple, and they allow you to email your files to your own gmail account. Do it!

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| **👪** | Time for backing up data- Now!  * Create a Google mail account (or similar) and email critical files to that account. * What would you do if your office burned down tonight? |

## Naming files

Information is hard to keep track of. Start by:-

1. Allocating a specific number or code to each experiment. It may be vanilla spacing at Widgeridoo Research Station, being run in 2011. A reasonable code could be VanSpace2011\_1. This means a trial at Widgeridoo, in a year (2011 in this instance), with the trial being No. 1. Don’t use /, or full stops in the code as this may cause problems when naming files with this code. Note that there is no need to put the name Widgeridoo in the filename- it is likely that the file is in a sub-directory that contains that research station’s name.
2. Whatever code you choose will be used in naming the field notebook, trial plans, data recording sheets and later spreadsheet files, word files and biometrical analyses.
3. Being consistent in naming files will save time and reduce confusion.
4. All files relating to that research should be stored in a directory under ‘My Documents’ with subdirectories allocated as necessary.
5. By keeping the code short you can add further information to the file name as necessary- for example ‘VanSpace2011\_1 Full data set.xls’ for the spreadsheet that contains all data relating to that experiment.
6. Your code should match the way others at your research station are naming files.

## Finding files on your hard drive

Google desktop is worth downloading and using. Google ‘how to use google desktop’. It allows you to quickly find information stored on your computer.

## Maintaining equipment used in field research

Tropical heat and rain quickly cause rusting of research tools. Good maintenance of tools will pay dividends in the research budget. Keep tools in a clean locked cupboard. Keep track of what has been borrowed and by whom. A small notebook tied to the inside of the cupboard will remind you to fill in borrowers name and date and agree on when it should be returned. Remind people to return equipment on time.

There is no point in having everything neat and locked away if researchers needing access to certain tools can’t get them because someone has the key and has gone on leave! It may be appropriate for those regularly working with some items to have them kept in a cupboard that they control with their own key. Losses are then more easily tracked. Field workers may have a different paint colour or code on their bush knife, spade, clippers, secateurs etc.

Tapes used for measuring trials will be cleaned and rolled up neatly. Leave in a hot dry place to ensure mould doesn’t ruin string or tapes.

Balances must be kept clean and well away from water. Fertilisers are corrosive. Ensure all fertiliser dust or spills are cleaned up promptly.

## Health and Safety issues

This is not a health and safety manual. However, health and safety are very important. Some tools used in the research environment are obviously very dangerous. Chainsaws come to mind as a key tool used at times by researchers- eg Harvesting Balsa trials or preparing sites where bush is cut down. This author regularly uses chainsaws, with leggings, steel capped boots, gloves and ear and eye protection. He has seen many users operating tools like chainsaws and others in the tropics – bare feet, no ear or eye protection. What can we do about this ‘problem’?

Your budgets should include safety equipment where appropriate.

Then look after the safety gear.

And finally- ensure the user makes good use of the equipment provided. Some people feel it is beneath them to use safety equipment. They should and they must use safety equipment.

Dusty environments around grain processing are common and dangerous. Eye, ear and breathing protection are all important.

Cutting grass with bushknives? Encourage workers to keep well apart. This researcher has had a bush-knife fly past his head in Tabubil some years ago, when a sweaty hand lost control of the knife. Safety as they say, in the mining industry – ‘is a priority’.

## Protecting your trial

Trials must be protected from animals. Budgets should include the cost of fencing material and the labour required to put in a good fence. Chickens and other animals are a fact of life in the village, but for your trial you do not want to examine the random damage effects of chickens on cabbage.

This may include people. Sometimes thieves come and destroy months of hard work. How can we reduce the theft? Firstly if the trial is ‘on farm’ then ensure that the local community agree with, support and understand the trial objectives. It needs to be their trial more than it is yours. Secondly it may help to have the trial out of site of people wandering by- especially if the product is edible or saleable.

Visit the trial site regularly. The best fertiliser for a field is the farmer’s foot applies to this section and to all of our research work. Visit often. Observe. People are more likely to respect you and the research you are doing with them if they see you involved, interested and keep informing them of results as they come to hand. People tend to look after things they own. Are they given the opportunity to own the trial?

Electric fences may be useful, but make sure you use appropriate (safe) electric fencing technology[[13]](#footnote-13). It is never safe to just design a system that gets plugged into whatever power you can obtain. Electric fencing is very effective with pigs and cattle. However the system needs to be on all the time or it is quickly useless.

# Trial design(s) - treatments, blocks, replication

## Introduction

This section deals with agricultural principles for research. It focuses mostly on crop and soil issues. Animals are not forgotten. There is a whole manual devoted to research with animals. This is available on our website[[14]](#footnote-14).

The PRAP leaflet (long out of print) written by Dick Morton is a very helpful guide. In it he states-

‘Agricultural trials are practical experiments to find the ‘best’ something; whether this is a variety, breed, fertiliser, feed, pesticide or some combination of these. The things being compared to find the best are called the treatments. The treatments are applied to plots.

A plot may be an area of a crop or a pen of pigs or chickens, or indeed anything to which a treatment is applied. A common mistake is to think that treatments are applied to animals or plants. This is so only if there is one animal or plant per plot. More often there are several…’

In a Randomised complete block design, the plots are organised into blocks. That way the number of plots per block is the same as the number of treatments. We will discuss various trial designs, but we must start by understanding variability as this is at the heart of decisions we make regarding our experiments.

## Variability – at the heart of agricultural experiments

Variability is the random unevenness that occurs in yield of a crop or growth rate in animals when they are 🡪

* growing in the same field, without anything added by a researcher or farmer.
* chickens producing variable numbers of eggs each week, but they are all fed the same feed.
* Mango trees yielding different amounts of fruit, although they seemed to be the same.

Variability is a key concern for all researchers. Without variability, life would be much simpler- and less interesting! Variability and our guesses (sometimes knowledge) about the extent of variability have a large effect on the way we design trials. Let’s discuss variability for starters, then we’ll consider how trial designs assist us in coping with variability, so that our trial’s treatments can be evaluated effectively.

Putting it as simply as we can- if our landscape is really variable, we may waste our time in doing an experiment. The background variability may be greater than our treatments. Look at the photo below (Plate 1). The variability caused by wireweed in oats is almost unbelievable. Imagine your treatments- fertilisers or insecticides having that kind of effect?! This is background variability that makes this field entirely unsuitable for standard field experiments.

So we may shift to a new piece of ground for our experiment. The soil may appear uniform, but it may not be as uniform as the researcher would like. Take the garden area you are familiar with- perhaps last year, some rubbish was heaped up and burned. What happened? The fire created increased variability in that garden area - leaving a burnt and ash rich area, surrounded by depleted areas where plants with their nutrients were removed and piled in the one area, subsequently burned (or allowed to rot). There could well be many parts of the garden where small fires were burned. These practices are a ‘must not do’ for any serious research area!

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| Plate 1 Extreme variability in oat crop – caused by variable weed infestation (*Polygonum aviculare*), New Zealand. |

There are many ways that variability can be increased. Livestock may ‘camp’ on one area, and their dung and urine will enrich one part of a garden over another.

It is harder, by far to reduce variability, once it is increased.

Temperate agriculture, with large fields of one cultivar[[15]](#footnote-15) (one type of plant within a species- one variety of carrot or corn for example) show this variability very clearly.

Tropical gardens tend to hide the variability, as gardens are often on sloping land, with many various plants. Sweet potato tops can look much like their neighbours, hiding the differences in yield rather well! Finally, with crops like sweet potato or bananas – they are harvested over weeks or maybe even months, hiding the variability that exists.

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| Plate 2 Extreme variability in soil conditions- Western Province, Papua New Guinea  . | soil variability white black soil1 |

Extreme variability means that this landscape (above) will prove unsuitable for field experiments. If this is the only land available, your experiment will require extra replication and careful blocking based on past crop yields. Some areas will still have to be excluded from your plots. Differences between treatments will need to be large, to give a ‘significant’ difference. If a cultivar is only – on average – 15% better than a control- in this kind of landscape it is unlikely that your experiment will deliver a significant difference in your statistical tests. The background variability in soil depth and therefore crop growth will be greater than the differences between treatments.

This manual will cover a range of techniques we have to manage variability. Let’s consider the ways variability is increased.

### Landscape and Topography

Start with a hill slope. There will be a range of soil types on that slope. Parts may be covered with deep ash from a recent or ancient volcano. Perhaps you are in a river bed, where in the space of just a few metres the soil changes from deep silt to almost no top soil and coarse gravels. Water holding capacity and its effect of crop yield will change more dramatically than the change you are trying to measure- say cultivar difference in coffee or cabbage. These differences show up dramatically when you are in an aircraft above a site and soil conditions are very dry.

### History of the research area

Imagine an experiment looking at the effect of lime on reducing club root in brassicas. Those plots that received 10t/ha of lime will be very different, for many years to come compared with those that received no lime. This may affect subsequent research results conducted in the area.

Another experiment may have some plots of corn receiving 10t/ha of fresh goat/sheep manure, while others receive 100 kg NPK fertiliser/ha and other plots may be control- receiving none at all. You can see how quickly the land is made unsuitable for further experiments- at least until those differences have reduced. We have techniques to reduce that variability- and the most common is to grow a couple of crops of corn or root crops or plant pasture so that over time the variability is greatly reduced.

This is important. It may be that half of the area grew corn last year and half grew Aibika and then was left in weeds. If you must establish the trial in this area ensure that complete blocks are grown on the area that had corn and another complete block (or blocks) of treatments are grown on land that had Aibika previously.

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| rice among logs after burn and planting 0008 iowara | Plate 3 Experimentation in very variable land.  Experimentation on this kind of land, where soil and forest residue is very uneven will be difficult. Many replicates are going to be necessary, and some areas may need removing from the trial layout. |

### Coping with rain and hilly sites

The runoff following heavy rain on hilly sites can destroy plots and much hard work. Plan for runoff by careful site selection, listening to those who know the land better than you do.

Dig a ditch across the top of the site to ensure that heavy rain is unable to wash through the middle of plots. Walk around the trial during heavy rain and make ditches to manage runoff.

Consider leaving some guard areas between plots in grass that can also help reduce the build up of water. Intermediate ditches on the contour can also be used to reduce soil erosion.

### Dealing with variability

The following checklist should help in making sure that each of the plots in an experiment are as close to the same as the other plots as is possible.

1. Your biometrician should be someone involved right from the start. You may not be lucky enough to have a biometrician handy. Emails might help to put you in touch with someone willing to offer advice. My experience is that biometricians are willing to be helpful- especially when the questions are posed at the start of a process, not in a patch up job when writing up a poorly designed experiment. That is such a waste of time and resources.
2. When deciding on a trial site, look up and down and around. Check for areas that have shade or perhaps large tree roots taking up moisture and fertility.
3. Keep well away from rock outcrops, old fence lines, old tracks where people or animals or vehicles have travelled frequently.
4. If you are on a hill slope look at where runoff water flows. Visiting a trial site after heavy rain could be depressing if many of your plots have been damaged by erosion. It’s best to learn about these possibilities from those more experienced than you are.
5. Ask advice from those with good experience – field staff often have long experience with the research area.
6. One of the features that lead to variability in village situations is the burning of rubbish and leaves in small heaps (mentioned earlier). Many people gather up leaves and rubbish and burn them right where the heap is. This burning will leave behind a small area with higher fertility than surrounding land. This means increased variability. If possible keep away from areas that have been burned like this.
7. When you lay out plots you need to avoid these areas, even if all you do is put in a dummy plot. The plot is planted but never measured. It may mean that the blocks take on different shapes, but it is better to keep away from areas that you know have variability.
8. The trial plan and a large stick in the dummy plot will indicate that this is not a trial plot. Having determined that there is a gradation in fertility for example then aim to put all of block one in the area of highest fertility and all plots of another block in the area of medium fertility with the last block being on least fertile ground

### Plot size and shape, guard areas

Plot size and shape depend on:-

1. Which stage of the experimental process you are starting at. (For example for a collection of taro lines from villagers, it may be necessary to evaluate many lines in ‘one plant’ plots. However when you are at the stage of, for example, grazing trials, then very few species will be in the trial and plots will be large- perhaps 0.1-0.5 ha each.)
2. Trial site, slope, surrounding areas, perhaps large trees, buildings, roads, rivers, rocks etc,
3. How the trial will be established- (eg the size of a drill (machine used in sowing). Many of us will plant a crop by hand. Hand planting and harvesting allows various plot sizes to be used, but care will be needed to establish the same population across each treatment),
4. The type of crop, or animal species being researched.

Sometimes a treatment will cause some crops to grow much larger than others. Perhaps there is a cultivar difference. In the case of cassava there may be interest in grafting to different root stocks, causing some plants to grow 2-3 times larger than the standard or control un-grafted plants. This may mean that some plots need to be much larger than others. You need to discuss these issues with a biometrician – before planting.

As plot sizes increase it is harder to ensure that all plots in one block are on land that is uniform.

Guard rows are important and should be planned for carefully. They ensure that the experimental plants grow as if they were part of a large paddock of the crop. Without guard rows crops will get access to more (or less) sun and soil moisture and fertility than would be normal. Our results would not be representative of what a larger scale farm operation could be expected to achieve. On the other hand our trial plants could be damaged by wind if there are no guard areas.

Guard rows are used to ensure that the whole area is planted to the crop- if some areas are left unplanted then a later researcher will find that we have increased soil fertility and variability. Weeds would grow in the unplanted area also causing problems for later researchers.

Trials can’t be established right up to permanent fences, close to trees etc, so these ‘waste’ areas are planted into the crop that is most commonly being planted. Sometimes dummy plots have to be used- to get past a rock outcrop or place where rubbish has been burnt- plant these areas as if they were guard areas.

Please look at the trial plans provided to see how guard areas actually work in field trials.

### Edge Effects

Where a row or rows on the outside edges of a crop are growing much better than rows in the middle - we have an edge effect. We should not harvest/measure the outside row or rows, as they are obviously different to the bulk of the crop, growing in the middle. This effect is very important. Our sampling strategy to measure yield must take account of edge effects and our trial plan must have allowed for edge effects. You can see how important it is to have experience when planning a field experiment.

## Experimental designs and layouts in field experiments

This section relies on a number of examples. We will also go to the field, and look at field experiments, then discuss each experiment in groups- with trial plans in front of us.

Understanding the principles in this section is crucial to being an effective field researcher.

First, how does blocking help in overcoming problems with variability? This is best described by using an example. A couple of definitions are needed – replicates and blocks🡪

A replicate is a group of all of the treatments, appearing once for each treatment.

A block describes how that replicate is laid out in the field, or on the glasshouse bench.

Here’s our fictitious but quite possible example. Mary is a Vanuatu based extension officer and she has been asked what fertiliser is best to use on sweet corn. Does it grow best with chemical fertiliser or animal manure. We have two kinds of animal manure- chicken manure from broiler cages and goat manure, collected under a goat house. She is also thinking about profitability- which option is best for the farming families she works with.

The chemical fertiliser she uses is a compound mix from the local agriculture store.

So, let’s just consider how the experiment may be laid out in the field.

### Randomised Complete Block Design

Mary realises she needs a control plot of corn that gets no added chemical or animal manure. That is treatment 1.

She figures the other treatments as shown in the table below.

Table 6 Mary’s manure and fertiliser experiment, Vanuatu.

|  |  |  |
| --- | --- | --- |
| Treatment No. | Description | Comments |
| 1 | Control | No added fertiliser |
| 2 | Goat manure | How wet is the manure? This will make a big difference to the amount of nutrient being applied. Some chemical analysis of the manures will be needed to ensure you know how much N, P and K are being applied per plot. That way comparisons with the chemical fertiliser will be possible. |
| 3 | Chicken manure | Broiler manure can be very variable, depending on the amount of manure mixed with sawdust. |
| 4 | Chemical fertiliser (50 kg N/ha) | Info needed in a real expt. |
| 5 | Chemical fertiliser (100 kg N/ha) |  |

Mary could choose either a completely random design or a randomised complete block design. Both options below (a) and (b) are Randomised complete block designs.

|  |
| --- |
| trial layout simple ACIARa |
| From Asher, C., Grundon, N and Menzies, N. 2002. How to unravel and solve soil fertility problems. ACIAR, Canberra.[[16]](#footnote-16) |

Figure 1 Mary’s Vanuatu experiment – shown with two different layouts. The trial has five treatments, each with four replicates, laid out as four randomised, complete blocks- meaning each block has one of each of the treatments in it. a) Layout of blocks on a site with a gradient in soil fertility; b) Layout of the same experiment but at a site that has known areas with ash and old tree stumps.

Layout (a) is laid out as if the only variability in the site is due to a fertility trend – possibly a slope from top of page to bottom. Layout (b) is the layout used by someone with greater understanding of the site and its background variation. Note that more land is being used with layout b.

Both layouts a and b (above) are known as Randomised complete block designs. Why? Each replicate is laid out as a complete block- all treatments in a replicate together in a block of plots. The blocks in b are moved around to reduce the effects of problem areas like old tree stumps or old burning heaps.

There is always a challenge with sites like that shown on the right in the figure above (b). How far from the ash and the tree stumps does a plot need to be, before it is essentially the same as the plot next to it? If the researcher places a block further from the tree stump, there is a chance they move the block into another problem- perhaps swampy ground near the bottom of the hill. These questions – of site and block selection- come down to experience. Talk to those who know the site and to those who understand trial design. Remember a biometrician should always be consulted.

There’s more on this below- see footnote[[17]](#footnote-17) .

### Completely random design

The simplest experiment is a completely random design where for example the manure and fertiliser experiment Mary wants to use is laid out with four replicates, but no blocks. By chance the first four plots, of treatment 1- Chicken manure, of a completely random design (that was replicated four times) could be side by side. Most researchers consider this would be very unwise. So we never use completely random designs – but they could be useful in a laboratory bench testing germination for example, where all parts of the bench are deemed the same as other parts.

For Mary’s experiment here is the field layout possible if she chose a Completely Random design. Plot numbers are not shown. Treatments are shown below, and note how, by chance all of treatment 1 occur near the ‘top’ of the trial. There are no blocks, just 4 replicates of 5 treatments.

|  |  |  |  |
| --- | --- | --- | --- |
| 1 = Control | 1 = Control | 1 = Control | 4 Fert. 50 kg N/ha |
| 3 = Chicken manure | 4 Fert. 50 kg N/ha | 1 = Control | 2 = Goat manure |
| 4 Fert. 50 kg N/ha | 3 = Chicken manure | 5 Fert 100 kg N/ha | 4 Fert. 50 kg N/ha |
| 5 Fert 100 kg N/ha | 5 Fert 100 kg N/ha | 5 Fert 100 kg N/ha | 2 = Goat manure |
| 2 = Goat manure | 3 = Chicken manure | 2 = Goat manure | 3 = Chicken manure |

So far we have dealt with simple experiments- a range of treatments – chicken manure compared with goat manure and two levels of fertiliser. There are very powerful biometrical tools available for understanding treatment differences. In the experiment above (Table 6 on page 49) single degree of freedom F tests could be completed that assess the following questions🡪

1. Compare control with any kind of fertiliser.
2. Compare chemical fertiliser with animal manures.
3. Compare goat manure with chicken manure.
4. There is one single degree of freedom test left. It may be possible to compare the two levels of chemical fertiliser.

These orthogonoal contrasts/single degree of freedom tests need explanation from a biometrician. They are mentioned here as few researchers know of this powerful analysis.

### Factorial design

These are very common designs. When two or more variables are studied we use a factorial design.

Following Mary’s initial work on manures and fertiliser she may become interested in a possible interaction between goat manure and chemical fertiliser. Maybe corn yield is enhanced by providing both goat manure and fertiliser.

The simplest possible experiment looks like this.

Two levels of goat manure x two levels of chemical fertiliser. This would be a 2 by 2 factorial design with just 4 treatments and we could have four or five replicates. We are normally more comfortable with a trial that is larger, to assist in sensible/worthwhile analysis. Once again, a biometrician assists in explaining reasons why we look to a larger experiment.

For our purposes- here is how the treatments could be considered. They are provided for you, in standard order, which we discuss in more detail in the following pages.

Getting standard order right, for a factorial design is a case of following three rules.

Firstly multiply the factors to find out how many treatments there are and right down treatments 1🡪 4 on the left hand side of a page.

Now take the first factor and repeat its levels down the page. 1,2,3, 1,2,3, 1,2,3 etc. In this case it is -+, -+.

Then the next factor is put at the first level, until the pattern repeats. See the table below.

Table 7 Simple 2 x 2 factorial experiment outlined in standard order for treatments.

|  |  |  |
| --- | --- | --- |
| **Treatment Number** | **Goat manure** | **Chemical fertiliser**  **(rate must be clearly identified)** |
| **1** | **-** | **-** |
| **2** | **+** | **-** |
| **3** | **-** | **+** |
| **4** | **+** | **+** |

This manual provides a number of examples of factorial designs. Eg the description/example of a factorial, which has been *laid out in the field* as a randomised complete block design - page 54 and following.

### Split plot design

Sometimes one of the treatments in a factorial design requires a layout with main plot and subplots.

Please note- a researcher uses a split plot design because they are forced to. You don’t use a split plot design unless you have to. If possible, use a standard randomised complete block design. If particular treatments force you into it- use a split plot design, as discussed below.

Let’s keep working with our original experiment of various manures that Mary wants to assess. An extension officer explains there is a big need for insect (or disease) control and suggests some plots need spraying with insecticide as part of an experiment. Spray drift and insect behaviour mean that the new, larger experiment is laid out as a split plot design, where main plots are spray and subplots are manure treatments. Here is how the treatments look now.

Note that at this point – refer below- the experiment could be laid out in the field as either a Randomised complete block design or a split plot.

If we used a RCBD each treatment would be randomly allocated once in a block.

If we use a split plot design, the layout would be as shown below 🡪

1. main plots of insecticide sprayed or unsprayed have within them subplots.
2. The subplots are the fertiliser treatments.

Table 8 Standard order for a simple factorial, which will be laid out in the field as a split plot design

|  |  |  |
| --- | --- | --- |
| **Treatment No.** | **Manure** | **Insecticide**  **(Or spray**  **Or perhaps irrigation)** |
| 1 | Control | **-** |
| 2 | Goat manure | **-** |
| 3 | Chicken manure | **-** |
| 4 | Chemical fertiliser (50 kg N/ha) | **-** |
| 5 | Chemical fertiliser (100 kg N/ha) | **-** |
| 6 | Control | **+** |
| 7 | Goat manure | **+** |
| 8 | Chicken manure | **+** |
| 9 | Chemical fertiliser (50 kg N/ha) | **+** |
| 10 | Chemical fertiliser (100 kg N/ha) | **+** |

In the trial plan overleaf, sub-plot treatments need to be randomly allocated. Use the random number table (page 123) to allocate treatments 1-5 to the first five plots of block (replicate) 1 and the same random number table to allocate treatments 6-10 (above) to plots numbered 6-10 (still replicate one).

Then repeat for replicate/block two.

Figure 2 Part of the trial plan for a split plot design where insecticide sprayed main plots are separated by ‘extra’ guard areas from unsprayed main plots.

|  |
| --- |
| split plot design 2011 |

Note the largest gaps between plots are where there is a shift from sprayed to unsprayed.

A more complex example of a split plot design is explained on page **Error! Bookmark not defined.**.

Class exercises will reinforce your understanding of these various designs.

### Latin square

An example of this is provided on page 103 – the number of replicates is the same as treatments and each treatment occurs once in each row and once in each column. (Refer to the example provided).

## Standard Order

Standard order is a way of looking at the whole set of treatments for a trial. To help us understand standard order - lets take an example, from the researchers in the high altitude program, based at Tambul. The key problem facing potato farmers is late blight.

An advisor to the program has come up with some cultivars that may be better than the local cultivar and some fungicides that may help. Note that we are now looking at two ‘variables’ - cultivar and fungicide. At the heart of our experiment we are asking this question.

***Do some cultivars respond differently to disease control measures (fungicide)?***

The researchers plan an experiment that has 3 cultivars by two levels of fungicide. To keep things easy for us, here are the three cultivars- Supreme, Sebago and Local, and the two rates of fungicide we are going to use are Nil and High. We can define those two rates later.

1. How many treatments are there? 3 Cultivars by 2 fungicide levels = 6 treatments.
2. We talk to a biometrician who suggests we lay this experiment out in 4 randomised, complete blocks, where each block, or replicate has 6 plots, with the treatments occurring once in each block.
3. To get started we list the 6 treatments and build up a standard order for the treatments.

Table 9 Standard Order for a trial with 3 potato cultivars by two levels of fungicide

|  |  |  |
| --- | --- | --- |
| **Treatment Number**  We know that there are 6 treatments so we start by writing down the 6 treatments | **Cultivars**  It doesn’t matter whether we start with cultivar or fungicide level, but having started with cultivar we have to write down all of the cultivars, one after the other | What are we going to write in this column? |
| 1 | **Local** |  |
| 2 | **Sebago** |  |
| 3 | **Supreme**  (It doesn’t matter which order we write them in, so long as we are consistent) |  |
| 4 | Can you fill out the rest of the table  without turning the page to see the  answer? Give it a go. Traim tasol. |  |
| 5 |  |
| 6 |  |

Table 10 Standard Order partially completed for a trial with 3 potato cultivars by two levels of fungicide

|  |  |  |
| --- | --- | --- |
| **Treatment Number** | **Cultivars** | **Fungicide – two levels- nil and high.** |
| **1** | **Local** | **Nil** |
| **2** | **Sebago** | Do we write **high or Nil** here? The key to figuring this out is to keep writing Nil, until the pattern in the cultivar column changes and it doesn’t change until we get to treatment 4, when local is the cultivar. |
| **3** | **Supreme** |  |
| **4** | **Local** |  |
| **5** | **Sebago** |  |
| **6** | **Supreme** |  |

Table 11 Standard Order completed for a trial with 3 potato cultivars by two levels of fungicide

|  |  |  |
| --- | --- | --- |
| **Treatment Number** | **Cultivars** | **Fungicide** |
| **1** | **Local** | **Nil** |
| **2** | **Sebago** | **Nil** |
| **3** | **Supreme** | **Nil** |
| **4** | **Local** | **High** |
| **5** | **Sebago** | **High** |
| **6** | **Supreme** | **High** |

So we have the standard order laid out and we know that we have 4 replicates.

We can start a data recording sheet and in this sheet we are going to use random order tables to inform us as to which treatments will be randomly allocated to plots.

How many plots in total are there? 6 treatments by 4 replicates = 24 plots.

A partially completed trial plan is provided overleaf - refer to Effective Trial Plans on page 62 for guidelines for preparing trial plans.

Figure 3 Trial plan for Tambul Potato by fungicide Trial- No 2005\_1.

|  |  |
| --- | --- |
| Slide1 | location |
| Internal plot layout of potatoes |

Can you fill in the missing information for reps 2, 3 and 4 (from the previous pages)? Note that this plan provides four key elements – a title with key information, a plan of the trial, how to get there and orient yourself as well as layout within each plot. Many plans need that amount of detail.

Table 12 Plots and treatments for a trial assessing three cultivars by two fungicides.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Plot Number** | **Replicate** | **Treatments** | **Variables that you measure**, eg height, visual score, number of plants, weight of plants etc. | Variables that you measure | **Comments** that need to be remembered for each of the plots. Only some plots will have some comments written. |
| 1 | 1 | **4** |  |  |  |
| 2 | 1 | **3** |  |  |  |
| 3 | 1 | **1** |  |  |  |
| 4 | 1 | **6** | How do we get started in filling out this column? Answer- keep reading!  We open any stats textbook and go to the random number page.  We have 6 treatments to allocate randomly to the first 6 plots, which make up all plots of our first replicate. We open the random number page and point to any column or row of data. This can be anywhere on the page.  We see numbers like this:-  …*7493 1168 5729* …( from the random number page)  We start with the first number- perhaps it is a 7. We don’t need that number so we move to the next number which happens to be a 4, so we write 4, because 4 is in the set of numbers we are looking for.  The next number is 9 – we ignore that, but the next after that is 3 so it gets written down. The next number was 1 – we use that, but ignore the next 1 as it is no longer needed. 6- we need that, 8 we ignore, and 5 is used. The last number has to be 2 because it is the last of the 6 numbers we were looking for.  We repeat the exercise for the next 3 replicates. | | |
| 5 | 1 | **5** |
| 6 | 1 | **2** |
| 7 | 2 | Can you fill |
| 8 | 2 | out the rest? |
| 9 | 2 | Pls do, as |
| 10 | 2 | you need to |
| 11 | 2 | if you are |
| 12 | 2 | going |
| 13 | 3 | to be able |
| 14 | 3 | to fill in the |
| 15 | 3 | next page. |
| 16 | 3 |  |
| 17 | 3 |  |
| 18 | 3 |  |
| 19 | 4 |  |
| 20 | 4 |  |
| 21 | 4 |  |
| 22 | 4 |  |
| 23 | 4 |  |
| 24 | 4 |  |

What is missing in this sheet, if we were to use it as a data recording sheet for our experiment?

Yes, you are right, treatment numbers are not as helpful as actually writing down the cultivars and fungicide that will be used on each plot. Now that we have allocated treatments to plots, we can modify the sheet, so that it becomes a data recording sheet.

It may look a bit like that shown below. (Note we now have a heading portion to our data recording process).

Table 13 Data recording sheet for Potato Cultivar by Fungicide Treatment

|  |  |
| --- | --- |
| **Potato cultivar by fungicide Trial 20\_\_** | Refer to Miss Sarah Researcher,  Address given here. |
| Date of measurement:- | Email address. |
| Main people involved:- | Ph. Numbers- anything to help contact the researcher |
| General Comments (note we built this data recording sheet as two separate tables, for ease of working in M’soft Word) | |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Plot | Rep | Tmt | Cultivar | Fungicide | Visual score[[18]](#footnote-18) | Plant Number per plot | Comments |
| 1 | 1 | 4 | Local | High |  |  |  |
| 2 | 1 | 3 | Supreme | Nil |  |  |  |
| 3 | 1 | 1 | Local | Nil |  |  |  |
| 4 | 1 | 6 | Supreme | High |  |  |  |
| 5 | 1 | 5 | Sebago | High |  |  |  |
| 6 | 1 | 2 | Sebago | Nil |  |  |  |
| 7 | 2 |  | Can you fill out the rest? | |  |  |  |
| 8 | 2 |  |  |  |  |  |  |
| 9 | 2 |  |  |  |  |  |  |
| 10 | 2 |  | If you were going to do visual scores for damage etc, it would be best to use a recording sheet that shows plot numbers without any treatment information. That way your judgement is not biased by knowing what the treatments were.  (Some rows missing to fit it all into one page). | | | | |
| 11 | 2 |  |
| 12 | 2 |  |
| 13 | 3 |  |
| 14 | 3 |  |  |  |  |  |  |
| 15 | 3 |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
| 20 | 4 |  |  |  |  |  |  |
| 21 | 4 |  |  |  |  |  |  |
| 22 | 4 |  |  |  |  |  |  |
| 23 | 4 |  |  |  |  |  |  |
| 24 | 4 |  |  |  |  |  |  |

Use a footer to inform the reader of how many pages there are. Eg 1 of 3.

# Getting started in the field

|  |
| --- |
| measuring balsa log |
| Plate 4 Measuring balsa logs as part of Keravat LAES research. |

## Trial Protocol[[19]](#footnote-19)

Before starting research there is literature to search and reading to do. That is a topic in its own right, covered very briefly in this manual.

Provide colleagues and your supervisor with a trial protocol or pre-schedule. Trial protocols should give another scientist or supervisor enough information to really understand what you are trying to achieve and how you are going to go about it- including the key points in methods and measurements. Farmers or other growers are likely to offer helpful suggestions. Include them in the discussions.

|  |
| --- |
| Discuss your research plans with colleagues, farmers and others |

Each research station should have a standard procedure ensuring that prior to a new experiment being started, the researcher presents information and plans for wider discussion. This protects you from wasting time and encourages teams to work, supporting each other. Don’t skip this step.

Appropriate headings for a trial protocol are shown in the table overleaf. You may need to provide other headings appropriate for your particular research.

Table 2 Headings normally required in a Trial Protocol

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Headings** | **Comments** | | | |
| Title | Keep it simple and self-explanatory. eg. Effects of different rates[[20]](#footnote-20) of organic manure on potato yield. | | | |
| Trial Code | This code follows through all file names in computers- including data recording sheets, trial plan etc. | | | |
| Objectives | These are developed following discussions with farmers, other scientists, technicians and your literature review. | | | |
| Farmer involvement | Detail the ways in which you have involved growers/farmers in the development of this research proposal.  Also provide evidence that you will ensure farmers engage with and learn about the research. | | | |
| Reasons for the experiment | Give these very briefly. Most of these should have been outlined as part of the literature review process. | | | |
| Duration | Particularly important in rotation trials which can be extremely demanding in terms of costs (time, travel etc) and often hard to analyse. | | | |
| Trial Design | State the basic information relating to trial design.  For example 5 (levels of) Nitrogen by 2 species in a 5 x 2 factorial replicated 4 times. The trial will be laid out as a completely random [[21]](#footnote-21)design or randomised complete [[22]](#footnote-22)block design. | | | |
| Team | Who will be involved in doing the research? | | | |
| Rates, level of various factors[[23]](#footnote-23)  eg | Describe the key elements of the trial design. If it is 5 rates of Nitrogen- then provide the rates of Nitrogen and also the grams of urea or other fertiliser that will be applied per plot or per pot. Show calculation for ease of checking. | | | |
| kg N/ha | kg Urea/ha | Pot or plot area – give units. | g Urea /pot or plot. |
| 25 kg N/ha |  |  |  |
| 50 kg N/ha |  |  |  |
| 100 kg N/ha |  |  |  |
| Basal treatments | This could be insecticide, fungicide, herbicide, fertiliser, water etc. As for the table above, give all the detail necessary to allow a supervisor to check that the correct material at the right rate is going to be applied. | | | |
| Cultural details | Site Preparation  Planting- Row spacing and distance between plants? In potato trials it is common to separate plots by using a red marker potato so that it is clear which plot various plants belong to. | | | |
| Potting mix or soil type | What are the plants going to grow in? Any site history? | | | |
| Cage size | Important for animal research. How many in a cage? Size of feeders, provision of water (include emergency water supply for when the power fails), fresh air, protection from sun… | | | |
| Plants or animals to be used. | Seed type- obtained from, seed line number etc. ie provide detail relating to plant material.  Germination test results- with detail as to how the germination test was done.  Age of animals, upper and lower weights that are acceptable…, particular genetic issues? | | | |
| Sampling strategy during growth of the experiment. | Give areas or numbers to sample and position in plots.  Particularly important for crops or animals where some destruction of experimental material occurs during sampling.  Where soils are sampled during crop growth it will be important to consider setting aside uniform areas for final harvest soon after the crop is established. These areas will not be sampled during the life of the crop. | | | |
| Trial Plans | Refer to the examples in this manual. | | | |
| Data Recording | Plan your data recording process and prepare data recording sheets. Bear in mind that data will most probably be entered into a spreadsheet or database- will that process be easy? Will someone else be able to read the numbers? Will there be space for comments etc.  Detail about data recording on page 59. | | | |
| Final harvest | Think about all of the measurements that will be made and describe these – especially any sub-samples that will be taken for further analysis. | | | |
| Chemical analyses | Where material will be analysed later, remember to ensure material is not contaminated, nor is it rotten or eaten by mice or insects. Don’t store samples for a long time, especially in tropical conditions. | | | |
| Biometrical Analysis | Who will provide assistance? | | | |
| Economic assessment | Research is not just for research sake- it is for the benefit of real people, normally requiring some assessment of economic, gender, workload implications. | | | |
| Expected publications | Where will information be published? | | | |

## Effective Trial Plans

Effective trial plans are simple and clear, and contain the following information:-

1. Trial title. Refer to each trial in only one way- whether in internal reports, excel data sheets or the trial plan.
2. Contact details for the primary researcher on the trial plan- give an email address if possible.
3. A location plan helps a visitor find the trial site. This is particularly important for research operating on farmer owned land.
4. Show features such as large trees, house, beach or direction to the nearest town so that people are able to see which way to hold the plan, relative to the trial. A North direction marker is also useful.
5. The plan should clearly show plot numbers, treatments and block numbers. Where possible use no abbreviations or if they are necessary- make sure that there is a key on the plan to show what abbreviations mean.
6. It is best to use real names rather than treatment numbers, which carry less information, especially for those unfamiliar with the trial. For example use Sequoia (a potato cultivar) rather than Tmt4. Tmt4 may well be Sequoia, but using the actual name in the trial plan helps to reduce confusion.
7. Don’t make changes to the trial plan!! If you do, you run the risk of people being totally confused. If you HAVE to make changes, then try and destroy or at least put a bold line through the out of date version so people know which contains the accurate version.
8. Get someone senior to check your draft plan. Once you have incorporated their suggestions, then-
9. Make plenty of copies of the trial plan and give a copy to anyone who is involved in the trial.
10. Refer to the examples as a guide – page 103.

|  |  |
| --- | --- |
| Note that it may be much easier to draw a plan using dark pen and rulers, with clear hand-writing than to make your plan using Microsoft Word. A scanner can be used effectively to allow you to incorporate the plan into documents, as a .jpg file. If you really want to use the computer to make your plan- consider using software like PowerPoint, which is more powerful for diagrams than Word. The Office 2000 training CD-ROM provides helpful ideas for using PowerPoint. Three separate pages were used to build the plan overleaf. The PowerPoint file is on the website - called Trial Plan for Tambul Potatoes.ppt | j0237438 |

Refer overleaf for an example of a trial plan. We will work on more of these in class.

Figure 4 Randomised Block design, Effect of Clover cultivars on clover percentage in pasture

Randomised Complete Block Design- 9 overdrilling treatments.

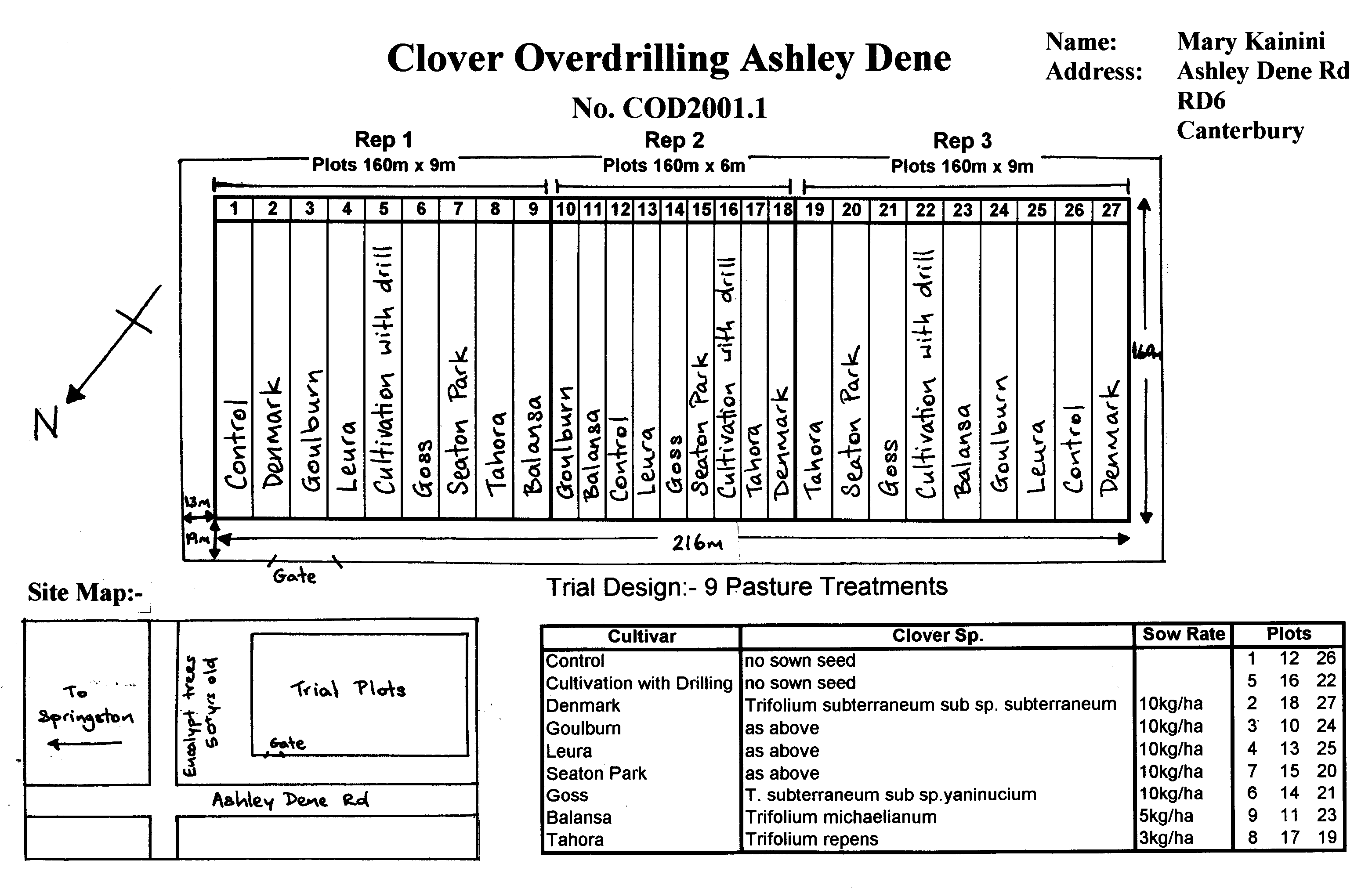
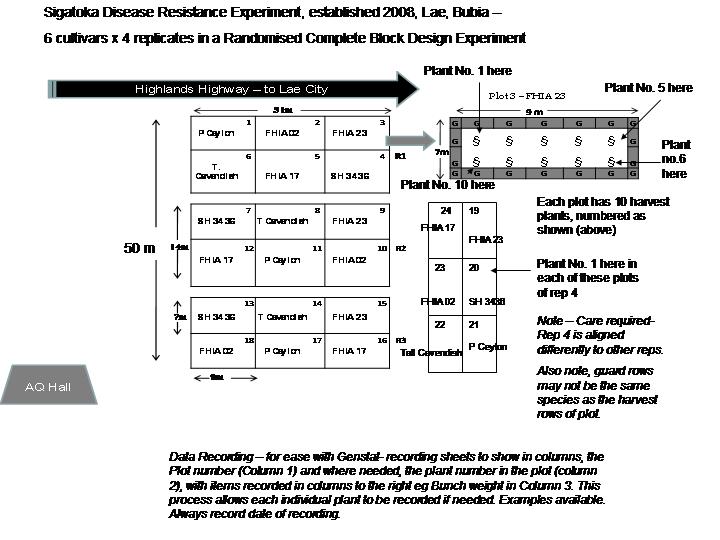


Figure 5 Banana experiment – trial plan with key features required in an effective trial plan – developed during recent training program.



## Visitors?

Right from the outset train people in how to move through your experiment. Don’t let them walk all over plots (This assumes you know better and don’t walk across plots when moving from one to another!).

Provide visitors with a professional looking, accurate and informative trial plan and perhaps your research background/protocol that helps them understand how the research is to proceed.

## Laying out, pegging and labelling plots

Plots vary in size from individual plants in rows right up to many ha paddocks in grazing experiments. This section deals mainly with crop and pasture plots where area is crucial for all subsequent measurements. The starting point is a right angle at the corners of plots and blocks so that areas are accurate and trials look good. This is important because some years after an experiment there may be a reason for assessing the effect of treatments on for example soil fertility. Knowing that the corner of a plot was exactly here and that the trial had been marked out in an exact manner allows old plots to be found. If things are done in a rushed and haphazard manner at the start it is likely that the experiment may continue in a similar vein. Pursue excellence!

A right angle can be found with only one measuring tape, but it is best to use two 30 m tapes as shown below.

|  |  |
| --- | --- |
| right angle dark good1 | Needed:-   1. At least one but preferably two 30 m tapes. 2. Pegs- appropriate final height, bearing in mind height of crop and length of time the trial will grow. 3. String- 100 m will be very useful in most field trial situations. Remember to keep it in a dry place to stop it rotting. 4. Hammers for pegs to be used for long term trials. |

Figure 6 Method of obtaining right angle in field, using a 9, 12 and 15 m sided triangle obtained from two 30 m tapes, and string lines.

With reference to the diagram above, start by determining the corner of the trial, probably closest to the entrance to the field. Keep away from gates and leave a good margin from a permanent fence or road. Remember that turning tractors with implements will have compacted soil, so leave about 7 m from the fence. Put in two pegs, each the same distance from the fence and run a tight string line between the two.

Now with two tapes set up as shown above use the fact that a triangle with sides 9, 12, 15m will have a right angle.

If some key pegs are put in on the outer edges of plots tightly pulled strings and eyesight can be used to put in intermediate pegs. If plots don’t line up properly you can be sure that someone has made a mistake with a peg. Recheck the measurements.

Perhaps the best and most permanent place for labels is in the well-drawn trial plan. Labels have a way of being shifted, blowing away in the wind, or simply fading in rain and sun. Don’t rely on field labels to tell you important information about plots or treatments that have been applied.

In some circumstances you will be able to use GPS and google maps, but that is an unlikely possibility for most of us.

However, be prepared to locate at least two corners in an experiment by measuring from (at least) two key points- a tree, a post, gate etc so that each corner can be identified if pegs are lost/removed.

## Sampling

Bob Meyer in his very helpful ‘Basic Statistics Course- Reference Notes’ has a module on Sampling. In this he states 🡪

*‘The use of sampling is the basis of most agricultural research where the initial aim of an experiment is to estimate the parameters of a population by studying only a small selection or sample of the values available in the population. When the population is not uniform, the method of obtaining a sample is critical*

*Variation between the individuals in a population leads to difficulties if attempts are made to generalise results based on a sample. If it were not for this ever-present variation a sample consisting of a single value would provide all the information about the population… the following questions should be asked-*

*Why is it necessary to sample?*

*How is a sample obtained?*

*How large a sample is required?’*

Experienced researchers can assist in helping you with sampling strategies. Biometrical advice is critical- and that advice will change depending on the study.

Take a study that is interested in the percentage of body fat in pigs fed different feeds. If the assessment requires a dead animal hanging on hooks in an abattoir, clearly sampling will be necessary if further animals are to be measured in two weeks, when they are more mature. The researcher can’t kill them all in the first assessment.

Sampling is a fact of life.

In many crop experiments done in Melanesia a crucial measurement is yield and often that is the only measurement made in an experiment. In that case it is tempting to measure all the plants from a plot- but because of edge effects this would be inappropriate. What edge effects are known or likely? In other words, you cannot/should not harvest right out to the edge of the plot. Refer back to the sweet potato experiment and yield example. Edge effects were dealt with by having guard mounds.

The reasons for the research will dramatically alter the way plots are managed. Sometimes we need to know soil moisture (or soil fertility) during the life of the crop. A sampling strategy that allows cores to be taken without interfering with growth of the remaining crop is needed. You will need to seek advice in situations like this, and long somewhat narrow plots are likely the best option. There will need to be at least 2-4 m2 left totally undisturbed, and marked early on, so that final yield can be measured. That will leave the rest of the plot for a sequential process of sampling for moisture etc.

For the purposes of specific soil sampling techniques you are pointed towards a complete manual which is available for download and was written by Dr Thiagalingam, with some modifications by Dave Askin. The chapter titled ‘Guidelines for soil sample collection and preparation for chemical analysis’ on page 41 of his manual is particularly useful.

Let us consider sampling in a plot to determine yield. There are a number of factors to consider🡪

1. Do parts of the plot need to be destructively sampled for soil nutrients, moisture content or early, optimum and late harvest?

### Making a circular quadrat for sampling in pasture etc

What length of rod is required to make a circular quadrat of 0.25 m2?



So if you want a 0.25m2 quadrat, what length of rod will you need to use? First calculate the radius of the circle that is 0.25 m2 in area.



=  so  = 0.28 m or 28 cm. Does that sound/feel reasonable? Please think about that and make your decision. Always think about your answers to questions like this. Remember that four of these quadrats must add up to 1 m2.

So, now that we know the radius our quadrats will need to be in order to be 0.25m2, we can calculate their circumference:

2 x pii x radius = circumference

2 x 3.14 x .28 = circumference = 1.76 m

Checking back… pii x r2 = area so 3.14 x 0.28 2 = 0.25 m2

So take a 1.76 m length of rod and bend it into a circle and weld the 2 ends together, and the resulting quadrat will allow a sample of 0.25 m2.

### Samples for chemical analysis

1. Don’t throw the plant material away if chemical analyses are going to be needed.
2. The amount of material analysed for various chemicals will be a tiny amount, relative to what was grown. Seek advice relating to the amount of material to take from the field, then the amount to grind, and finally the amount to send to the lab. Experienced lab technicians should be able to guide you. 1-2 kg of fresh green material would normally be an absolute minimum to start the process with.
3. Make sure to book your samples in with the lab, seeking clarity about a reasonable time frame in which to wait for analysis results.
4. Know how much you will pay for chemical analysis, and have that budgeted for.
5. Store samples for later chemical analysis in places where mice, rats or cockroaches can’t damage the samples. In the tropics this is not easy. Sealed lids on tins or drums is the most effective method to look after samples- in an air conditioned room.
6. Get straight onto grinding, then analysing samples so that there is less time for insect or small animal damage.

### Oven drying samples

When weighing dry samples in paper bags from an oven make sure the samples are dried at 70 deg C until they are fully dry. This means a sample you have tested at say 9 am hasn’t lost weight by a 12 noon weighing. Normally 24 hours is sufficient to dry samples- but if someone else puts lots of wet samples in the oven then your samples will absorb water and you will have to wait and test your samples again.

Using a digital balance the following steps work well🡪

1. Place the bag plus sample in the bag on the digital balance.
2. Press the tare button so that bag plus sample weighs zero.
3. Remove plant material and place in a tray off to the side.
4. Replace the bag with any tags or labels on the balance.
5. Do not press the tare button.
6. The negative weight is the weight of plant material.

## Harvesting your experiment

|  |
| --- |
| Work one block at a time  Involve the biometrician in your research  Discuss plans with your supervisor. |

There is much to think about prior to harvest and having a team well prepared and clear about each part of the task is critical to success. It is wise to go to the field at least a day before harvest and work on some guard areas to see how the process will work. A biometrician should be part of this planning process- they are likely to highlight issues that you can take note of and add value to your experiment.

Take key field staff with you. They must be clear about requirements.

### Harvest rows

|  |
| --- |
| population counts |
| Figure 7 Using a quadrat to assess plant population |

Following germination it is normal to assess plant population by counting plants in plots. Where crops have been drilled with a machine in rows 15 cm wide then a U shaped metal quadrat can be used as shown in Figure 7

It is placed randomly in the crop, in harvest rows only. For plots that have 10 rows then the outside 2 rows on each side will be treated as non-harvest rows and the counts will be made over the 6 inside rows.

If the U shaped quadrat is long enough to span three rows as shown in the diagram then it’s effective length is going to be 7.5 cm (1/2 the row distance in the first row, two full rows of 15 cm each, then a final half row of 7.5 or 45cm. We know the length, and if the quadrat is to be finally 0.1m2, then we can calculate the width.

*Calculating the width of the quadrat:-*

*Area = length x width and therefore* 

 or 22cm wide, or 220mm.

You could make up a quadrat for use in maize crops where rows are planted at 50 cm spacing, but in reality other techniques may be better. For example you could take a length of bamboo 2 m long and count the number of plants down a length of row that is 2 m long.

It is good to mark out final harvest areas when it is easy to see individual plants. This means you may like to peg each corner of the harvest area so that other measurements- eg soil moisture tests during the life of the crop will not interfere with the final harvest area. 2-3 m2 are commonly harvested in a final harvest for kg DM/ha. These final harvest pegs should be hammered or pushed firmly into the ground and be tall enough or brightly coloured so that they can be clearly seen at final harvest.

What would you do if you thought some of these pegs may be stolen? Think about measurements you could make now- to permanent reference points and record on a copy of your trial plan.

For each type of crop there will be general rules relating to how many plants, and the area needed to ensure that enough plants are harvested to reduce CV% to a reasonable level, allowing differences between treatments to be determined. It is a good idea to talk with experienced researchers and biometricians.

### Harvest – do’s and don’ts

When actually harvesting here are some pointers to keep in mind🡪

1. Make sure writing is legible and prepare for wet conditions- large clear plastic bags help with a strong clipboard.
2. Remember to make photocopies/scan raw data sheets, so that if a sheet is lost, all is not lost!
3. Remember to get the data into the computer and then make backups of the data and store those backups in a different building. Memory sticks, external email accounts, DVD’s, external hard drives- all are useful. Don’t rely on just one backup.
4. Always collect data from one replicate or block at a time. This means that all replicates have been measured in similar conditions and it should be the same working team of researchers who do all of the plots of one block. Where possible finish all plots of one block before moving on and it is best to finish one block before taking a break. Sometimes of course that is impossible.
5. Bear in mind the need for different teams, sometimes in different parts of a field or labs, to take different data recording sheets and complete particular tasks. For example when harvesting a root crop like sweet potato it is normal to measure tuber yield and possibly weed yield in the field with one data recording sheet, but counts and assessment for disease or insect damage may be done inside or in a different part of the field, with a different data sheet.
6. Finally, taste tests may be done on sub-samples, using a different sheet again, even though all of these data may end up in one spreadsheet. Planning is crucial to effective and efficient data handling.

**All data sheets need:-**

1. A trial title
2. An address in case the sheet is lost
3. Plot numbers on left hand side and things you measure in variables (’fields’) in columns to the right
4. Space on your sheet for comments
5. A code that is used throughout the life of the experiment. This code is used on trial plans, data recording sheets and in filenames in the computer,

**Don’t!**

1. Don’t put space for calculated columns, averages etc on data recording sheets – computers do that work.
2. Don’t copy data from one sheet to another- this leads to errors. Instead, plan with your biometrician how the data will ‘flow’ from field to datasheet to computer (often a spreadsheet) to biometrical program. Asking questions of your biometrician before you act will definitely save you time and will save your research organisation money. Plan ahead.

### Estimating yields in Crop and Pasture Experiments

The title of this section includes the word ‘estimating’. Estimating is there for a reason. We are seeking to measure something- but it is an estimate. There is uncertainty around our measurement. (Later when you consider presenting information, you will need to consider the degree of accuracy to which you present your estimate. 12.324 kg +/- 0.566 kg is a bit of nonsense that is best corrected[[24]](#footnote-24)).

Getting yield data on crops and pastures is often a primary reason for doing research. Farming families may want to know what effect fertilizer or cultivar type or hedgerow mulch will have on the yield of taro, or sweet potato or wheat or rice.

In the tropics root crops are commonly grown and it is reasonable to present fresh yields of tubers.

Lets start with a taro experiment, where the final yield area of plots measure 5 m x 10 m and all taro is harvested from the plot. (Imagine one plot weighed 55 kg).

It is likely that taro has had the tops cut off (that raises interesting issues relating to biological yield and commercial yield) and several buckets of taro have been weighed. For detail of calculations refer to the spreadsheet provided for you.

Yield in tonnes/ha = 55 kg/(5m x 10m is harvested area) = 1.1 kg / m2

Or 1.1 x (100m x 100m) /1000 tonnes/ha = 11 tonnes/ha.

|  |
| --- |
| **1 kg / m2 = 10 tonnes / ha.**  **Good to remember!** |

(We divided by 1000 to go from kg to tonnes as there are 1000 kg in a tonne).

Now imagine that a different crop of taro was harvested by taking 10 plants down each of 3 rows, a total of 30 plants. Rows are 0.75 m apart and plants are 0.3 m apart in the row. If 12 kg of taro was harvested how many kg/ha are harvested?

kg/m2=Weight harvested / area harvested = 

kg/m2 = 12 kg/6.75 m2 or 1.78 kg/m2 or 17,778 kg /ha or 17.8 tonnes/ha

Table 14 Data recording sheet for Clover Sowing Experiment

COD20\_\_.01

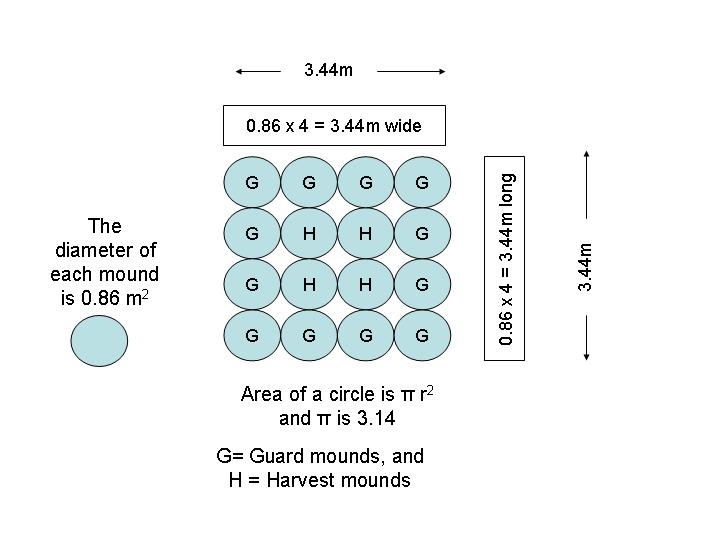
|  |  |  |  |
| --- | --- | --- | --- |
| Date of Recording |  | Name: |  |
|  |  | Address: |  |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Plot No. | Rep | Estimate of percentages | | | | | | Comments |
|  |  | Clover | Rye  grass | Other Grass | Weeds | Bare  ground | Dead |  |
| 1 |  |  |  |  |  |  |  |  |
| 2 |  |  |  |  |  |  |  |  |
| 3 |  |  |  |  |  |  |  |  |
| 4 |  |  |  |  |  |  |  |  |
| 5 |  |  |  |  |  |  |  |  |
| 6 |  |  |  |  |  |  |  |  |
| 7 |  |  |  |  |  |  |  |  |
| 8 |  |  |  |  |  |  |  |  |
| 9 | In this data sheet we don’t provide the actual treatments as a column - just the plot numbers… Why not provide the treatments?  Some rows missing to allow this sheet to fit on the page. | | | | | | | |
| 10 |
| 11 |
| 16 |
| 17 |
| 18 |  |  |  |  |  |  |  |  |
| 19 |  |  |  |  |  |  |  |  |
| 20 |  |  |  |  |  |  |  |  |
| 21 | Answer. When visually scoring plots it is best to take the plot on face value, rather than have information that can affect the score because you thought a particular treatment would do better than another…  (This sheet actually needs how many rows?- Refer to previous page. | | | | | | | |
| 22 |
| 23 |
| 24 |

With reference to the discussion above on sampling you should realise that harvesting a plot for yield is one form of sampling. There are plenty of pitfalls to be aware of. For example where 4 mounds of sweet potato are grown as a plot of one cultivar next to four mounds of another we can find that one cultivar has spread over the top of another cultivar. This kind of behaviour by sweet potato needs consideration- long before you get to harvest. Here is another good reason for discussing your trial design with experienced researchers.

A researcher wants to calculate yield of a sweet potato trial where the plots looked like that shown below. (Note that guard rows have been added to keep one cultivar from harming another- this is a very considerable increase in work load, but will increase the accuracy of your estimations of the differences among cultivars.

The four mounds are indicated by the H for harvest in the plan below.



Calculate kg/ha if the total of the four harvest mounds was 28 kg of sweet potato tubers.

Don’t read the next section yet. Take that diagram, make the calculation and then see if you got it right or not!

Not yet- do the calc first! What did you get?

kg/ha from the four harvest mounds-

Firstly, beware. All that information about the diameter and area of the circle/mound is an easy mistake to make. You can’t estimate yield in kg/ha or kg/m2 without taking into account the ‘dead’ space between mounds. That area is part of the field and must be accounted for.

So, ***treat the mounds as if they are squares***. That is an important start and an error often made.

We are calculating kg fresh tuber/ha.

We have 28 kg / 4 harvest mounds. What area are the four mounds taking up in the field?

Yield in kg / 4 mounds = 28 kg / (0.86 +0.86) x (0.86 + 0.86)

(Calculate area that the 28 kg came from – length x breadth).

Yield of 28 kg came from 2.96 m2

28/2.96 = 9.46 kg /m2 or 9.46 kg/m2 \* 100 x 100 kg/ha = 94.6 tonnes/ha.

Is that a large, medium or small yield?

|  |
| --- |
| Get used to thinking about your measurements, weights, lengths etc. Understand what makes sense so that you can see errors before they become serious problems. |

This is a very important question. Get used to thinking about yields, weights, measurements. That way you can be aware of nonsense and mistakes when your data and results make no sense.

To answer the question… the highest yields this researcher has seen were 10 kg / m2 in potatoes (100 tonne/ha) and 15 kg of apples per m2 (150 tonnes /ha). They were extremely high yields. Sweet potato yields are more commonly 15 tonne/ha. How much[[25]](#footnote-25) is that in kg/m2?

### Components of yield and coping with theft

Assuming you took all sensible precautions to reduce or stop theft… theft has still happened. What can you do when trying to assess yield in a crop? This question is best answered by discussion with senior researchers and a biometrician. The answer to estimating yield following theft requires careful analysis of the affected plots and plants/animals and is answered by effective sampling of non- affected areas. Identify areas unaffected and measure yield there, while using those values to assist in estimating what the yield would have been in the affected area.

For example corn plants may have had some cobs stolen. Careful component of yield studies will help you estimate the total yield- kg/m2 (perhaps described as kg/garden bed of 10m x 10 m?) that would have occurred.

Corn yield is made up of multiplying the number of plants / m2 by the ears on a plant and each ear’s grain yield is calculated by multiplying grains per ear by individual seed weight. Individual seed weight is often calculated by counting two or three lots of 100 seeds and weighing each lot of 100 seeds with an accurate digital balance. Where seed counters (automatic) are available, it is common to weigh 1000 seeds.

g/m2 = (Plants / m2) x (Ears / plant) x (grains / ear) x (1000 seed weight g/1000

kg/m2 = (Plants / m2) x (Ears / plant) x (grains / ear) x (seed weight g/1000 (now kg/m2 as our weight was g, but divided by 1000 we have kg/m2))

Where some ears have been stolen it is possible, by careful study of each plant in a harvest area to estimate yield.

In many parts of Melanesia corn yield is less about dry grain yield and more about corn cob yield. How would you modify the calculation / estimation based on what farmers consider as yield in corn? Refer to the USA based photo below, highlighting the importance of Nitrogen in growing large seeds, and therefore large cobs.

|  |
| --- |
|  |
| <http://www.agry.purdue.edu/ext/corn/news/timeless/yldestmethod.html> |

How might a researcher estimate yield in a sweet potato experiment, where some plots have been raided by thieves?

### Workload in sampling and measurement

What happens when the workload is too great? One suggestion is to consider talking with your biometrician. They are the people who are best able to suggest different sampling methods that may allow a useful reduction in workload. At other times they will warn you of possible problems with analysis if you change sampling techniques.

|  |
| --- |
| Time for Group Discussion- Sampling  Sometimes it is possible to see a workload that is going to keep a team of 6 people busy harvesting a large experiment for the next 6 months!  For example someone may want to count all of the tubers (or flowers, or fruits etc) from the plots… To do this could take days.  Clearly this is not sensible or cost effective. What should the research team do in this instance?  What steps would you take if you were in this position? |

### Harvesting wet plant material and drying for DM estimation

If samples will be used for chemical analysis, remember that old fertiliser bags, fertiliser residue on the back of a truck etc- all these will ruin your careful work. Be careful!

A spreadsheet showing how a set of samples taken during Practical research skills training is available at [www.cdwi.net/library](http://www.cdwi.net/library) search for velvet bean and fallow.

### Measuring Weight and Length

#### Weight

|  |
| --- |
| weighing clock face balance2 |
| Figure 8 Using a clock face balance  A, B and C. What do you think. Write your answers **before** looking below![[26]](#footnote-26) |

Using a clock face (Salter) balance requires skill. Firstly if you are weighing green plant samples it is important to ‘tare’ the balance to zero, using a small thumbscrew which is often at the top of the balance. This means taking the container that will be used to weigh all the samples and making sure that when empty it weighs zero.

Here are some further pointers to keep in mind:-

1. Use the right size balance. You can’t accurately weigh 3 kg animals with a coffee scale designed to weigh up to 50 kg. A 5 kg scale would be more appropriate.
2. Make sure you or the person weighing on your behalf can read all the positions on the balance correctly. Experience shows many people get mixed up with 1.05 and 1.5. Check and double check. Ask if you are not totally sure.
3. Keep balances out of the wind or rain.
4. Make sure that the bucket, or weighing sheet is not touching a tree or tripod
5. Use the same bucket to weigh all samples in.
6. Regularly check that the empty container still weighs zero.
7. Remember to do all weighing one replicate at a time.
8. Where samples are dirty brush off the dirt and make sure that the bucket doesn’t slowly get dirt building up in the bottom.
9. Prepare data recording sheets before you start.
10. Where material is to be dealt with by others later- make sure that any labels are permanent and will not get mixed up. Will moisture destroy the label?

Using a digital balance is easier, but the rules above still apply. Make sure you have a spare, charged battery with you if you are weighing in the field.

#### Measuring Length/Diameter/Width

After weighing the most common measurements researchers make involve length. Be sure you are able to use tape measures or rulers accurately. Be careful with tape measures designed for forestry use. Some of these automatically calculate diameter from a circumference. In some circumstances you will need to use callipers to measure trunk diameter- of young trees or other plants. Be sure you know how to use these- ask if necessary. You may need to take two measurements- one North/South and one East/West to get two values for the computer to average later. Don’t waste your time doing averages when the computer will do the job quicker and more accurately than you or I can.

## Using spreadsheets for data management

1. You don’t have to use Excel for your spreadsheet tool- libreoffice is the open office equivalent that is powerful and free.
2. Layout data clearly and simply – each record should show its Rep, factors (treatments) etc
3. Use meaningful headings
4. Eliminate data breaks in table – no empty rows or columns
5. Pivot tables and charts are a good way to visualize your data integrity
6. Use a single row header and improve look of layout - wrap, align text, move, hide columns
7. Prepare your computer tabulation format before field recording and prepare a suitable data recording sheet for field use.
8. Set up a checking system for field recordings – eg Weigh all potatoes from a plot, then separately weigh the marketable and ‘pig’ or ‘reject’ tubers. Late you can compare the total weight to the sum of the separate weighings
9. Arrange your data columns and sort data for presentation to the biometrician
10. Use annotation and comment sheet for others and future reference
11. Name your worksheets with recognizable names
12. Check your computer calculations and formulae by hand to ensure your logic is correct – Is the data sensible?

Indicate missing plots with an asterisk – do not insert the average of the other reps.

# Calculations for Field Experiments

There are many kinds of calculations that field researchers need to be familiar with. This chapter provides you with worked examples for many of these.

One task is to help ensure that farmers are putting on the right amount of the best kind of fertiliser- to optimise the economic return from say capsicums grown for the Mt Hagen markets. To help determine these issues we need to be able to apply the right amounts of fertiliser, knowing how much of each element is being applied.

Table 3 Abbreviations commonly used and some symbols.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **As said** | **Abbreviation** | **As said** | **Abbreviation** | |
| hectare | ha | Metre | M | |
| kg per ha | kg/ha or kg ha-1 | grams per pot | g/pot or g pot--1 | |
|  |  | g per metre squared | g/m2 or g m-2 | |
| and some other things to keep in mind- | | | | |
| 1 ha =100 m x 100 m |  | 1000 mm, 100 cm and 1 m are the same length. |  | |
| Quantity | Application | Unit | Symbol |
| Area | Land Area | square metres or ha | m2 or ha |
|  | Leaf Area | square metres or squre cm. | m2 or cm2 |
| Density | Soil Bulk Density | kg per cubic metre | kg m-3 or kg/m3 |
| Electrical Conductivity | Salt tolerance | siemens per metre | S m-1 or S/m |
| Elongation rate | Plant growth | millimetres per day | mm day-1 or mm/day |
| Ethylene production | Nitrogen fixing activity in legumes | nanamoles per plant per second | nmole plant-1 s 1  or nmol/plant/s | |
| Extractable ions | Soil | milligram per kg | mg kg-1 or mg/kg | |

When calculating amounts to apply, it is important to develop a feel for what looks right. What does a kg weight feel like, how long is a metre? Think about 500 g or 1 kg bags of rice. Weigh them in your hand. The next time a balance tells you that an animal weighs 1 kg- does it seem reasonable? Is it close to the 1kg bag of rice? If not, recheck.

|  |
| --- |
| **Always get someone else to check calculations before applying fertilisers or other chemicals to trial plots.**  **Get it right first time!** |

When applying fertiliser to plots if the amount is out by a factor or 10 or 100 then we hope you will start to get a feel for what looks right and go back and check before you have applied a wrong rate. If in doubt ask! Even if you are quite sure you are right, always get someone else to check your calculations before applying fertilisers or other chemicals to trial plots. One mistake now can ruin a whole trial and waste a great deal of time. Get it right first time!

## Weight of fertiliser per plot

### Weight of fertiliser when we know area of plot and rate of fertiliser / ha to apply?

Let’s start with the simplest possible example.

A researcher wants to apply 200 kg / ha of Urea to a plot measuring 3 m x 8 m. How much fertiliser to apply?

We first calculate how many kg / m2 that is.

200 kg / 100 m x 100 m = 0.02 kg / m2 or 20 g per m2.

As it is to go on 24 m2 our researcher must apply 480 g of fertiliser / plot.

### Weight of fertiliser when we know area of plot and amount of an element to apply?

Generally a researcher thinks in terms of the weight of an element in kg to apply per ha (kg/ha). Perhaps we are keen to see the effect of Potassium on sweet potato. We must find a fertiliser that will not also apply nitrogen or sulphur to confound (confuse) the results and interpretation.

We chose KCl (Potassium chloride) as the fertiliser. After talking with other people and looking at the literature we want to apply a rate of 80 kg K/ha

**Question- Some plots measuring 3m x 7m require 80 kg K/ha (80 kg of potassium per ha). How many g of KCl should we apply to each plot?**

Step 1. Calculate the percentage of K in KCl.

|  |  |
| --- | --- |
| Element | Atomic Weights  (see below) |
| K | 39.096 |
| Cl | 35.457 |
| Molecular weight of KCl | 74.553 |



Step 2. Calculate the amount of KCl to apply per ha to achieve 80 kg K/ha



We read this as 152.55 kilograms of potassium chloride per ha.

Step 3. Now calculate the amount of fertiliser (KCl) to apply to each plot which receives 80 kg K per plot.

If you have trouble seeing why we used the equation above, then the step by step calculations below will be useful

We want 152.55 kg KCl/ha so in kg/m2 we need to divide 152.55 by the number of metres squared in a hectare.

kg KCl/m2  or 0.015255 kg KCl/m2

g KCl/m2 = 0.015255 x 1000 or 15.255 g KCl/m2

and so for plots 3m x 7 m we have 15.255 x 21 = 320.36 g per plot. We weigh out 320 g of fertiliser into bags, carefully label the bag and set aside for future field application.

|  |
| --- |
| **Remember:- g/m2 x 10 = kg/ha**  **So, 15 g/m2 is the same as 150 kg/ha**  **Remember also, to quote yields for farmers in ways that help make things clear for them. Do kg / ha make sense? What might make sense with cocoa yields or yields of bananas? (There is plenty to think about in both examples).** |

## Checking table

The next page gives a checking table to use in field experiments. Use the table to check that your calculations are correct.

Note these tables don’t help with elements- they are designed to be used once we know how much of the actual fertiliser needs to be applied.

Table 4 Checking table for conversions from kg/ha of fertiliser to kg of fertiliser/plot for field experiments- when the rate to apply is known and the plot area is known.

The amount of fertiliser needed for a plot is calculated first. Then having calculated the exact amount to weigh out for each plot, use the table below as a quick check to ensure you have no mistakes.

If our plots were 20 m2 (refer earlier example) and we wanted to apply 200 kg/ha we would need 0.4 kg of fertiliser. Our plots were 24 m2 and we calculate 0.48 kg or 480 g. That sounds right.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **kg/ha** | | | | | | | | |
| 100 | 200 | 300 | 400 | 500 | 600 | 700 | 800 | 900 |
| **m2 in each plot** | 1 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
| 5 | 0.05 | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 | 0.35 | 0.40 | 0.45 |
| 10 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
| 20 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.2 | 1.4 | 1.6 | 1.8 |
| 30 | 0.3 | 0.6 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.7 |
| 40 | 0.4 | 0.8 | 1.2 | 1.6 | 2.0 | 2.4 | 2.8 | 3.2 | 3.6 |
| 50 | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 |
| 60 | 0.6 | 1.2 | 1.8 | 2.4 | 3.0 | 3.6 | 4.2 | 4.8 | 5.4 |
| 70 | 0.7 | 1.4 | 2.1 | 2.8 | 3.5 | 4.2 | 4.9 | 5.6 | 6.3 |
| 80 | 0.8 | 1.6 | 2.4 | 3.2 | 4.0 | 4.8 | 5.6 | 6.4 | 7.2 |
| 90 | 0.9 | 1.8 | 2.7 | 3.6 | 4.5 | 5.4 | 6.3 | 7.2 | 8.1 |
| 100 | 1.0 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 200 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| 300 | 3 | 6 | 9 | 12 | 15 | 18 | 21 | 24 | 27 |
| 400 | 4 | 8 | 12 | 16 | 20 | 24 | 28 | 32 | 36 |
| 500 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 |
| 600 | 6 | 12 | 18 | 24 | 30 | 36 | 42 | 48 | 54 |
| 700 | 7 | 14 | 21 | 28 | 35 | 42 | 49 | 56 | 63 |
| 800 | 8 | 16 | 24 | 32 | 40 | 48 | 56 | 64 | 72 |
| 900 | 9 | 18 | 27 | 36 | 45 | 54 | 63 | 72 | 81 |

## Establishing the right population

### From known row and plant spacing – how many plants / m2?

If we are going to establish plants at 50 cm row spacing and 30 cm between plants- how many plants per m2 are there?

 plants / m2

(or 6.7 x 100 x 100 plants per ha = 67,000 plants/ha.

### Weight of seed required per plot?

Before we can start we need to know

|  |  |
| --- | --- |
| population required in plants/m2 | eg 130 |
| plot size | eg 15 x 1.5 |
| 1000 seed weight | eg 48 g in every 1000 seeds.  Or 4.8 g in every 100 seeds. You need to count out 3 x 100 seeds and weigh, and take an average. Then test those three lots of 100 seeds for germination. |
| % germination | in this case 83% of seeds germinated in our test. |

The calculation is as follows:-





=169 g/plot

A couple of pointers:-

How do we remember to multiply by 100 divided by % germination? The weight of seed must increase if the germination percent is less than 100%, so the 100 is divided by the percent germination as shown in the equation.

Perhaps you don’t have an automatic seed counter? Do three hand counts of 100 seeds and weigh these and average for use in the equation above. Don’t throw those lots of 100 seeds away- refer below.

### Germination tests?

If you keep your seeds cool and dry- preferably in a fridge- they will last longer, but can you be sure that they are still good? To do a germination test[[27]](#footnote-27)🡪

1. Put exactly 100 seeds on top of a damp, folded paper towel on a large dinner plate.
2. Put the towel and seeds into a large plastic bag and fold over the end.
3. Label the container with the date and seed variety being tested.
4. Leave at room temperature for a week or so.
5. Count the number of seeds that sprout:
   1. 100 = 100% or perfect germination
   2. 90 = 90% or excellent
   3. 80 = 80% or good
   4. 60-70 = 60-70% or poor -- sow more thickly if this is a home garden, but if it is for research purposes- you will be trying to source more vigorous seed.
   5. 50 or less = 50% or less -- throw the seed out!

By the way, it’s good to do three of these germination tests when preparing for a trial.

Perhaps you are going to sow with a drill and you are not too sure how much seed to order. Remember to also consider guard areas and order at least 15% more than an exact amount of seed required.

For many of us, hand planting will be done, using field labourers in large teams. There is much you can do to ensure the correct spacing is achieved. Split bamboo sticks will need to be laid out, with planting positions marked. These positions will tell field staff where to plant, down each row.

Remember to have other sticks, perhaps not bamboo to set the distance between rows in a plot.

Remember also to have someone else check your calculations.

# Applying fertiliser, herbicides and pesticides

Most of us use simple hand-held equipment to spread fertiliser, and spray on herbicides or pesticides. We often see coloured photos of equipment available to others but our own research station has only some old equipment, that looks pretty dirty and dusty.

Don’t be too quick to judge that dusty equipment. Beneath the dust is a tool that we are going to use to ensure that to the best of our ability we will apply the right amount of chemical, safely and evenly.

This section starts by outlining principles and throughout are some helpful pointers to make the best use of equipment that may not be the latest.

|  |
| --- |
| **If more than one person is involved in spreading fertiliser, then each person should complete a block of treatments.** |

## Applying fertiliser by hand

Be consistent. It is best to use just one person to spread the fertiliser to all plots, but if a number are involved- what should you do?

First run string along the edges of all plots so that a clear line helps ensure that fertiliser is spread up to but not beyond the boundaries of each plot.

|  |
| --- |
| **Spray nozzles wear out. As they wear the flow rate increases and the droplet size increases. This can reduce the effectiveness and evenness of spraying. Fine droplets are what you want for most spraying purposes.** |

Have some practise bags set up to spread on a piece of land close to a tree or fence- somewhere that cannot be used for trials in the future.

Put half of the fertiliser into a bowl, the other half remaining at the corner of the plot- making sure it is clear which plot it belongs to.

Take small handfuls scattering the fertiliser while walking slowly up and down the plot. Aim to get to the end of the plot with the first half of the fertiliser spread. Now get the other half of the fertiliser and repeat the exercise walking backwards and forwards across the plot.

Be aware of the effect of wind on fertiliser. Also if you are spreading Nitrogen fertiliser during hot sunshine much of the nitrogen can be lost as ammonia to the atmosphere. It is best to put nitrogen fertiliser on just before rain, or if possible work the fertiliser into the soil.

## Applying chemical with a hand sprayer

Beware. It isn’t good enough to trust that chemical will be applied at the right rate, just because a labourer commonly does the spraying. You as lead researcher must be sure that what you intend, really happens. Many disasters in research start with poor or wrong spraying!

### Calibration of Sprayers (using a knapsack sprayer as an example)

Modified from <http://www.aglearn.net/resources/vegIPM/sprayerCal.pdf>

Step 1. Measuring the **volume application rate** (VAR) – amount of liquid being applied

Before a researcher/farmer can be sure they are using the correct dose of pesticide on a particular crop, the VAR must be known. The concentration, and more practically, the volume to add to the spray tank, depends on how many litres of spray will be applied (i.e., the VAR). If the VAR is not known, it needs to be determined by spraying a small area – we use 5m x 5m. The way to do this for a backpack lever operated sprayer is described below.

* Measure out a waste area for test purposes which is 5 m x 5 m (use a bigger test area for a tractor-mounted sprayer). This will give 25m2. Mark the corners with sticks.
* We need to know how many mls you used while spraying the 25 m2. There are various options. Here’s the one that is likely to work best for you. Tip out all remaining water in sprayer.
* Now put in 5 litres of water.
* Spray the area of 5 m x 5 m.

Tip out the remaining water – into a bucket and measure the volume. The difference is clearly the amount of liquid you used.

*This calculation is as shown below-*

*ie (volume used (litres)/area sprayed m2) x 10,000 = Volume Application Rate*

*If the volume of water used was 1 litre, when spraying 25m2, this corresponds to a VAR of around 400 l/ha. If the volume used was 1/2 (0.5) litre, this corresponds to a VAR of around 200 l/ha.*

Step 2. Adjust volume application rate (VAR)

For a lever operated knapsack sprayer, if the volume used on 25 m2 was more than 1 litre, this will give a VAR which could be considered too high (more than 400 l/ha) and in some cases, wasteful of pesticide. The researcher should either fit a smaller nozzle to the sprayer, or, if the nozzle is already small enough (giving a flow rate of less than 800ml/min), he/she should modify the spraying technique (walk faster) to apply less spray to each plant, in other words spend less time spraying it. After these equipment and/or technique adjustments, the researcher should measure VAR again to make sure it is **approximately 300 l/ha – or 750 ml per 25 m2**. If you are closer to 400 l/ha or 1 litre used when spraying 25 m2 that is likely to be fine.

### A knapsack spraying example worked out, step by step

In the highlands of PNG potato late blight has required assessment of rates and type of fungicide. It is of course crucial that the right amount is used, particularly when researchers aim to define optimum rate of a chosen fungicide.

Consider the following possibility. A researcher has a fungicide that has 26.3% active ingredient in a wettable powder and the recommendation is to use 230 g ai/ha in 300 l/ha of water. (Modify these rates etc to suit your needs. You may be able to skip down to step B below.

Step A – Assure yourself that you are applying a required amount (VAR) over something like 25 m2. In our case we are aiming for 300 litres of liquid per ha.

*ie (volume used (litres)/area sprayed m2) x 10,000 = Volume Application Rate*

If we use 1 litre of spray on 25 m2 we apply 400 litres per ha. See calculation below.

 x 10,000 = 400 l applied in each ha.

So how many litres do we use in 25 m2 if we want to apply 300 litres /ha? We can calculate simply from the ratio, but the actual calculation is as follows

300 litres applied in each ha =  x 10,000 m2 where n is the number of litres to apply in the 25 m2 trial or test area.

When n is the amount used in a knapsack when spraying 25 m2 then

n = X 300 = 0.75 litres (750 g) must be used when spraying 25 m2.

This is checked by working with the field staff so that their application rate for the chemical is appropriate over the 25 m2. So long as they continue in the field at the same rate, they should continue to apply the liquid at the right rate.

So Step B- Chosen fungicide has 26.3% active ingredient in a wettable powder and the recommendation is to use 230 g ai/ha.

Therefore g product per ha is

= 874.5 g product per ha.

In the experiment we have only 4 plots to spray with this particular chemical and each plot is 5 m x 3m = 15 m2.

How much chemical do we need to mix in our knapsack with how many litres of water? Remember we already know that our speed of walking and our nozzle all work out at a rate of 300 litres of water / ha.

We will mix enough spray to cover 4 plots x 15m2 = 60 m2 with a 20% extra mixed = 60 x 120/100 = 72 m2

We need 0.75 litres for every 25 m2. Therefore we need (0.75/25) x 72 = 2.16 or 2.2 litres of water over 72 m2.

We have calculated that we need 874.5 g of our wettable powder and that would spray one ha.

(874.5 g /100m x 100 m) \* 72 m2 = 6.3 g of chemical (wettable powder in this instance), mixed with 2.2 litres of water – and will be sufficient to cover 72 m2.

This amount of chemical will be weighed accurately, mixed to a paste in a small container, then that will be flushed with gentle water flow into about 2 litres of water in the knapsack. When the container used to mix paste is quite clean, we empty the last of our 2.2 litres of water into the knapsack.

You might tare to zero a 10 litre bucket, fill with water to 2.2 kg (ie 2.2 litres) and that would be the total amount of water to use in the mixing and filling process. Most of us don’t have accurate balances, so it would be more sensible to measure the volume of water accurately.

### Another example- Karate on Corn

Karate, a common insecticide states on the bottle that we should use 10 mls of Karate in 10 litres of water.

We want to spray young corn while applying 300 litres of mix (10 ml Karate/10 litres of water) per ha.

Our plots are going to be 5 m x 6 m and there are 20 plots that require spraying with a standard rate of Karate.

So we must spray 5 x 6 x 20 = 600 m2 and allowing for 10 % over we will be spraying 600 x 1.1 = 660 m2.

At 300 litres / ha spraying rate (walking speed and nozzle and pumping pressure- all calibrated – refer above) this is 300 litres / (100 m x 100 m) = 0.03 litres/m2 (same as 30 ml/m2).

Or for the whole area to spray we need 660 x 0.03 = 19.8 litres of spray.

19.8 litres of spray require how much karate to be added?

Directions state – use 10 mls of Karate in 10 litres of water or 1 ml in 1 litre. So we need 20 mls of Karate in 20 litres of water and that should be more than sufficient for our task.

### Issues to keep in mind – when spraying

1. Once the volume required per sprayer tank has been calculated, the researcher needs a small measuring cup to make sure the amount added is correct. A measuring cup should be provided by the store when the pesticide is bought but if it is not, you should borrow one or make one using a borrowed cup as a reference.
2. The cost of a measuring cup is much less than the cost of mistakes in application - either wastage of pesticide, poor spray results or dangerous pesticide residues in vegetable produce.
3. After any use of a sprayer the unit needs careful and thorough washing out. The herbicide residue that you used last month could still kill the seedling papaya’s that are your prized experiment this month…
4. If possible have one sprayer used only for herbicides and another for fungicides and insecticides. That way a precious crop[[28]](#footnote-28) isn’t killed by residual herbicide in the tank.
5. Don’t leave spraying issues up to field labourers alone. This is such a critical step. The lead researcher must be involved directly, ensuring that the spraying was exactly as planned.
6. Keep safety as a priority. Safety gear is to be used at all times. This is especially important when dealing with the concentrated chemicals- gloves and eye protection are a must.
7. For farmers spraying for late blight- start spraying the clean crop areas. Finish with those garden beds showing damage. Then leave the area and wash out gear and rinse off gumboots, leggings etc. (Key point- don’t spread the disease during a farmer owned spraying operation by starting with the worst affected beds. Plan to go from clean to diseased then a direct exit from the crop to a clean up of spraying equipment.)
8. Do not spray during windy conditions. Normally early in the morning is best. There isn’t much point spraying late in the day, if afternoon rain is going to wash the spray off the crop.
9. Some sprays may harm plants if sprayed during very hot sunshine. Experienced operators will know this. Otherwise learn by reading warning labels, check the internet, and make your own notes relating to pesticide applications (field diary).
10. Always make sure the equipment is clean- residual herbicide in a tank may kill your precious crop.

### Spray nozzle selection

The nozzles on a sprayer serve three main functions:

1. Meter the spray liquid
2. Break the liquid in the tank into droplets
3. Disperse these droplets into a specific pattern.

On a boom sprayer nozzles must have

1. Even distribution
2. Produce the desired droplet size and flow rate
3. Minimise the effect of boom instability
4. good wear characteristics (Note that brass nozzles wear out quickly. Special plastic and nylon nozzles have the best wear characteristics. Note that as nozzles wear the droplet sizes change dramatically and the flow rate increases).

|  |  |
| --- | --- |
| Table 5 Spray nozzle do’s and don’ts | |
| **Do** | On a boom use only one make and size of nozzle. |
|  | Do make regular checks on flow rates. Flow rates should be within plus or minus 5% of average of flow rates from all nozzles on the boom. |
| If new tips are fitted, check the flow rate of these, it’s possible the tip has been numbered incorrectly. |
| If the nozzle assembly has more than one tip check that the correct tip is in the spraying position. |
| For boom sprayers using fan type nozzles check that nozzle tips are about 10 deg offline with boom so that adjacent jets do not interfere with each other. |

|  |  |
| --- | --- |
| **Don’t** | |
|  | Clean the orifice (hole in spray jet that gets blocked with ants, leaves and dirt) with a piece of wire. |
| Don’t put any part of nozzle assembly- filter, check valve, tip to your mouth to blow through it for cleaning. If you do, you may poison yourself. |

## Rainfall and Irrigation

### What does 65 mm of rainfall mean?

|  |
| --- |
| **1 mm of rain equals 1 litre per m2** |

What does it mean when someone says ‘yesterday we got 65 mm (millimeters) of rain?’ Is this a lot or a little? 65 mm of rain relates to the depth of water. This is why **rainfall is measured in mm NOT milli-litres**. If you took all the rain that fell on a football field during a 65 mm rainfall- and somehow collected it all and spread it evenly over the football field- the depth of water would be 65 mm. Or, put another way, if at the start of a 65 mm rain a swimming pool was 1 m deep, after the rain it would be 1065 mm deep.

Sometimes in really high rainfall areas people talk of rainfall in metres- Tabubil in Western Province of Papua New Guinea, for example, gets about 11 metres of rain a year. That is the same as 11,000 mm. So, here is one way of imagining this. For Tabubil there would be an 11 m high ‘column’ of water sitting on the football field. In the same way, every m2, every ha, every village, in this 11m rainfall zone, would during the course of a year get 11 m depth of water- if it was all collected at one time. That is a lot of water!

We measure this water with rain gauges.

### A good rain gauge has the following features

Store bought rain gauges have the following features in common:-

1. They have a knife sharp, circular, top edge so that the collecting area is very accurately defined.
2. A funnel makes sure that water entering the rain gauge doesn’t evaporate before you measure the rain.
3. The sloping sides of the funnel also help to ensure that water falling within the area of the rain gauge doesn’t splash out of the rain gauge.
4. A measuring cylinder, below the funnel, has been especially calibrated to allow you to measure the rain that has come into that particular rain gauge. Note that the measuring cylinder in a rain gauge should not be used as if it was a normal 100 ml or 200 ml measuring cylinder. (These rain gauge measuring cylinders are calibrated to tell you the depth of water falling within the whole of that rain gauges area). Note that if the measuring cylinder has overflowed, simply tip water into the base of the measuring cylinder until you have an exact measure of water in the cylinder. Record this, throw that water away and fill up the measuring cylinder again, from the water in the base of the rain gauge- record and keep doing this until all water in rain gauge has been measured. Obviously if the rain gauge is totally full and overflowing, then you no longer have an accurate measure of rain which has fallen. It is normal to record rainfall every day, at 0900h. During very heavy rain it would be good to check that the rain is not going to be too much for the rain gauge- if necessary take an interim reading. Record this carefully.
5. They are mounted on a pole so that they are well off the ground. You don’t want splashes of rain off the ground able to enter the rain gauge.
6. They are mounted well away from buildings and trees so that your measurements are accurate.

Some simple, cheap rain gauges have sloping sides and are graduated with a specific scale. They don’t have a measuring cylinder, and are accurate with small amounts of rain, but harder to read accurately when a lot of rain has fallen.

### Make your own rain gauge

Perhaps you can’t afford to buy a rain gauge. A simple tin fish can is able to give an estimate of rainfall. Although a rain gauge as described is never going to be really accurate, it is a good thing to get an idea of how much rain has fallen during the last 24 hours.7

Take an ordinary straight sided can - as large as possible, and sit it on top of a pole that is about 1.5 m high, so that rain outside the tin can’t splash into the tin, then the depth of water measured with a ruler or tape measure will be the amount of rain that fell. (Make sure that your ruler starts at 0mm. Most rulers don’t start at 0mm. Cut a ruler to make sure it measures depth of water accurately- ie it starts at 0mm. Simple eh! Go back to the description above to make sure you site your can style rain gauge in the best possible place. Remember too that rain falling will easily evaporate after rain. (A paint can will not be good as the lip of the can is wide and will reduce the amount of rain that you measure in your ‘rain gauge’.

### How do we calculate the volume of water to apply when irrigating land?

Although rainfall is measured in depth, when we come to irrigate land we often need to know how many litres to apply to achieve 65 mm of rain on a plot that could be 40 m x 100 m? To work that out, we need to know that 1 mm of rain is equal to 1 litre of water in each m2.

So we have 100 x 40 = 4000 m2 x 65 litres of water for every m2 which equals 260,000 litres of water to apply 65 mm of rain to the plot measuring 4000m2.

### Assessing evenness of irrigation sprinklers

There are many ways of applying water. You will find that applying water evenly is very difficult. Wind, worn out nozzles, partially blocked nozzles, different nozzles, distance from a nozzle, changing pressure down a line of nozzles (sprinklers) will all affect the amount of water being applied to different parts of the field. Assessing evenness of water application can be done in a simple and cheap manner. Collect about 50 tin fish cans, all the same size- 300 g is about right. Put them out in a grid pattern. Run the sprinklers for about 1 hour and then measure the amount of water in each can- Use a volumetric cylinder so that measurements can be made quickly- before too much of the water has evaporated.



# Scientific Photography

Excellent scientific photography takes time and effort. If you think about presentations you have seen, it isn’t hard to realise that many photos add very little to the understanding of an audience. Your photographs can be different. This chapter, originally written some years ago by David Hollander, Lincoln University will give you many useful tips.

Great research photos requires more preparation and care than normal photography. Plan your photography in advance. Make sure you have spare batteries, memory cards and plenty of time. Prepare labels before you go outside. If you are new to this type of photography, work slowly and methodically, thinking about light, background, and how the photos may be used.

It doesn’t matter what type of camera you use. For most field photography you can achieve good results with any reasonably modern camera. The points below outline the steps involved in making scientific photographs.

### Steps and ideas in picture making

1. Decide first what information is required in the picture.
2. Arrange the subject and/or the camera to present the essential information as clearly as possible.
3. Put the camera on a tripod!
4. Avoid cluttered pictures – be ruthless with extraneous details.
5. Move in close – fill the frame with the subject. Eliminate any superfluous picture elements.
6. Look carefully at the background – will it interfere with the subject?
7. If a horizon is included in the picture, make sure it is horizontal!
8. Examine the lighting carefully before taking pictures.
9. Include labels and/or scale as appropriate.
10. Check focus/Press the shutter.

|  |  |
| --- | --- |
| Sci Phot example_a | Sci Phot example 2 |
| Plate 5 The goal of scientific photography- the story told clearly and unambiguously. | |

1. **Decide first what information is required in the picture**

In scientific photography, this is the most important step for good results. If you are photographing a plant, or animal for example, include just the one specimen in your picture and make sure the subject fills the picture area.

1. **Arrange the subject and/or the camera to present the essential information as clearly as possible**

Where you take the picture from (i.e. the position of the camera relative to the subject) is one of the most powerful photographic controls. Spend some time placing the camera (and the subject if it is movable) so the picture shows the features you wish to describe. With some subjects (e.g. animals) you may need to take several pictures to be sure of getting a good one.

1. **Put the camera on a tripod**

The most useful and valuable photographic accessory is a tripod. It allows you to take a series of pictures from the same position and eliminates the risk of blurred pictures due to camera movement (the biggest single cause of unsharp photos). If you have access to a tripod, use it. If you don’t have a tripod, use other items as a rest!

1. **Avoid cluttered pictures – be ruthless with extraneous details**

Look carefully through the viewfinder to see exactly what is included in your picture. We tend to concentrate on just the parts of the picture we think are important, but the camera will record everything equally. If there are any unnecessary features in your picture, remove them. It may be possible simply to move the offending items, or you may have to move your location. Before taking the picture, look carefully at the edges of the viewfinder frame. Are there any distractions at the very edges of your picture? If so, get rid of them.

1. **Move in close – fill the frame with the subject. Eliminate any superfluous picture elements**

Having checked your picture, check it again. Probably the easiest way to improve many record photos is to get closer. Be careful with some simple cameras that you don’t move too close. Make use of macro or super-macro features to allow a closeup of disease or insects- but remember to use something to provide a sense of size- a match head, matchbox etc works well.

1. **Look carefully at the background – will it interfere with the subject?**

Depending on the subject matter, there may be little you can do about the background. But in many cases (e.g. photos of small specimens, particularly where these are moveable) you can improve the picture by having a simple, plain background that contrasts with your subject. You may be able to use the wall of a building or introduce an artificial background (e.g. a piece of clean card or larger piece of cloth) to separate your subject from its surroundings. Blue is a good colour for a background, particularly where the key elements are green plants.

1. **If a horizon is included in the picture, make sure it is horizontal**!

If this seems obvious, think again! It’s amazing how many photos have sloping horizons. This is easily corrected, but you have to think of it first!

1. **Examine the lighting carefully before taking pictures**

Is part of the subject in shade and part in sunlight? If so, the two parts will not record well in your picture. Ensure lighting is even over the whole of your subject. The best lighting to use for scientific records is bright overcast (no strong shadows). If you can wait for a bright cloudy day, do so. If not, you may be able to photograph small moveable subjects in an area of open shade (e.g. the shadow side of a building). Or you may be able to use a well-lit area indoors, but be careful to turn off any artificial lighting! Working indoors may require long exposure times (anything longer than 1/60 sec can cause blurred photos), so be sure to use your tripod.  
You can take good photos on a sunny day but the lighting is more difficult to control. If you are working with small subjects in a sunny situation, you can improve your pictures by using a reflector board (any large white surface) near the subject (but out of the picture) on the opposite side to the sun. This will lighten the shadows, making it easier to see detail in both highlight and shadow areas.

If working in a large-scale situation, work with the sun coming over one shoulder (i.e. not directly behind you and not too much to one side). Avoid shooting into the sun (i.e. with the sun in front of the camera)—this can produce effective lighting for some situations but is difficult to control.

1. **Include labels and/or scale as appropriate**

If you are photographing a series of subjects, it is vital to know what treatment is being recorded in each picture so that you can correctly identify your pictures in the future. The surest way to do this is include a label in each photo. If you do include labels, make sure they are legible and neat. Hand written labels can look scruffy and give your work a slapdash appearance. Prepare your labels on a computer…keep the amount of text to a minimum and make the text large enough to read (e.g. 36 pt minimum). You will need to prepare some system of supporting the labels in your pictures. And you will need to be accurate! Make sure the correct label is used in each picture!

Your subject may benefit from a scale being included in the picture. If possible use an accurate scale with dimensions clearly marked. Your scale should be appropriate for the size of your subject. If farmers are the primary audience, use scales that they will make sense of – eg a hand, or a matchbox, biro etc.

1. **Press the shutter**

You can use auto-exposure for good results in most cases. Be careful with flash…some cameras fire a flash automatically. If so it may be best to take one photo with flash and one without if possible.

# Data screening, calculations, analysis and reporting

This is the part we have been waiting for! You have been in the field, watering, weeding, fertilising, or feeding and cleaning etc and now you have the results of the experiment in your hands.

Don’t let the story die with lack of interest and analysis. If you have planned data collection well, you will be able to rapidly analyse and see a table of means.

This is a topic that is best learned by practise. We will make time for plenty of practise in our training and our website provides example data sets in spreadsheets.

There are some issues to consider before we place too much emphasis on a table of means. First🡪

### Biometrical input

This topic requires professional biometrical input. This is not the manual you need, nor the training course to cover those aspects of data management. Ensure you have talked with the biometrician before you start your research. If that has been done, you are well on the way to success at this stage.

Secondly 🡪

### Data screening

Data screening starts with ensuring that the team involved in measurement / harvest are very clear about all the processes and measurements required. Are you really sure that the team can use all the equipment and take accurate measurements. Have you checked? Is there a team leader in place.

Having assured your self of the team’s abilities, you still need to check your data. A careful look may well show up problems.

Assuming you are using a spreadsheet- one tip is to select a row and change the colour for that whole row. If it is a large data set, you may wish to do this for a few of the rows here and there.

Now you can sort variables- weights, lengths of crop or animal largest to smallest. Values that are nonsense soon stand out. These are known as outliers.

Outliers are data items that are obviously out of the range expected. For example, mango seedlings are all between 1 and 1.8 m tall- except for the one that is 16 m tall! This is an outlier- and might be reasonably seen to be a typing / data entry error. It is likely that you can go and check/re-measure. If possible go and do it. In the instance provided there is a very good chance that the value should have been 1.6 m.

Sometimes it isn’t that simple. The value you are looking at may be very different to the equivalent values in other replicates. There are statistical tests to be done here- refer biometrical training. Sometimes the outlier is clearly an error. Sometimes you are lucky enough to be able to go back and check a measurement. This is a very powerful reason for getting on and analysing data as the research progresses.

It may be that the outlier is caused by measuring something that wasn’t actually part of the experiment. Maybe an animal or animals have jumped fences and arrived in a pen they shouldn’t be in.

Data screening involves a number of practical skills- something like a detective- looking for patterns, calculating so that outliers become clear.

Take for example a sweet potato experiment, where a total yield from a mound was recorded, then the weight of reject and saleable were also measured along with counts.

The spreadsheet should calculate for you the addition of saleable and reject. That weight can now be compared (by subtracting one from the other) with your first weight which was the total yield in the field from each mound. A large discrepancy here informs you of a problem.

These data screening skills are best learned by doing. We will work with various data sets to learn data screening skills.

### Missing data?

Imagine a trial where a bag goes missing between harvest and chemical analysis. The data set will have a missing value. What should you do to cope with this value. Reps 1, 2 and 4 are available and their average is 3.2%N. Could you just enter that average into the missing rep 3? NO. There are many reasons for saying NO. Please accept that the answer is always a resounding NO.

Most software that will do analysis of variance will accept an \* in place of the missing value. You can’t put a zero in that rep 3 as the value is missing, not zero. By putting \* there, the computer will do some sophisticated analysis to take into account the missing value. Seek advice from the biometrician, particularly where there are a number of missing values.

Honesty is at the very heart of science and research. Don’t ever put in a value to make the data look good. That kind of temptation has seen the ruin of plenty of people. Don’t let it happen to you.

### Calculations

Don’t ever do what a computer can do for you. But always check that the computer’s calculations are correct. This checking isn’t because you are worried that the computer may make a mistake. Rather it is because your calculation may have errors. Check and ask someone to check on your behalf.

There is much to learn about calculations. Pivot tables, auto filter, sorting are all part of the learning that we will engage in- as a class.

### Reporting the results of research

We have prepared a manual for you- visit the library at [www.cdwi.net](http://www.cdwi.net) to view. This training course will not cover reporting in any detail- but it is a crucial area to consider. The way you report will depend to a large extent on your audience.

Remember a key partner and key audience should be the farming families of your nation. Consider their needs for appropriate information and relevant analysis.

What do we mean- relevant analysis? It should take into account costs and benefits, gender issues and time required- at least!

For more, download the file – Communicating the results of research.

# Calculating Percentages

Beware. Be very careful! Percentages can easily mislead and are too often miscalculated. A yield of 2 tonnes/ha for some crops is miserable. Even though the yield may have increased by 100% the result is still miserable! Take note of the various calculations here, using them to ensure your own presentation of percentages is accurate and helpful. If you are in doubt it may be better to refer directly to the yields or amounts presenting an actual yield change rather than a percentage.

## Percentage Changes

To calculate a simple percentage increase or decrease, adjust 100% by the given instruction. If it’s a percentage increase, add the percentage to the 100%. If it’s a percentage decrease, minus the percentage from the 100%. Put your answer over 100 and then multiply this fraction by the original quantity.

|  |  |
| --- | --- |
| Increase $300 by 2.5%. | It’s an increase, so 100% plus 2.5% = 102.5% |
| Reduce 468m by 12%. | It’s a decrease so 100% minus 12% = 88% |
| Trees are spaced at 2.5m x 2.5m in a field. Another field is to be planted. Mary, a forest researcher suggested that a 15% increase in trees would increase profit. What would the new spacing be? | If we assume an area of 1ha then that ha is 100m x 100m = 10,000m2. Each tree occupies 2.5m x 2.5m which equals a total of 6.25m2. We need to know how many trees there are currently. In order to figure this out we take 10,000 and divide it by 6.25 = 1600 trees.  in a ha, and Mary has suggested a 15% increase in the number of trees:-  Now that we know how many trees we are going to plant in our 1ha block of land we can calculate the new spacing. To do this we simply take 10,000m2 and divide 1840 trees which gives us 5.43m2 per tree. If we then take the square root of this number we can find the spacing. The square root of 5.43m2 = 2.33m.  - ie the new spacing will need to be 2.33m x 2.33m. |

## Finding the amount before a change

You are finding the amount before an increase or decrease.

|  |  |
| --- | --- |
| The price of coffee has increased 2.5%. The new price is K2.50. What was the original price of coffee? | It was an increase so 100% + 2.5% = 102.5%. Divide this by 100 = 1.025 The new price is K2.50. To find the original price we need to divide K2.50 by 1.025% which equals K2.44.  was the original price of coffee. |
| A farmer decides her chickens are not selling quickly enough. She offers a 20% reduction in price and is now charging K12 per bird. What was her original price? |  |

|  |  |
| --- | --- |
| A group of researchers have increased their average sweet potato yield by 18% over the last 20 years. Their current yield is an average of 25t/ha. What was their average yield 20 years ago? | The yield has increased so 100% + 18% = 118%. Divide this by 100 = 1.18. The current average yield is 25t/ha. To find the average yield 20 years ago we need to divide 25t/ha by 1.18 which equals 21.19t/ha. |

|  |  |
| --- | --- |
| The price paid for an item is K20. This price included 12.5% tax. What was the price before tax? |  |

|  |  |
| --- | --- |
| Another item in a different shop is offered at K20. However this time tax of 12.5% has not yet been added. What is the final amount that the buyer will need to pay? |  |

## Finding the Amount of Change

Here we have an original figure and an updated figure. We are looking to find the percentage increase or decrease between the two.

|  |  |
| --- | --- |
| The price of coffee has increased from K2.50 to K2.85. What is the percentage increase? |  |

|  |  |
| --- | --- |
| Last week a roadside stall was selling pineapples for 30t. This week they’re only 25t. What is the percentage decrease? |  |

|  |  |
| --- | --- |
| Doing field research 006 [1024x768] | Plate 6 Researchers and Field Extension officers from PNG, Solomon Islands and Vanuatu learning at a recent training course in Lae and Aiyura, PNG. |
| PNG Experimentation 2011 043 [1024x768] |

# Examples of Trial Plans and Data recording sheets

In this section a trial plan and part of a data recording sheet are given.

## Hints for Using Word to produce these plans and data recording sheets.

1. Do use your ruler, pen (black) and scanner to help in making a trial plan. Lots of hours can be wasted trying to make something in a word processor when a pen and paper would have done. A combination of parts that are drawn by hand and parts that are made with a computer (both in spreadsheets and word processor) and then glued and scanned works very well.
2. Adding a row- go to the right hand end of the table (your cursor should be outside the table) and tap the Enter key. This adds a row to a table.
3. F4 in M’soft Word will repeat the last operation. Hold Shift key down and tap F5. Repeat this to take you to the last three places you have been in your document.
4. Tables can have another table inserted into a cell. This can help with layout. Some tables can be used which have all cells set to no line- ie the table doesn’t show up when printed, but can help with layout of the information.
5. Use the ruler bar (View Ruler)- to help modify column widths. Sometimes the last column gets to be too large for some reason and you can’t see the last column boundary. Go to ‘View/Normal’ and this will help you to squeeze the table up- now go back to ‘View/Page Layout’.
6. Refer class files and consider using them as templates for your own work.
7. To **establish headings throughout a document**, use heading 1, heading 2 and heading 3. You can access these automatically by sitting the cursor on the line that you have typed the text for the heading, and then holding Shift and Ctrl down and tapping the 1, 2 or 3 key. If that command doesn’t work, you are able to set a shortcut key to the heading styles by using format style command. By using standard headings you will be able to make use of the outline mode (View outline) to move large blocks of text around. You will also be able to set up automatic table of contents with correct page numbers.
8. (**To establish Tables of Tables or figures**- Use the Insert menu at the top of the word screen and choose ‘caption’. The insert caption command will create a paragraph, that has the style called ‘caption’. You can modify the style of text by using the Format Style command. When using insert caption, choose whether you want to insert a new table or figure or something different- you can add new options- like Appendices or Plates etc. This will result in something like this- Table 1. Average yields of wheat …
9. To refer to this table from any point in your document, you insert a cross reference. Remember you can choose to insert just the label and number in the cross reference- Word defaults to the whole heading which is normally inappropriate.
10. Now at the start of the document type in something like Table of Tables. This paragraph should be just a normal paragraph, perhaps bold and larger size. Below this paragraph use the insert index and tables command and set options appropriately.
11. CTRL A will select the whole document and F9 will update all of the table references). It is important to do this final step so that all cross references are correct.

Figure 9 Sweet Potato Trial- Factorial Design plus control- (*Plan needs improvement*)

|  |
| --- |
| kaukau expt wrong1 |

**Factorial plus a control, Blocking not contiguous[[29]](#footnote-29)**

How would you improve this plan?

See next page for some ideas…

Figure 10 Sweet Potato Trial Plan, Improved

|  |
| --- |
| kaukau plan dark good2 |

Plot numbering is as shown because visitors arrive at the bottom left corner of the experiment. If this is confusing, then it would be better to make plot 16 the first plot. Whatever- don’t change half way through an experiment.

The site map helps to reduce confusion.

Table 15 Sweet Potato Data Recording Sheet (a)

**Sweet Potato Pruning Experiment W\_KKPrun04[[30]](#footnote-30)**

|  |  |
| --- | --- |
| Date of Recording: | Name of Recorder: |

Address: (ph, fax email could be given) 147 Main Rd, Widgeridoo Research Station, Widgeridoo.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Plot No. | Block[[31]](#footnote-31) | Treatment | Total Tuber Yield (kg) | Total fresh wt of weeds (kg) | Sub sample green of weeds (approx. 200g) | Dry wt of weeds | Comments |
| 1 | B | H2 |  |  | 203 | 24.4 | This sheet contains the main data recorded in the field- weight of tubers and fresh weight of weeds.  The data sheet is then taken inside (or a copy of it) and the total weight of weeds is sub-sampled for an estimation of the dry weight of the weeds.  It is normal to mix the weeds up on a large bench or table- and then spread them out. Take diagonal quarters, remove those and then mix the remainder. Repeat the process of mixing and discarding until you have approximately 200 g ready to go into an oven drying tray. Remember to weigh the approx. 200 g accurately. |
| 2 | B | L4 |  |  | 200 | 24.3 |
| 3 | B | Control |  |  | 199 | 24.1 |
| 4 | B | L2 |  |  | 201 | 24.3 |
| 5 | C | L4 |  |  | 194 | 23.3 |
| 6 | B | H4 |  |  | 210 | 25.1 |
| 7 | D | H2 |  |  | 211 | 25.2 |
| 8 | D | L2 | Data not given. | | These data are for example only, not real data. Note that in both columns values are given to 3 significant figures. | |
| 9 | D | L4 |
| 10 | D | Control |  |  |
| 11 | A | L2 |  |  |
| 12 | A | H4 |  |  | 197 | 23.7 |
| 13 | A | Control |  |  | 201 | 24.2 |
| 14 | A | L4 |  |  | 203 | 24.4 |
| 15 | A | H2 |  |  | 212 | 25.4 |
| 16 | C | Control |  |  | 204 | 24.5 |
| 17 | C | H2 |  |  | 201 | 24.2 |
| 18 | C | H4 |  |  | 199 | 24.1 |
| 19 | C | L2 |  |  | 205 | 24.5 |
| 20 | D | H4 |  |  | 197 | 23.7 |

Table 16 Sweet Potato recording sheet (b)

**Sweet Potato Pruning Experiment W\_KKPrun04**

|  |  |
| --- | --- |
| Date of Recording: | Name of Recorder: |

Address: (ph, fax email could be given) 147 Main Rd, Widgeridoo Research Station, Widgeridoo.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Plot No. | Block | Treatment | Wt of marketable tubers (kg) | No. of marketable tubers | Wt of reject tubers (kg) | No. of reject tubers | Comments |
| 1 | B | H2 |  |  |  |  |  |
| 2 | B | L4 |  |  |  |  |  |
| 3 | B | Control |  |  |  |  |  |
| 4 | B | L2 | For the weight of marketable tubers, you may need more than one column. Why is this? Because sometimes the scales we have available can’t weigh all the tubers in one go. Remember that when you have all the data, enter it all into the computer and let the computer do all the calculations. It is a waste of time, and likely to lead to mistakes if you regularly use a hand calculator to add or subtract or calculate means. Don’t do it, except to check that the computer is doing the sums as you require.  You need to go out to the field, prior to the main harvest, with your gear and test your system before you get a lot of people together and work on a large experiment, like a tuber crop- eg potatoes, sweet potato etc. | | | | |
| 5 | C | L4 |
| 6 | B | H4 |
| 7 | D | H2 |
| 8 | D | L2 |
| 9 | D | L4 |
| 10 | D | Control |
| 11 | A | L2 |  |  |  |  |  |
| 12 | A | H4 |  |  |  |  |  |
| 13 | A | Control |  |  |  |  |  |
| 14 | A | L4 |  |  |  |  |  |
| 15 | A | H2 |  |  |  |  |  |
| 16 | C | Control |  |  |  |  |  |
| 17 | C | H2 |  |  |  |  |  |
| 18 | C | H4 |  |  |  |  |  |
| 19 | C | L2 |  |  |  |  |  |
| 20 | D | H4 |  |  |  |  |  |

Note. This data sheet links to the previous sheet, but could easily be a different team working on counting and weighing sub-sets of the field harvested material. It is likely that some of these data could be recorded inside- in a lab or shed.

Can you think of ways of checking these data with the earlier sheet- later using your spreadsheet skills? What would you do?

Figure 11 Latin Square Design, Insecticides on Cabbages

|  |
| --- |
| cabbage trial plan1 |

Figure 12 Cabbage trial recording sheet[[32]](#footnote-32)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| CABBAGE TRIAL (CAI2002.03): Insect counts (Monday counts, 1 day before spraying) | | | | | | | | | | | | | | | | Recorder: | | | | | | | | | |
| Date | |  | | | | | | | | | | | | | | Note comments below | | | | | | | | | |
|  |  |  | DBM |  |  |  | CROCIDOLOMIA | | | |  |  |  |  |  | semi | SPIDER | | |  |  |  |  |  |  |
|  |  | Plant | |  |  |  | Egg |  |  |  | SPODOPTERA | | | Hellula | | loop |  | other | | Pulis | Flea |  |  |  |  |
| Plot | Tmt.  No | No | Egg | L | L | Pupa | Batch | L | L | L | Eggs | L | V | L | L | sm.b | yelo | lg | sm | wesp | beetle | Ants | Aph | Adu | Juv |
|  |  |  |  | I/II | III/  IV |  |  | I/II | III/  IV | V | LI/II | III/  IV |  | 1/2 | 3/4 |  |  |  |  |  |  |  |  |  |  |
|  |  | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | 2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | 3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | 6 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | 7 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | 8 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | 9 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | 10 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

Figure 13 Forestry Trial Plan showing Trial Design and planting in plots- Sheet A

Trial Design:- 3 Spacings by 2 thinning treatments, replicated 4 times= 24 plots.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  | | --- | --- | --- | | Tmt No. | Spacing | Thinning | | 1 | 3.0 x 3.0m | Thinned | | 2 | 2.5 x 2.5 m | Thinned | | 3 | 2.0 x 2.0 m | Thinned | | |  |  |  | | --- | --- | --- | | Tmt No. | Spacing | Thinning | | 4 | 3.0 x 3.0m | No thinning | | 5 | 2.5 x 2.5 m | No thinning | | 6 | 2.0 x 2.0 m | No thinning | |

Tree layout and numbering in each of the 6 treatment plots.

|  |  |  |
| --- | --- | --- |
| Plot layout where **Thinning** is applied at year n. | | |
| Treatment 1. 3.0 x 3.0 m | Tmt 2. 2.5 x 2.5 m | Tmt 3. 2.0 x 2.0 m |
| |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | G | G | G | G | G | G | G | | G | T1 | H8 | T15 | H22 | T29 | G | | G | T2 | H9 | T16 | H23 | T30 | G | | G | T3 | H10 | T17 | H24 | T31 | G | | G | T4 | H11 | T18 | H25 | T32 | G | | G | T5 | H12 | T19 | H26 | T33 | G | | G | T6 | H13 | T20 | H27 | T34 | G | | G | T7 | H14 | T21 | H28 | T35 | G | | G | G | G | G | G | G | G | | |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | G | G | G | G | G | G | G | | G | T1 | H8 | T15 | H22 | T29 | G | | G | T2 | H9 | T16 | H23 | T30 | G | | G | T3 | H10 | T17 | H24 | T31 | G | | G | T4 | H11 | T18 | H25 | T32 | G | | G | T5 | H12 | T19 | H26 | T33 | G | | G | T6 | H13 | T20 | H27 | T34 | G | | G | T7 | H14 | T21 | H28 | T35 | G | | G | G | G | G | G | G | G | | |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | G | G | G | G | G | G | G | | G | T | H | T | H | T | G | | G | T | H | T | H | T | G | | G | T | H | T | H | T | G | | G | T | H | T | H | T | G | | G | T | H | T | H | T | G | | G | T | H | T | H | T | G | | G | T | H | T | H | T | G | | G | G | G | G | G | G | G |   (Tree numbers same as Tmt 1 & 2) |
| Plot layout at planting where **No Thinning** to be applied. | | |
| Tmt 4. 3.0 x 3.0 m | Tmt 5. 2.5 x 2.5 m | Tmt 6.2.0 x 2.0 m |
| |  |  |  |  | | --- | --- | --- | --- | | G | G | G | G | | G | H1 | H8 | G | | G | H2 | H9 | G | | G | H3 | H10 | G | | G | H4 | H11 | G | | G | H5 | H12 | G | | G | H6 | H13 | G | | G | H7 | H14 | G | | G | G | G | G | | |  |  |  |  | | --- | --- | --- | --- | | G | G | G | G | | G | H | H | G | | G | H | H | G | | G | H | H | G | | G | H | H | G | | G | H | H | G | | G | H | H | G | | G | H | H | G | | G | G | G | G | | |  |  |  |  | | --- | --- | --- | --- | | G | G | G | G | | G | H | H | G | | G | H | H | G | | G | H | H | G | | G | H | H | G | | G | H | H | G | | G | H | H | G | | G | H | H | G | | G | G | G | G | |

G = Guard trees, T = Thinned trees, H = final harvest trees.

Note:- Size of plot changes because of spacing changes and in this design the same number of trees in each plot are being managed for final harvest.

Figure 14 Tree experiment Trial Plan Sheet B

Second page of Tree experiment showing how plots are laid out in the field. Note plots are different sizes as spacing changes, although all plots have the same number of final harvest trees.

|  |
| --- |
| tree popn expt1 |

This page has to be read along with the previous page to ensure the researchers have all the required information.

## Comments on Forestry Plan.

This trial needs two pages to complete the trial plan.

On the first page a site location, indication of trial design and overall layout of plots is given. The second page ensures that everyone is clear about the tree layout in each of the 6 treatments, where some trees are thinned prior to final harvest.

Finally in a long term forestry trial trees are either harvest trees or guard trees. It is normal to have only one guard row of trees in each plot. With more guard rows the trial becomes very large and there is a greater chance that soil fertility gradations will occur within a block. Plots at one end of a block may get more fertility than those at the other end. So, plots are kept as small as possible, but large enough to ensure that the harvested trees will be behaving as if they were actually part of a forest of uniform trees all grown at that spacing or fertility or moisture treatment.

## Data recording in Forestry Experiments

In the plots as shown there are two harvest rows, each row having 7 trees. If a tree has died early in the trial, even where the dead tree was replaced this replacement tree will tend to be smaller than those around it. Comments need to be made in trial diaries and on recording sheets so that these replacement trees do not become part of the standard data set.

Table 17 Tree Population x Thinning Expt- WRS2002.02

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Name of Recorder | | | | | Address:- |
| Date of recording | | | | |  |
| Plot No. | | | | | Treatment |
| Tree | Thin or Harvest? | DBH[[33]](#footnote-33) | Tree Score  1- 5 [[34]](#footnote-34) | Comments | |
| 1 |  |  |  |  | |
| 2 |  |  |  |  | |
| 3 |  |  |  |  | |
| 4 |  |  |  |  | |
| 5 |  |  |  |  | |
| 6 |  |  |  |  | |
| 7 |  |  |  |  | |
| 8 |  |  |  |  | |
| 9 |  |  |  |  | |
| 10 |  |  |  |  | |
| 11 |  |  |  |  | |
| 12 |  |  |  |  | |
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Table 18 Tree Population Experiment WRS2002.02

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| --- | --- |
| Name of Recorder | Address:- |
| Date of recording |  |
| Plot No.[[35]](#footnote-35) | Treatment |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Tree No. | Total length of tree | Billets – Diameter (over bark) in cm | | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
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|  |
| --- |
| Time for Group Discussion-  Take a look at the trial plans and data recording sheets in this module. Now take a look at some of your own plans and data recording sheets. Think about these questions:-   1. Could someone new to this trial look at my plans and data and understand what was being done here? 2. Could they take over the running of this trial if I had to leave suddenly? 3. How can I improve my trial plans and data recording sheets? |

# Assessment

These notes are given to help you when supervising junior staff members.

## Assessment Schedule For Researcher’ S Diary

Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Title and Address, phone fax etc |  | | | |  |
| all relevant details given (Title, author…) |  |  |  |  | relevant details omitted |
| Actions |  |  |  |  |  |
| Actions clearly stated |  |  |  |  | Actions unclear. |
| Addresses, contact information for people visited, working with clearly stated so that they can be contacted in the future |  |  |  |  | many important details missing |
| organisation clear & logical |  |  |  |  | organisation unclear/illogical |
| material relevant |  |  |  |  | much irrelevant material |
| clear concise style |  |  |  |  | vague/diffuse style |
| legible & well set out |  |  |  |  | untidy & diff to read |
| appropriate length |  |  |  |  | too short/too long |

Date assessed: ………… Mark: ….… Signature:

## Trial Plans

Aim:- Draw a trial plan for a field experiment that ensures that scientists, technicians and visitors can rapidly understand what is being researched in the trial.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Title and Address, phone fax etc |  | | | |  |
| all relevant details given (Title, author…) |  |  |  |  | relevant details omitted |
| Trial plan detail |  |  |  |  |  |
| How to get there map clear |  |  |  |  | No map to help visitor get to trial site |
| Significant features to help with orientation included |  |  |  |  | Many important details missing |
| North arrow included |  |  |  |  | North arrow missing |
| Plot numbers clear and sensible |  |  |  |  | Plot numbers confusing, not clear |
| Treatments clear without having to keep referring to a key |  |  |  |  | Treatments unclear, confusing |
| Orientation of plan sensible in terms of normal entry to trial |  |  |  |  | Orientation of plan confusing |
| Dimensions clear and allow plots to be located again if pegs lost |  |  |  |  | Dimensions of plots, distance to permanent fences etc not clearly marked |
| Where sensible, plots are drawn roughly to scale |  |  |  |  | Dimensions are so far from scale that layout is confusing |
| legible & well set out |  |  |  |  | untidy & diff to read |

Date assessed: ………… Mark: ….… Signature of Assessor:

## Assessment Schedule For Essay/Reports

Author\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Title\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Title and Headings |  | | | |  |
| all relevant details given (Title, author…) |  |  |  |  | relevant details omitted |
| Abstract |  | | | |  |
| Self explanatory by itself, without needing to go to main body of paper |  |  |  |  | Important details missing |
| Objectives and scope clearly stated |  |  |  |  | Objectives and scope unclear |
| Clear statement of conclusions |  |  |  |  | Conclusions vague or lacking |
| Summary |  |  |  |  |  |
| objectives and scope clearly stated |  |  |  |  | objectives and scope unclear |
| adequate outline of main findings |  |  |  |  | impt details missing |
| clear statement of conclusions |  |  |  |  | conclusions vague or lacking |
| Introduction |  | | | |  |
| clear statement of problems/ reasons for subject to be examined or clear interpretation of question |  |  |  |  | statement/interpretation inadequate or lacking |
| adequate background to problem/subject |  |  |  |  | inadequate background |
| clear definition of relevant terms/concepts |  |  |  |  | unclear definition |
| clear statement of objectives & limits of Essay/report |  |  |  |  | failure to state objectives & limits |
| Body |  | | | |  |
| organisation clear & logical |  |  |  |  | organisation unclear/illogical |
| material relevant |  |  |  |  | much irrelevant material |
| adequate analysis |  |  |  |  | account largely descriptive |
| all impt aspects considered |  |  |  |  | several impt aspects not considered |
| strong evidence of careful selection & critical appraisal of literature |  |  |  |  | little evidence of careful selection & critical appraisal |
| strong evidence of original & creative thought |  |  |  |  | little evidence of original & creative thought |
| strong evidence that key arguments/concepts are well understood |  |  |  |  | evidence that key arguments/concepts are poorly understood |
| arguments & statements well substantiated (by reason, references, figures, or tables) |  |  |  |  | failure to substantiate arguments & statements |
| effective use of figures & tables |  |  |  |  | figures & tables add little to the argument |
| Presentation |  | | | |  |
| Written in own words |  |  |  |  | too much copying or paraphrasing |
| clear concise style |  |  |  |  | vague/diffuse style |
| legible & well set out |  |  |  |  | untidy & diff to read |
| effective use of paragraphs & subheads |  |  |  |  | poor paragraphing. Too many/few subheads |
| effective captions for figs & tables |  |  |  |  | figs & tables not self explanatory |
| pages, figs & tables appropriately numbered |  |  |  |  | failure to number pages, figs & tables |
| appropriate length |  |  |  |  | too short/too long |
| consistent SI units of measurement |  |  |  |  | inconsistent/non SI units |
| literature correctly cited & referenced |  |  |  |  | many incorrect citations |

Date assessed: ………… Mark: ….… Signature:

## Assessment Schedule For Verbal Presentation Conference/Seminar Paper

Presenter\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Topic\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Beginning time:-\_\_\_\_\_\_\_\_\_\_ End Time\_\_\_\_\_\_\_\_\_\_\_\_ Minutes over or under allocated\_\_+/-\_\_\_

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Introduction |  | | | |  |
| Effective |  |  |  |  | Didn’t catch the attention of audience |
| Humour used effectively |  |  |  |  | No use of humour |
| Main body |  | | | |  |
| Excellent flow and development of ideas |  |  |  |  | Ideas largely disjointed, poor flow |
| Main points well covered |  |  |  |  | Impt details missing |
| clear definition of relevant terms/concepts |  |  |  |  | Unclear definition or unrealistic expectation of background knowledge of audience |
| Summary |  | | | |  |
| Main points well summarised |  |  |  |  | Summary lacking or very poor. |
| Presentation |  | | | |  |
| Diction, pronunciation clear |  |  |  |  | Diction, pronunciation very hard to understand |
| Used eye contact very effectively |  |  |  |  | Lack of eye contact |
| No unhelpful mannerisms |  |  |  |  | Tended to move around in ways that were distracting |
| When speaking, faced audience |  |  |  |  | Tended to talk to the overhead or whiteboard |
| Overheads/visual presentation |  | | | |  |
| Size – able to be read well |  |  |  |  | Couldn’t be read- too small |
| Colour- easy to read |  |  |  |  | Wrong colours, couldn’t be read |
| Wise use of texture in graphics |  |  |  |  | Textures not used, colours hard to distinguish |
| Pictures- wise choice |  |  |  |  | Pictures didn’t add to the topic |
| Powerpoint used wisely |  |  |  |  | Powerpoint distracted from the message |
| Presenter organised before the presentation |  |  |  |  | Presenter started to organise after introduced by chairperson |

Date assessed: ………… Mark: ….… Assessor\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# References

Asher, C., Grundon, N. and Menzies, N. 2002. How to unravel and solve soil fertility problems. ACIAR.

Cheng, Yvonne.; Horne, P. 1997. Field Experiments with forages and crops- Practical tips for getting it right first time. ACIAR

Little and Hills, F. 1978. Agricultural Experimentation- Design and Analysis. John Wiley and Sons

Lindsay, D. 1987. A Guide to Scientific Writing. Longman Cheshire.

PRAP leaflet No. 1- How to lay out, maintain and record a randomised block trial.

<http://www.experiment-resources.com/factorial-design.html> useful links here for a reader wanting more advanced discussion of some of the core principles.

# Annexes

Annex 1 Research Skills Modules – a competency based framework for this manual.

From [http://www.hope.ac.uk/research/research-skills-modules March 2011](http://www.hope.ac.uk/research/research-skills-modules%20March%202011)

The joint research councils of the United Kingdom have joined forces and come up with some broad competency areas for Field Researchers. There are 7 modules and where appropriate this manual has followed those modules. We don’t cover all competencies - but for your interest here are the 7 broad areas that researchers are expected to show competency in.

The full list is provided below – with some detail.

**Module A: Research Skills and Techniques**The student is expected to demonstrate competency in the following areas:  
  
A1.  The ability to recognise and validate problems  
A2.  Original, independent and critical thinking, and the ability to develop theoretical concepts  
A3.  A knowledge of recent advances within one’s own field and related areas  
A4.  An understanding of relevant research methodologies and techniques and their appropriate application within one’s research field  
A5.  The ability to critically analyse and evaluate one’s findings and those of others  
A6.  An ability to summarise, document, report and reflect on progress

**Module B: Research Environment**The student is expected to demonstrate competency in the following areas:  
  
B1.  Show a broad understanding of the context, at the national and international level, in which research takes place  
B2.  Demonstrate awareness of issues relating to the rights of other researchers, of       
research subjects and of others who may be affected by the research  
B3.   Demonstrate appreciation of good research practice in their institution/  
discipline  
B4.   Understand relevant health and safety issues and demonstrate responsible working practices  
B5.  Understand the processes for funding and evaluation of research  
B6.  Justify the principles and experimental techniques used in one’s research  
B7.  Understand the process of academic or commercial exploitation of research results

**Module C: Research Management**The student is expected to demonstrate competency in the following areas:  
  
C1.  Apply effective project management through the setting of research goals, intermediate milestones and prioritisation of activities  
C2.  Design and execute systems for the acquisition and collation of information through the effective use of appropriate sources/ equipment  
C3.  Identify and access appropriate bibliographical resources, archives and other sources of relevant information  
C4.  Use information technology appropriately for database management/ recording/ presenting information

**Module D: Personal Effectiveness**The student is expected to demonstrate competency in the following areas:  
  
D1. Demonstrate a willingness and ability to learn and acquire knowledge  
D2. Be creative, innovative and original in one’s approach  
D3. Demonstrate flexibility and open-mindedness  
D4. Demonstrate self-awareness and the ability to identify own training needs  
D5. Demonstrate self discipline, motivation and thoroughness  
D6. Recognise boundaries and draw upon/ use appropriately, sources of support  
D7. Show initiative, work independently, with self-reliance

**Module E: Communication Skills**The student is expected to demonstrate competency in the following areas:  
  
E1.  Write clearly, in appropriate style for purpose  
E2.   Construct coherent arguments and articulate ideas clearly to a range of audiences  
E3.  Constructively defend research outcomes in oral discussion  
E4.  Contribute to promoting public understanding of one’s field  
E5.  Effectively support the learning of others when engaged in teaching/demonstrating

**Module F: Networking and Team-working**The student is expected to demonstrate competency in the following areas:  
  
F1.  Develop/ maintain co-operative networks and working relationships with supervisors/ colleagues/ peers, within the institution and in a wider field  
F2.  Understand the impact of one’s behaviour on others when working in teams  
F3.  Listen to others and give appropriate feedback

**Module G: Career Management**The student is expected to demonstrate competency in the following areas:  
  
G1.  Appreciate the need for and show commitment to continued professional  
Development  
G2.  Take ownership for/ manage one’s career progression, setting realistic goals and improving one’s employability  
G3.  Demonstrate an insight into the transferable nature of research skills  
G4.  Present one’s skill, personal attributes and experiences through effective CVs and develop interview skills

This list of competencies has strengths but some areas are not stated clearly enough. The greatest weakness is the lack of focus on the farming family. Research that makes a difference will normally follow the AR4D (Agricultural Research for Development) model. Farmers needs and aspirations are a crucial focus.

Priority setting involves farmers directly and through those who work with farmers. Research isn’t something that a research station does for farmers. Rather it is a mutual process and extension is an inter-related part of that process. Even calling it extension loses something of the meaning we wish to convey. Why? Because extension speaks of a one way flow of information from those who know, to those waiting passively. That isn’t the model we are pursuing.

Having said that, good research is built on appropriate skills, knowledge and abilities. This manual’s focus is on technical skills, knowledge and attitudes you need to have to be effective in undertaking AR4D. There are other resources to read, of course. Learning is an ongoing process, made much easier by the information and networking/partnership made possible through the internet. A team can be made up of people in a number of countries sharing information and results to the mutual benefit of all.

### Module A Research Skills and Techniques

#### A1 🡪 Ability to recognise and understand problems[[36]](#footnote-36)

Here are some questions to ask yourself.

Can you identify the research questions addressed in the research papers that you read?

“What research papers? I don’t read any research papers!”

There’s a concerning possibility here! Maybe you are doing an experiment without reading what others have already done in your area of interest. You could be wasting a lot of money and your time…

It is never easy in our work places to access good research papers. We have to work hard to get hold of the right information.

Here are some things to keep in mind, if you live a long way from a good library. Did you know there are 32,000 library citations relating to (PNG) agriculture at [www.pngnais.org](http://www.pngnais.org) and this will soon become www.mais.net[[37]](#footnote-37)? That provides a window into what has been done- but those papers are hard to track down.

Effective reading for many of us will involve strong networks- keeping track of people we meet at workshops – like this one, so that as new research is done we get a paper emailed to us. Certainly the internet is making it easier for those of us living a long way from a good library. The internet also allows us to both learn and share our learning. Fight hard for internet access, then, don’t abuse the privilege by downloading garbage or worse.

Have you clearly defined the research question(s) you will pursue in your research?

It’s hard to define clear questions without the benefit of others who have worked in your area. Make no doubt about this- others will have worked in your area of interest before.

When considering your research question- don’t be afraid to 🡪

1. State questions in simple English.
2. Ask simple questions.

Here’s two that may be appropriate.

1. Which of these four corn cultivars will yield best under normal Vanuatu farmer conditions?
2. Can I replace 50 kg N/ha applied as urea with either goat or rabbit manure, when applied at 5 tonne/ha to corn (or aibika or cabbage etc).

Keep it simple.

Can you develop valid research hypotheses from your research question?

Biometricians often state a null hypothesis as if it is at the heart of the research question. This means they state that the four corn cultivars (mentioned above) will have no significant differences in yield. In practical terms they are saying a farmer could plant any cultivar and each would yield much the same as any other. The experiment is run, in such a way as to properly test that assumption or hypothesis. The researcher is looking to see if there are any yield differences. When all yields are measured researchers, assisted by biometricians use techniques to determine whether the assumption was right- no differences, or wrong- some differences actually exist among those four cultivars. (Later the biometrician may take things further- can we say more to our farmers about the differences among those four cultivars.)

Ponder for a moment. If those four cultivars were grown in just four plots, but one of the plots was on an old track where top soil had been removed and another plot was right on top of a place where lots of rubbish had been burned. Would that be a fair test of the four cultivars? Not at all. Part of this manual is given over to the ways we establish experiments to ensure that the test of🡪

those four corn cultivars *or*

different feed rations for pigs or chickens etc-

are valid tests that will result in reliable/worthwhile information or advice for our farming families.

Can you give examples from the literature of problems that have been addressed by others, explain why those researchers addressed the problems as they did and discuss the advantages and disadvantages of those approaches?

This is important. We all need to read more critically. This isn’t about criticism of a negative nature. However, it is about reading with our critical faculties turned on. We will work through some exercises to ensure you understand what we mean by way of reading in a critical manner- to both learn from others and see weaknesses in their approach that leaves us room for our (improved) research.

Can you design an experiment(s) that addresses one of those research questions?

There’s much more coming about this later in the manual. Learning to design appropriate experiments is a big topic and one that should always involve both more experienced researchers as well as competent biometrician[[38]](#footnote-38)(s). The author has been very fortunate over many years to have biometricians available to discuss trial plans/designs. There is really only one key time to do this- and that is before you order seed, prepare ground and plant a crop or weigh those animals or plant that experiment on coffee or oil palm.

#### A2 Original, independent and critical thinking, and the ability to develop theoretical concepts.

Are you able to use new and innovative research ideas and strategies in your work?

Our research does not have to be totally new to be relevant. But we must seek to look at some areas that have often been forgotten in past research approaches. Perhaps transport and marketing of produce is more important than the evaluation of a new insecticide? In other words there are social dynamics that may be more important than traditional ‘technical’ issues that agronomists and soil scientists think of first…

This is called – thinking outside the box… It is important to think in ways that help you identify the crucial bottle necks for farmers, not just the ones that our own training has prepared us for.

In some areas, theft and jealousy may be more important limits to animal production than nutrition. What do you think?

#### A knowledge of recent advances within one's field and in related areas

You need to be able to:

1. keep up to date with the latest publications relevant to your area.
2. use a range of bibliographic and virtual sources to search effectively for information.
3. manage collected information so that it can be retrieved and cited appropriately.
4. communicate knowledgeably about your research area and discuss concepts in a scholarly way with academic colleagues.

#### Show an understanding of relevant research methodologies and techniques and their appropriate application within your ‘research field’ of livestock issues or plant pathology, entomology etc.

The bulk of this manual covers the skills and knowledge needed by us- as field researchers.

You need to be able to 🡪

1. show your understanding of what constitutes 'high quality' academic research in your field.
2. demonstrate an in-depth knowledge and understanding of appropriate research techniques and their application.
3. discuss and prioritise a range of methodologies to address a research question.

#### The ability to critically analyse and evaluate one's findings and those of others

This is partly covered in this manual – but involves biometrical skills, and the ability to read critically- understanding how your research can be compared effectively and appropriately with that of others.

This is a programme for research skills training which directly focuses on the required research competencies as set out by the Joint Research Councils of the UK. The student works out how to address each of the competencies and what evidence to use to demonstrate this. The student is aided in that task by a mentor.

Annex 2 To Take Lists

The lists below are general ones. Take some moments now to make your own lists – type or write them up and print onto card that stays with your bag and another copy in your car. Check before leaving home that you have what you need to do the job efficiently and effectively.

##### Meetings, workshops, seminars- office related

1. Advance bookings for meals, morning and afternoon teas? Cutlery, plates, cups etc on hand or booked?
2. Advance bookings of vehicles, accommodation, meeting rooms, equipment, people notified?
3. Bluetack
4. Guest speakers- accommodation- pickup and drop off for meetings?
5. Drivers know what is required of them and when?
6. Nametags
7. Notebooks and pens for participants
8. Overhead projector- acetates, screen
9. Paper- large for group work/posters and small
10. Paperclips
11. Pens for overhead projector
12. Phone on hand, battery charged? Phone checked!?
13. Slides and projector and screen
14. Spare bulbs for projection equipment
15. Tables and chairs
16. Video player, tv
17. Video projector- booked in advance?
18. Whiteboard cleaner and rags
19. Whiteboard markers

##### Farmer visits/on-farm research

1. Farming families involved in planning for meetings- do they know when the next visit/meeting is scheduled?
2. Maps clear for all those travelling?
3. Trial plans available for all?
4. Recording sheets- copies available- pre-planned so that data can be entered into a computer easily. Plot order on record sheets so that there will be no confusion when recording in the field?
5. What happens if it rains- covers/umbrellas/parkas?
6. Appropriate tools for the research- only you can answer this. Think about it, discuss with technicians and farmers before you get in the vehicle and drive a long way only to find that you have left behind something important. The list below will help.
7. Weighing equipment- buckets, cages, weighing sheets
8. Electronic scales- battery charged, spare battery? Power supply for recharging where possible? Contingency plan if battery power fails?
9. Cutting equipment
10. Ladders
11. Weeding equipment
12. Fencing equipment- posts, wire, nails, staples, tie wire, stays, spades, crowbars, bush knives.
13. Tattooing equipment- ink, enough numerals and numbers
14. Baskets, buckets, boxes, plastic and paper bags available to bring produce back to research station if necessary
15. Soil moistures- cans with lids- permanent labels- record sheets pre planned?
16. Soil augurs?
17. Vehicle checked?
18. Clipboard with plastic bags as cover in case of rain. Pens that can write when a little damp, but ink won’t smear?
19. With a large group you may need two or more of some items. Have you enough of each tool?

##### Travel planning and vehicle checks

1. Water, (radiator, windscreen and drinking water)
2. Tyres including spare- pressure and damage
3. Fuel including extra if necessary
4. Means of paying for more fuel as travel commences
5. Spare key
6. Torch
7. Itinerary ensures that driving at night in dangerous areas will not be necessary
8. Driver booked, and *per deims* agreed upon before travel commences.
9. Tow rope and rope for tying down load
10. Plastic or canvas covers for protecting cargo
11. Animal cages if animals to be transported- check to ensure urine etc will not damage vehicle
12. Movement permits arranged for animals?
13. Seat belts working properly for all passengers?

##### Finally, when you are getting ready to leave the village-

1. Are the farming families involved in this research absolutely clear about their responsibilities while you are gone? Are you sure they understand and are happy about what is required? Some further time now for you to listen to their needs/suggestions is very important. Remember this research belongs to them as much as to you.
2. Is the area fenced adequately?
3. Have you left behind copies of trial plans and trial protocol (perhaps just a simple set of rules/guidelines relating to the way the trial should be managed).
4. Have village leaders been briefed adequately?

Have you visited other organisations that may be involved or interested in your research (eg. DPI, NGO, church etc).

Annex 3 Atomic weights for commonly used elements

| **Element** | **Symbol** | **Atomic weight** | **Element** | **Symbol** | **Atomic Weight** |
| --- | --- | --- | --- | --- | --- |
| Aluminium | Al | 26.98 | Molybdenum | Mo | 95.94 |
| Arsenic | As | 74.92 | Nickel | Ni | 58.69 |
| Boron | B | 10.81 | Nitrogen | N | 14.01 |
| Bromine | Br | 79.90 | Oxygen | O | 16.0 |
| Cadmium | Cd | 112.41 | Phosphorus | P | 30.97 |
| Calcium | Ca | 40.08 | Platinum | Pt | 195.08 |
| Carbon | C | 12.01 | Potassium | K | 39.10 |
| Chlorine | Cl | 35.45 | Radium | Ra | 226 |
| Chromium | Cr | 52.00 | Selenium | Se | 78.96 |
| Cobalt | Co | 58.93 | Silicon | Si | 28.09 |
| Copper | Cu | 63.55 | Silver | Ag | 107.87 |
| Fluorine | F | 19.00 | Sodium | Na | 22.99 |
| Gold | Au | 196.97 | Strontium | Sr | 87.62 |
| Helium | He | 4.00 | Sulphur | S | 32.07 |
| Hydrogen | H | 1.01 | Tin | Sn | 118.71 |
| Iodine | I | 126.90 | Titanium | Ti | 47.87 |
| Iron | Fe | 55.85 | Tungsten | W | 183.84 |
| Lead | Pb | 207.2 | Uranium | U | 238.03 |
| Lithium | Li | 6.94 | Zinc | Zn | 65.39 |
| Magnesium | Mg | 24.31 |  |  |  |
| Manganese | Mn | 54.94 |  |  |  |
| Mercury | Hg | 200.59 |  |  |  |

Annex 4 Table of Random Numbers

8 2 0 3 1 4 5 8 2 1 7 2 7 3 8 5 5 2 9 0 6 3 1 6 4

0 8 7 3 3 1 9 7 5 2 5 7 6 9 8 0 3 6 2 5 1 2 7 5 2

2 3 3 8 6 1 4 2 4 0 2 6 1 8 9 5 2 6 9 8 3 4 0 1 0

4 7 5 5 6 3 0 7 7 1 9 1 6 1 7 4 1 7 1 3 7 9 3 3 7

1 9 3 9 5 3 4 9 5 5 2 7 5 8 0 3 4 8 8 1 2 7 5 3 4

2 8 7 8 1 4 1 4 9 4 2 4 1 5 2 9 4 6 2 1 5 2 8 1 9

8 4 8 5 1 3 9 6 6 0 7 2 1 9 0 2 0 6 7 0 6 0 1 3 0

0 3 8 8 4 7 5 1 5 1 7 3 4 5 2 0 7 4 7 9 6 6 7 7 4

3 5 3 1 9 3 7 4 9 5 0 2 0 1 4 6 2 5 4 5 8 5 0 9 2

3 4 5 9 5 2 7 9 8 9 0 5 5 8 5 1 7 7 3 5 5 4 7 7 2

4 1 5 3 0 9 1 3 7 2 5 8 7 7 1 3 6 3 9 7 8 7 9 1 7

7 2 9 5 6 7 8 5 4 5 3 4 5 4 1 9 8 6 7 5 7 9 3 1 8

5 9 2 8 9 8 6 4 4 1 5 3 7 7 0 8 0 2 5 6 0 6 1 2 0

1 3 3 3 9 0 5 2 8 7 4 0 9 0 3 7 3 1 7 9 4 5 5 2 8

4 6 0 1 0 8 6 2 1 0 0 5 0 3 1 5 4 9 0 3 7 4 7 0 1

7 7 0 6 6 3 2 8 8 5 8 9 5 6 4 0 5 9 1 8 0 5 4 9 4

3 3 8 5 7 5 7 4 3 4 5 7 9 6 9 5 0 7 7 6 6 8 8 5 9

9 1 7 1 3 6 9 2 9 1 9 4 2 3 3 0 8 1 8 7 7 6 4 7 2

6 2 2 8 0 9 4 5 3 7 2 5 4 6 6 5 6 6 5 0 4 6 5 6 8

1 7 5 9 0 0 2 0 5 6 5 8 5 1 9 5 3 3 7 4 0 5 8 2 4

0 3 9 6 9 4 7 3 5 7 0 6 5 4 7 1 1 8 5 3 2 8 0 9 8

3 0 8 2 8 1 4 4 1 6 7 6 6 9 9 9 7 5 8 9 6 4 5 9 0

9 4 9 1 2 2 0 1 3 2 4 6 7 9 1 8 8 2 9 8 3 2 6 2 9

7 2 5 1 4 4 9 6 5 2 8 5 5 1 0 8 2 6 2 0 6 9 2 2 3

9 9 2 5 7 4 3 1 2 3 6 4 1 5 2 4 0 4 2 2 8 7 1 8 2

2 0 9 1 8 9 4 4 6 1 4 8 6 7 9 2 5 0 6 9 3 3 0 1 2

6 5 2 6 1 2 1 7 7 1 4 7 8 1 4 2 7 3 7 4 0 0 1 2 9

1 2 9 9 6 4 2 5 3 2 7 4 3 2 3 3 8 5 3 3 6 5 5 3 2

3 2 8 3 7 9 6 0 4 8 6 0 5 4 1 1 4 9 0 5 0 9 4 4 1

0 9 3 4 1 1 9 5 8 3 2 4 6 7 3 4 4 9 2 3 7 2 5 7 8

6 7 5 3 4 2 1 5 5 0 1 2 4 7 5 5 2 6 8 7 8 2 8 0 3

9 6 0 1 3 0 5 3 6 6 2 9 6 0 3 4 7 6 1 1 9 1 6 5 3

4 6 9 9 6 7 8 5 8 1 2 9 2 6 2 4 4 9 0 5 5 4 5 2 0

9 7 7 1 9 2 6 5 6 3 3 6 3 6 8 3 9 9 8 7 7 2 7 9 7

7 5 3 3 3 3 7 3 7 6 7 3 9 1 1 2 3 9 0 9 5 9 6 5 7

2 8 1 3 1 3 4 2 1 0 3 1 2 3 2 0 2 3 9 7 7 5 0 6 9

6 0 9 4 8 8 5 5 3 7 9 0 0 0 0 1 9 2 0 6 1 5 8 4 2

3 5 9 0 7 7 0 1 8 1 2 9 3 4 6 9 2 8 9 8 9 8 6 5 5

4 4 8 1 1 7 4 4 7 4 4 4 1 6 5 9 3 6 5 9 8 3 2 4 3

6 3 9 7 0 6 2 5 3 3 2 6 0 5 1 2 4 3 7 1 0 7 8 2 1

To randomise any set of 10 items or less, begin at a random point on the table and follow either rows, columns or diagonals in either direction. Write down the numbers in the order they appear, disregarding those that are higher than then number being randomised and those that have appeared before in the series. If you wish to randomise more than 10 numbers, pairs of columns or rows can be combined to form two digit numbers and the same process followed as that described above (Little and Hills, 1978).

1. This chapter, by Miranda Cahn, comments by Sue Philpott, edited by Dave Askin [↑](#footnote-ref-1)
2. What is the difference between tending and weeding- Keep these forms simple- I would suggest you use one category = tending/weeding. [↑](#footnote-ref-2)
3. Is carrying crops close enough to marketing for it to sit in one category- (In other words, feel free to modify tables like this- keeping things clear and simple is important). [↑](#footnote-ref-3)
4. Normally only close to harvest with crops like rice and then this task becomes very important and time consuming. [↑](#footnote-ref-4)
5. In many instances food processing and food preparation may be similar enough to consider in one category only. What do you think, for your situation? [↑](#footnote-ref-5)
6. In some circumstances it may be sufficient to note child, rather than gender in the children, but in reality it is normally best to do as shown in this table- record gender of children involved as well as the adults. [↑](#footnote-ref-6)
7. Wait a minute! Your research? Whose research? Perhaps the research should be considered a truly joint partnership among a formal research team and the community/farmers involved- yes, men and women! [↑](#footnote-ref-7)
8. Mandy Cahn has provided an extensive list here. Most will be unavailable or at the best- hard to get in your remote location. However as internet access improves, so does the access to many documents on line. Oxfam have a valuable gender resource. [↑](#footnote-ref-8)
9. If you Google this term, you may find more useful information. [↑](#footnote-ref-9)
10. When we mention farmers we are not just talking about men here. We mean men and women. [↑](#footnote-ref-10)
11. PRAP - Participatory Rural Appraisal and Planning. [↑](#footnote-ref-11)
12. You and the farmers may not really know how much benefit the fertiliser will produce. That may be the starting point for a group of farmers experimenting to see the overall value of fertiliser. [↑](#footnote-ref-12)
13. eg [www.gallagher.co.nz](http://www.gallagher.co.nz) [↑](#footnote-ref-13)
14. [www.cdwi.net](http://www.cdwi.net) [↑](#footnote-ref-14)
15. Short for cultivated variety. Wanmun is a cultivar of sweet potato. [↑](#footnote-ref-15)
16. Each research station should have a copy of this excellent manual. [↑](#footnote-ref-16)
17. <http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sag3024> - extra information, but requires a biometrician to help you understand the detail they provide. [↑](#footnote-ref-17)
18. Remember that if you are using visual scores, you will have to describe what a score of 1 and what a score of 5 means. [↑](#footnote-ref-18)
19. Read the NARI research management manual for further detail relating to proposals, funding, budgets and other required procedures. It is posted to the [www.CDWI.net/library](http://www.CDWI.net/library) - search Russ Stephenson. [↑](#footnote-ref-19)
20. Each time you use a statement like this- think again. Can it be made more specific? Wouldn’t ‘Effects of from 0 to 5t/ha dry chicken manure on yield of sweet potato’ be better? [↑](#footnote-ref-20)
21. This design is used where experimental conditions are very uniform and there is no need to block.is not expected [↑](#footnote-ref-21)
22. This design is more commonly used because the experimenter considers there may be some gradient in the trial- whether it is a temperature or light gradient in a glasshouse or a moisture or fertility gradient in the field. Most field experiments are of this kind. [↑](#footnote-ref-22)
23. Factors are treatments like nitrogen and yam cultivar in an experiment. [↑](#footnote-ref-23)
24. How would you present that in a publication? Try 12.3 +/- 0.56. Note that 12.3 is three significant digits. [↑](#footnote-ref-24)
25. 15 tonne per ha is 1.5 kg / m2. [↑](#footnote-ref-25)
26. |  |  |  |
    | --- | --- | --- |
    | A | 0.1 kg or 100g | The level of accuracy here is as close as you can get. Perhaps C should be 1.73 but in reality with wind, perhaps even the movement of an animal… 1.7 is as good as you can get.  The important issue is that you agree with the values given for A-C. |
    | B | 1.05 kg or 1050 g |
    | C | 1.7 kg or 1700 g |

    [↑](#footnote-ref-26)
27. <http://gardening.wsu.edu/library/vege004/vege004.htm> [↑](#footnote-ref-27)
28. All crops are precious! Take care. [↑](#footnote-ref-28)
29. Blocks are contiguous when all plots of one block are together- perhaps in a row or square or rectangle shape. This is always best. In this experiment blocks were not contiguous because of the uneven nature of the crop and researchers were aiming to have plots within each block as uniform as possible. In the design overleaf blocks are shown as shaded- remember we need to harvest block by block, which can become confusing. Hence the need for a very clear plan. If you use colour to differentiate items, beware- some people are colour blind. [↑](#footnote-ref-29)
30. This code appears on all documents and data relating to this experiment- esp. Spreadsheet and biometrical files, and reports relating to this experiment. [↑](#footnote-ref-30)
31. Remember that all harvesting/measuring should be done block by block, so in this trial plot order is not always followed- refer especially to block D- plots 7,8,9,10 and 20. [↑](#footnote-ref-31)
32. This trial was assessed by recording 10 plants separately for each plot. So for the 16 plots of the experiment, there were 16 recording sheets used. This large amount of data results from the entomologist requiring detail about the age and species of insect present on the cabbages. [↑](#footnote-ref-32)
33. x m above ground for Diameter at Breast Height. [↑](#footnote-ref-33)
34. 1=very poor trees, 5 = excellent, straight trunks. [↑](#footnote-ref-34)
35. This is a crucial piece of information- needed because lots of data is recorded on many trees- all from just one plot. ie one plot gets one page. [↑](#footnote-ref-35)
36. Refer also to <http://www.scribd.com/doc/14806095/Developing-Research-Skills> [↑](#footnote-ref-36)
37. At the time of writing the system did not have a published URL – (web address) as it is due to go live in June 2011- look for it by googling Melanesian Agricultural Information system. It will be well worth the wait. [↑](#footnote-ref-37)
38. Biometrician- a person competent in the design and analysis of field research. Their input is crucial. [↑](#footnote-ref-38)