This Test As You Grow manual is designed to make crop tests as simple and practical as possible. The "Test As You Grow" concept enables you to set up crop tests as you carry out your normal cropping operations, with a minimum of disruption to the cropping program.

# ACKNOWLEDGMENTS

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Thanks to RGV Bramley, SE Cook, ML Adams and RJ Corner of CSIRO for their permission to reproduce three figures from their manual, On-Farm Experimentation using Precision Agriculture Technologies.

Part of the source material for this manual was generated from a Farmnote by Dr John Hamblin, now of Export Grains Centre, previously Director of CLIMA.

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# Test As You Grow

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# Test As You Grow

## Introduction

In the 1960's we had only three crop types, a limited number of varieties (and grain segregations) and little flexibility in cropping systems or inputs. We now have more than double the number of crop types, a wide range of varieties (and grain segregations for marketing), rotations, many new cropping practices (direct drill, no-till, furrow sowing etc.) and tremendous diversity and flexibility of crop protection systems.

The TopCrop Test As You Grow manual will help you design and carry out your own on-farm tests and trials. Make use of specialist input from the industry in designing, conducting and interpreting the results of 'on-farm testing' trials on your paddocks.

Research programs and the trials in each locality have not increased 100 fold to match the need created by the increase in the number of new crops, varieties, new crop protection systems and new crop establishment systems. There is a requirement for on-farm testing to complement the small plot trials. Farm businesses have a R& D component, part of which is paddock testing. By accessing specialist input from the industry you can have On Farm Testing on your paddock.

## Types of On Farm Testing

1 Paddock Comparisons - easily carried out using the 5 Key TopCrop Checks. Needs much care in interpretation. Use paddocks with same rotations and soil type.

2 Within Paddock Comparisons
   - a Split Paddock and use plus/minus treatments.
   - b Broadscale Trials - Innovative ways to replicate tests (increased confidence in results)
   - c Analytical Trials with range of treatments- require specialist input and often involve interactions.

Although we have used varieties as examples in our trial designs, any kind of treatment or variable can be tested using these designs. We have not included designs for two or three factor experiments (for example, seed rate x fertiliser rate) in this manual as they are too complicated and require specialist input.

# Chapter One - The Basis of On Farm Testing

**The basis of On Farm Testing is;**

- Growers make decisions by sorting all available information from a range of sources.
- Growers need to test out any new crop, variety or practice on their own farms before adopting them.
- Broadscale testing can add value to Research and Development results from intensive, small plot research.
- Growers and industry require measures on the level of confidence they can put on different crop test results for particular decisions.

For example;
(SP) Small plot trial results with a probability of greater than 95% of being real differences and not just chance (on grain yield).
(BT) Broadscale test results with a probability of 80% of being real differences and not just chance (on grain yield).

Both sources of information contribute in a complementary way to growers making better decisions. The small plot (SP) results give us a good idea of which varieties have genetic advantage (at that test site) and combined with other data sets from a program of Crop Variety Tests, over several seasons, can provide recommendations for a Region/Zone.

Specific adoption for a given paddock can be determined using the CVT results and the BT results from that paddock or equivalent.

# Chapter Two - Statistical Principles

**Statistical Principles**

It is very important to make sure the effect of the treatments that you observe are really due to the treatment and not due to any other factor such as differences due to soil fertility, weed competition or any other environmental factor. Otherwise, you will be making wrong decisions based on wrong assumptions.

For example, a farmer - Joe Smith, wants to test the performance of a new variety (B) of wheat against his favourite variety (A). Joe plants them side by side on two blocks of land, each a hectare in size. Variety A yields 2.3 t/ha and variety B yields 2.5 t/ha. Is it correct for this farmer to assume that variety B is superior to variety A? Such a deduction assumes that the higher yield in variety B is solely due to varietal differences and nothing else. However, the higher yield in variety B may have been due to many other factors such as soil properties, less weed competition, position in the landscape etc. If Joe planted the same variety A in both blocks of land, he may have got the same yield difference!

If a farmer divides part of a paddock into 10 or 20 small plots and treat all the plots the same with the same inputs and harvest and weighs all the plots separately, they will still see a plot to plot variation in yield. This variation is called experimental error (farmers who have been yield mapping know how variable the yields are within a paddock). When carrying out on-farm tests it is very important to keep this experimental error to a minimum. How this is done will be discussed later.

Since there are many sources of variability affecting yields of experimental plots, it is very important to devise procedures that can separate all other sources of variability from the factor being tested, which in this example is varietal difference. Therefore, varieties A and B can be judged different in their yield only if the measured yield difference between plots planted to two different varieties is larger than the yield difference between plots planted with the same variety. Hence, when designing on-farm tests it is important to find the yield difference between plots given the same treatment and the yield difference between plots given different treatments. Therefore, you need to replicate the treatments.

As experimental error is important in deciding whether an observed difference between treatments is real or just due to chance, the experiment should be designed to give a measure of experimental error. This is done by **replication,** or having each treatment repeated several times.

Supposing the farmer replicates each variety 4 times and lays out the trial as shown below, if the fertility gradient is from left to right, the variety B which is always located to the right of variety A, will always be in a less fertile plot than variety A. This causes a bias as variety A is always favoured (Figure 1). This bias is overcome by **randomisation,** whereby treatments are assigned to plots randomly by the use of random numbers or the lottery method. The treatments can be either drawn out of a hat or by drawing from a pack of cards, where treatments are assigned to different cards. Randomisation ensures freedom from bias and also reduces experimental error (Figure2).

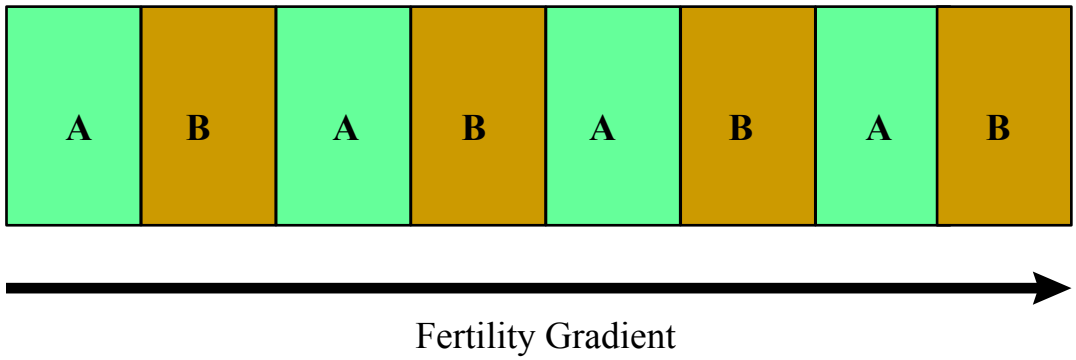


**Figure 1: Hypothetical example of a wrong experimental lay out.**

Another statistical principle is the **control of error**. This can be achieved by **blocking**. Blocking overcomes errors caused by fertility gradients or differences in fertility within paddocks. This is done by dividing the experimental area into blocks with uniform fertility or environmental conditions within each block, and subdividing the block into a number of plots equivalent to the number of treatments in the trial . For example, if you are testing 5 treatments including a control there should be 5 plots in a block (Figures 10, 11 and 12). This is done to control and minimise the experimental error by keeping fertility within blocks uniform so that all treatments to be tested have similar conditions, but there can be differences in fertility among blocks (replicates).

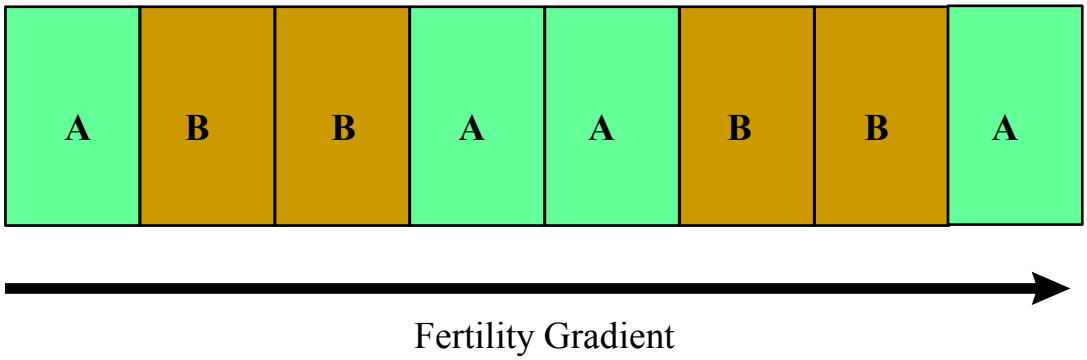


**Figure 2: An example of a correct experimental layout with two treatments.**

# Chapter Three - Conducting an Experiment

**Planning an Experiment - What To Do**

The first step is to think "What is the question that I want to answer?" "What do I want to test?". Then design a trial to answer that question. Let us take the case of comparing varieties. There are many innovative ways of doing this without interrupting cropping programs (contact TopCrop).

First, decide what varieties you want to compare. Limit your choice to six or fewer. You must include a control variety, normally your current favourite.

Next, decide which paddock to use, how much fertiliser you are going to apply, what your herbicide treatments are and so on. Make sure that all varieties get exactly the same treatments.

When you carry out the trial make sure that the varieties are planted in long but thin adjacent strips, so that all varieties cover the range of minor differences within the one soil type or slope (see figures). If there is major variation in the paddock, such as where there is more than one soil type, it is better to do two trials.

Plant across the known minor variation, for example all varieties are planted up and down a slope, not one above each other across the slope. If water erosion might be a problem, pick a uniform site which is protected by a contour or grade bank.

When you plant the paddock, make sure that you plant all the varieties on the same day. Mark the plot ends with posts and leave a gap between plots, eg., half a metre, so you know where one plot ends and the next one starts.

Use the TopCrop On-Farm Testing recording cards to record where each variety is and what other treatments you have applied (such as fertiliser rate), and details of the test strips. If you cannot monitor or record details of the test strips, the whole exercise will be a waste of time.

Make sure the plots are wider than your header so that you can harvest them easily. They must be big enough to give measurable yield differences (while still on a uniform site). Ideally, book the use of a weigh trailer or have a yield measuring device on your header.

**Achieving the Most From Your Trials**

**Three points need to be kept in mind to get the best out of your trials:**

- What sort of treatment you wish to investigate and its possible effects. For example, whether you are testing herbicides, new varieties or fertilisers.
- Pick your test site carefully so it is as uniform as possible and representative.
- Eliminate all other factors which might cause false differences between the treatments.

## Treatment Effect

Treatment effects fall into two broad cases. In one case there are clear cut differences, for example, did a herbicide kill the weeds? All that is needed to test the chemical is to spray it on and leave control strips without spray.

The other case is when something responds to varying degrees to a treatment or a factor, rather than in a yes/no fashion. The most obvious example that affects you is yield.

Measuring the effect of a treatment on yield is tricky and care is needed to get a meaningful assessment. Examples of this type of question are: 'Is variety A higher yielding than variety B?', or 'What is the best rate of nitrogen to apply?' This type of character is so difficult to assess because it is very much affected by both soil type and season. This is the very reason for regular on-farm testing.

## Selecting the Test Site

Your test site must be as uniform as possible. Variability in biological systems may be due to many things apart from the factor under test. These include soil type changes and differences in: planting date, fertiliser types and rates, varieties, depths of seeding, cultivation treatments, rotations, weed challenges, soil compaction, seeding rates, times of harvest and so on. Also, variations in slope and aspect (which way the slope faces) of the trial site are important. In fact almost everything you think of can affect the yield of a particular area of your farm compared with another area.

On top of all the problems listed previously, the effect of different treatments will change with the particular season. For example, the response that you get to applied nitrogen will depend in part on the rainfall. Or the yield of varieties may only differ if disease is present. Despite all this it is not too difficult to 'get it right'.

## Make It A True Test

You have to ensure that the results you get accurately reflect the treatments you applied, rather than some other source of variation. To get valid comparisons between your treatments it is important to:

- Use the same soil type in the same paddock (and avoid corners or double workings);
- Use the same varieties (unless you are comparing varieties);
- Use the same fertiliser at the same rate (unless you are comparing fertilisers or rates);
- Use the same herbicides (unless you are comparing herbicides);
- Plant at the same time (unless you are investigating the effect of planting date) and
- Use the same tillage (unless you are testing different tillage treatments).

## Harvesting

When harvesting make sure to leave a border of at least 0.5m on all four sides of the plot and harvest only the middle of each plot. This is not difficult if the plots are at least 1m wider than the width of the header. This eliminates the border effect.

Each plot should be harvested and weighed separately, and the weight recorded. Harvesting should be done in the same direction for all the plots rather than up and down harvesting. A representative sample should be taken from each plot for testing for protein, screenings, hectolitre weight etc.

If the same variety is planted in three replicates, do not harvest and weigh them together. It is very important to harvest and weigh each plot separately for statistical analysis.

*(Some paragraphs in this section of the manual have been extracted from Agriculture Western Australia's Farmnote No. 24/86 - So you want to do a farm trial, by John Hamblin.)*

**Figure 3: A grain weigh trailer used by the Corrigin Farm Improvement Group**

# Chapter Four - Levels of Testing

**Levels of Testing**

On-farm testing can be carried out at different levels of sophistication from paddock comparisons to replicated small plot trials. The level of confidence you can place on the outcome of the trial varies depending on the test level. For example, in replicated small plot trials the probability that the results are true and not due to chance can be more than 95%. In paddock comparisons, the probability that the results are true can be as low as 50 – 65%.

In decision making, the level of confidence you can place on the results of the trial varies with the level of testing. Examples of different levels of testing are given in the following pages.

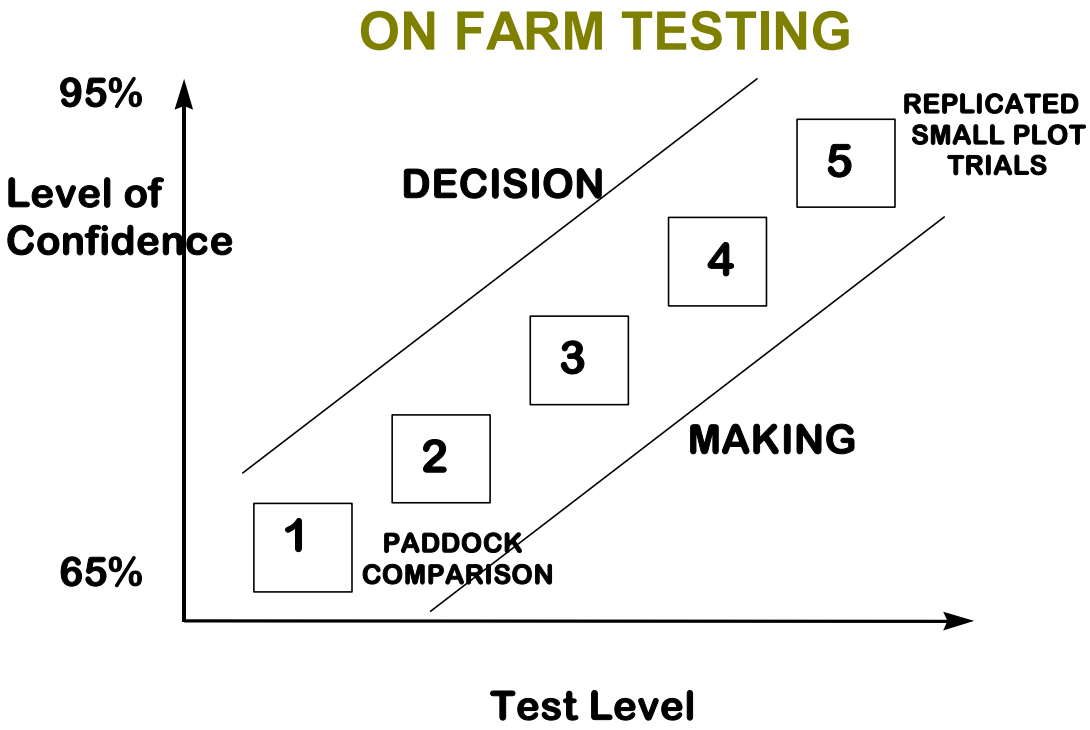


**Figure 4: Level of Confidence in Different Levels of Testing.**

# Level One Paddock Comparisons

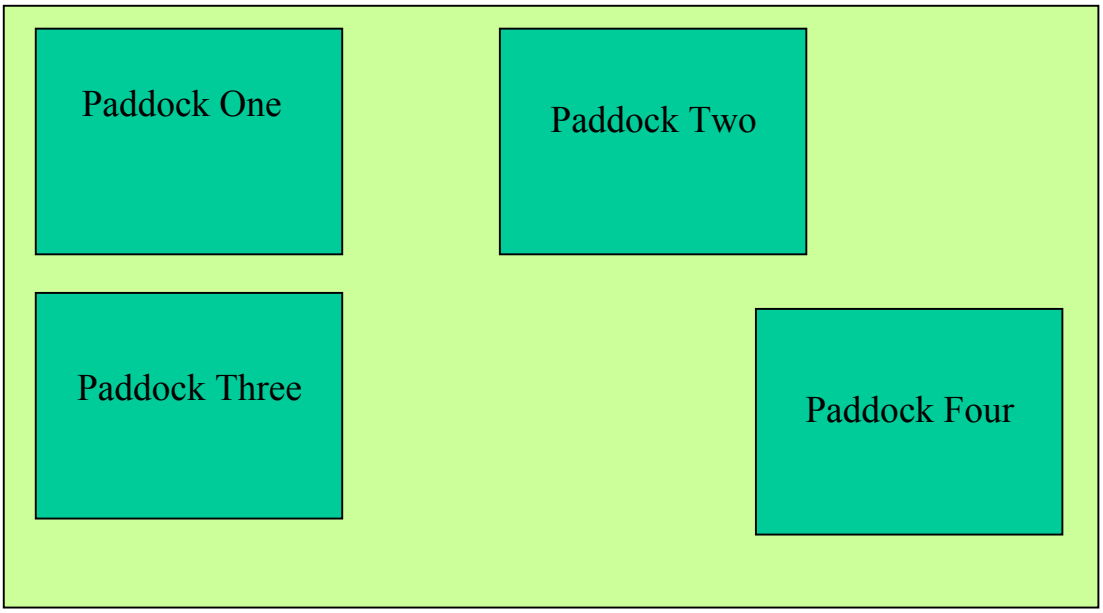


**Figure 5: Level One Between Paddock Comparisons**

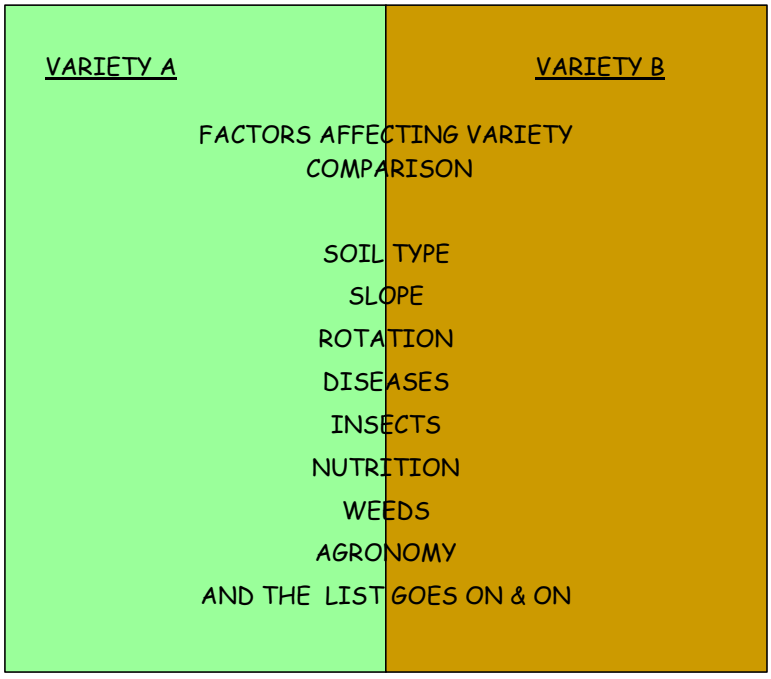


**Figure 6: Level One – Within Paddock Comparisons**

# Level Two Within Paddock Comparisons

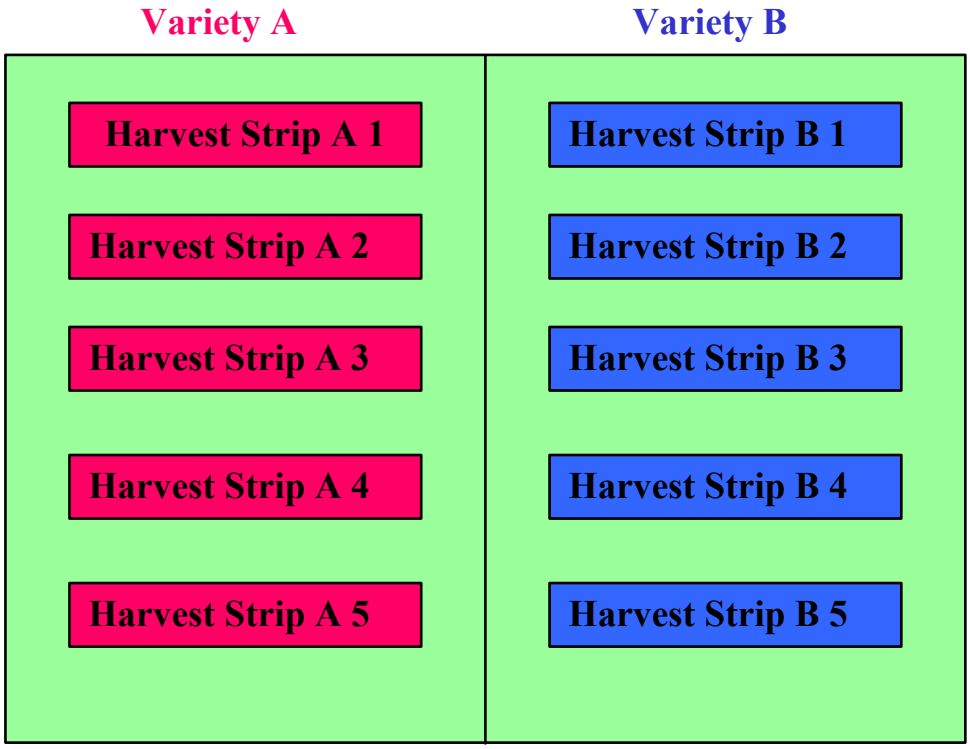


**Figure 7: Level Two - Comparing Two Treatments and Harvesting Paired Strips or Plots Separately**

Divide the paddock into two across soil type differences so that both sides have the same fertility levels and apply your two treatments. Treatments can be two varieties (as illustrated), two pesticides, plus or minus gypsum or lime, two fertilisers or even two production packages.

At harvest mark out paired strips of equal area (for example 0.25 or 0.5ha), and harvest and weigh the strips separately. The problems as shown in Figure 6 are still likely to impose a lower degree of certainty in the results obtained between varieties. However, if this test was repeated on a number of farms under as similar conditions (rotation, soil type) as possible then our certainty would increase about the treatments.

# Level Three Within Paddock Comparisons

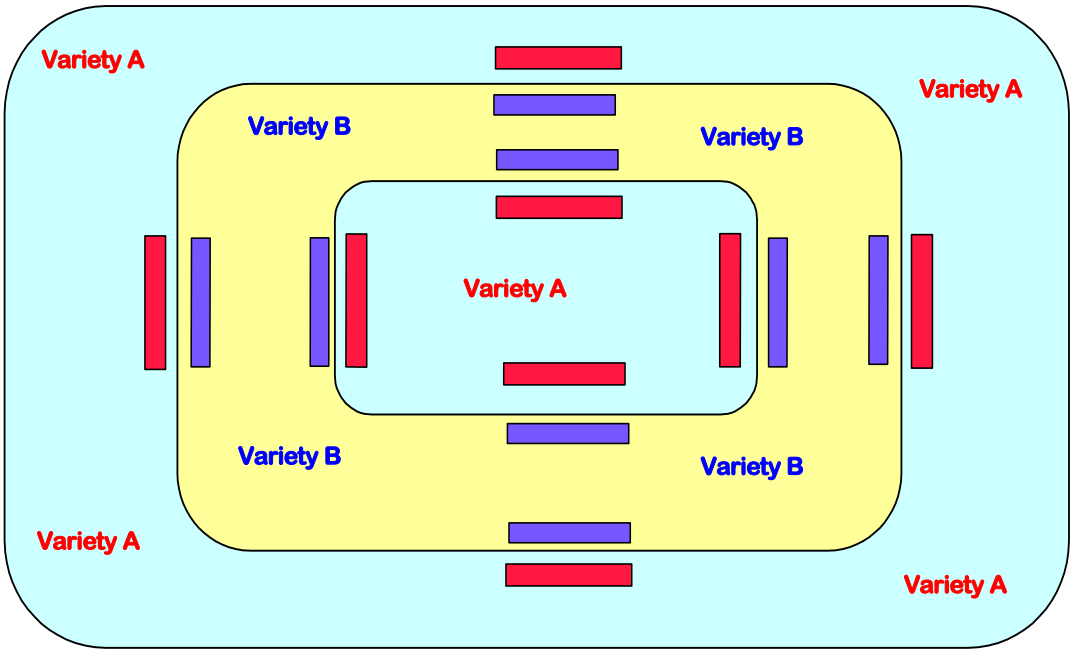


**Figure 8: Level Three Variety Comparison - Standard Sowing**

The paddock is seeded in three sections. The layout of the harvest plan (the plots) can be done in a less busy time, ie, during the growing season. Colored strips should be harvested separately.

# Level Three Within Paddock Comparisons

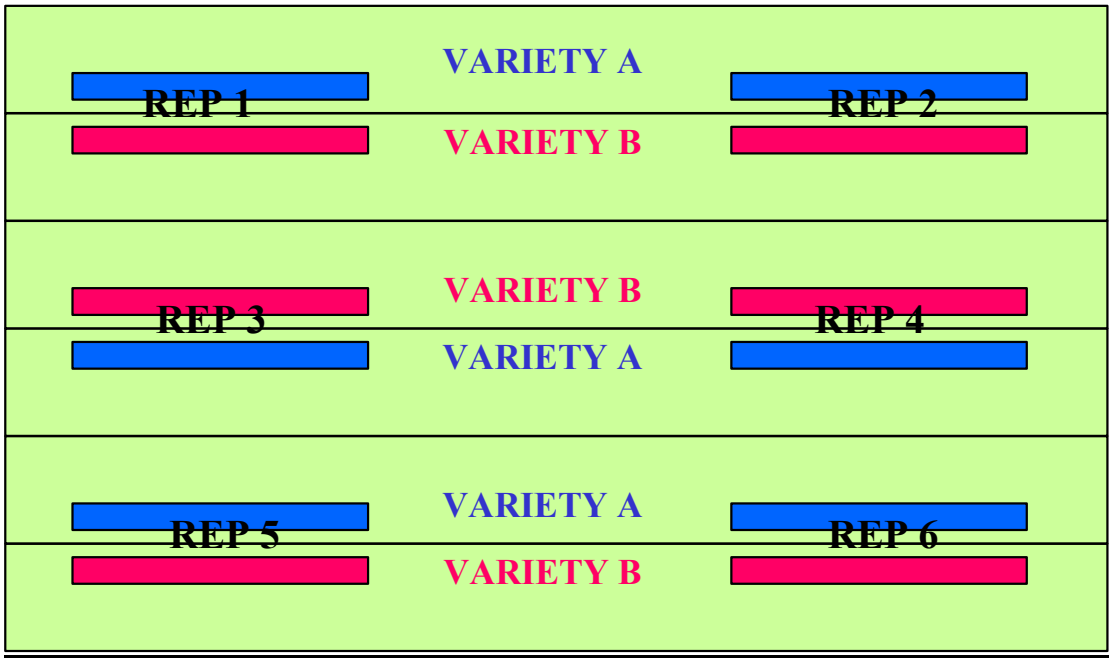


**Figure 9: Level Three Variety Comparison - Line Sowing**

# Level Four

**Minimum Requirements**

There are a number of minimum requirements for a Level Four broadscale farm test. Requirements will change depending on the factor tested. Some standard requirements are;

- The use of a standard variety, preferably every third plot
- Two replicates
- A uniform site
- Accurate recording and monitoring of test and site details. There are a number of monitoring tools provided by TopCrop, included in the Test As You Grow Kit.

# Test As You Grow

## "Level 4" Test ****

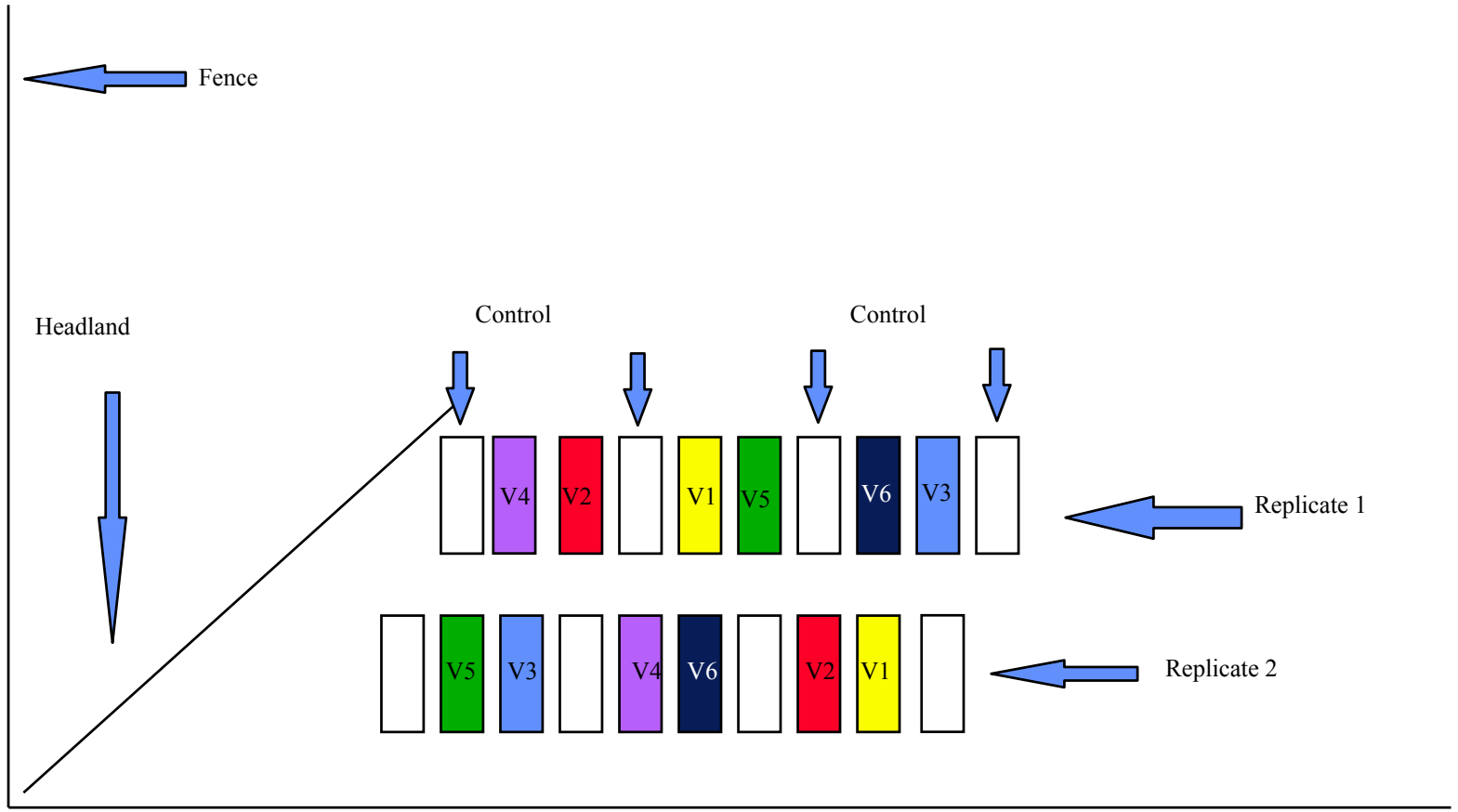


**Figure 10 - Level Four Layout Example**

# On Farm Testing

## “Level 4” ****

Layout Example

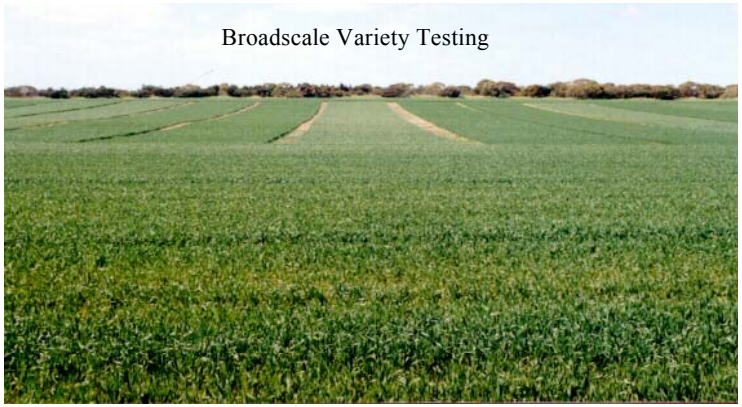





**Figure 11: Level Four Layout Example**

# On-Farm Testing

## "Level 5" *****

Layout example

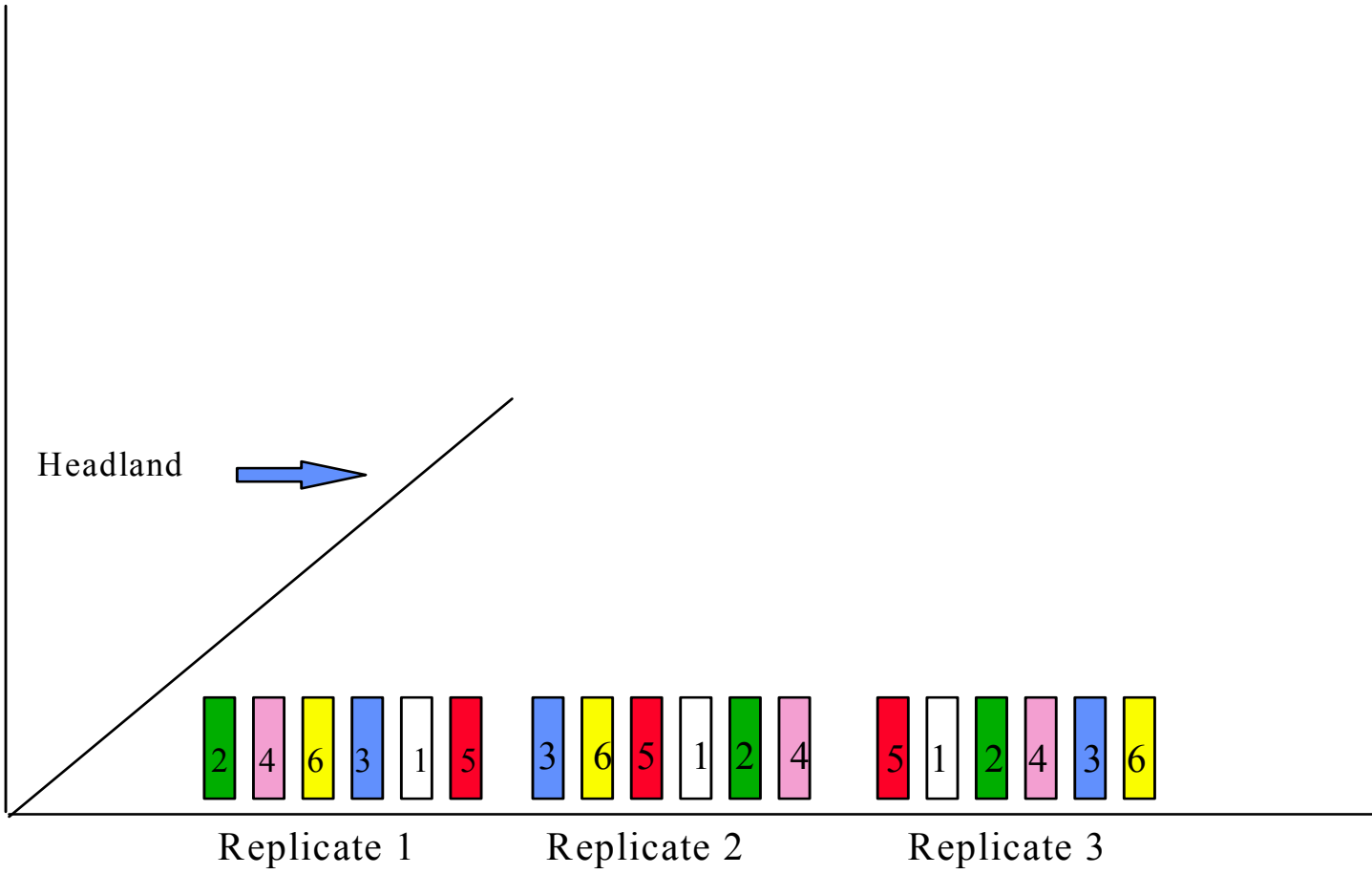


**Figure 12: Level Five Layout Example**

# Chapter Five - Precision Agriculture Technology

**On-farm Experimentation - Using Precision Agriculture Technologies**

Growers who wish to do on-farm experiments using Precision Agriculture technologies such as yield monitors, are encouraged to obtain a copy of an excellent manual to be published by Grains Research and Development Corporation (GRDC). **"On-farm Experimentation: A Farmer Guide to the Design of Farm-Scale Experiments Using Precision Agriculture Technologies"** produced by RGV Bramley, SE Cook, ML Adams and RJ Corner, CSIRO Land and Water. This manual describes both simple and complex experimental designs which can be carried out with or without variable rate application machinery.

The use of Precision Agriculture (PA) technologies for on-farm testing offers two main benefits. First, through the use of a GPS and yield monitor, they allow experiments to be carried out more accurately than is generally possible. Second, the use of variable rate technology (VRT) in laying out the experiment enables very complex, whole paddock experiments to be established with minimum effort and with very little disruption to your normal cropping program. Note however, that the use of PA does not mean that the experiment has to be complicated - both simple and complex experiments can be carried out using PA. All the experiments discussed in the 'Test as You Grow' On-farm Testing Manual can therefore be carried out using PA.

Precision Agriculture involves the use of a GPS unit attached to your farm machinery with differential correction to pin point exactly where you are in a paddock (to within 2-3 m), a yield monitor and a moisture sensor in your harvester so that the yield is recorded and geo-referenced while harvesting to produce a yield map and the use of variable rate application machinery (VRT) for seeding, fertiliser application etc. VRT makes it possible for application rates to be changed on the go in a pre-determined pattern according to an application map. The farmers who have yield mapping capabilities but still do not have VRT, can do many of the experiments discussed in the 'Test as You Grow' On-farm Testing Manual as well as more complex strip plot designs without VRT.

This CSIRO on-farm experimentation manual describes simple experiments such as strip plot designs for up and down treatment application which are suited to test one level of 2-4 variables or 2-4 levels of one variable which can be replicated several times across the paddock. For those growers who seed round and round the paddock, donut designs (similar to our on-farm testing level 3 design for round the paddock seeding) are described. Another simple, but innovative design discussed is the split planter design (similar to the example of a correct experimental layout in Fig 2 of our on-farm testing manual, showing how to overcome the problem of a fertility gradient, in the section on statistical principles).

The more complex designs, which do not require VRT, such as two way strip plot designs where several levels of one variable are applied in one direction and several levels of the second variable are applied across the first variable at right angles are discussed by Bramley *et al*, along with very complex designs requiring VRT, such as, the chequerboard design and wave designs.

A copy of the manual by Bramley, Cook, Adams and Corner can be obtained from the Grains Research and Development Corporation.

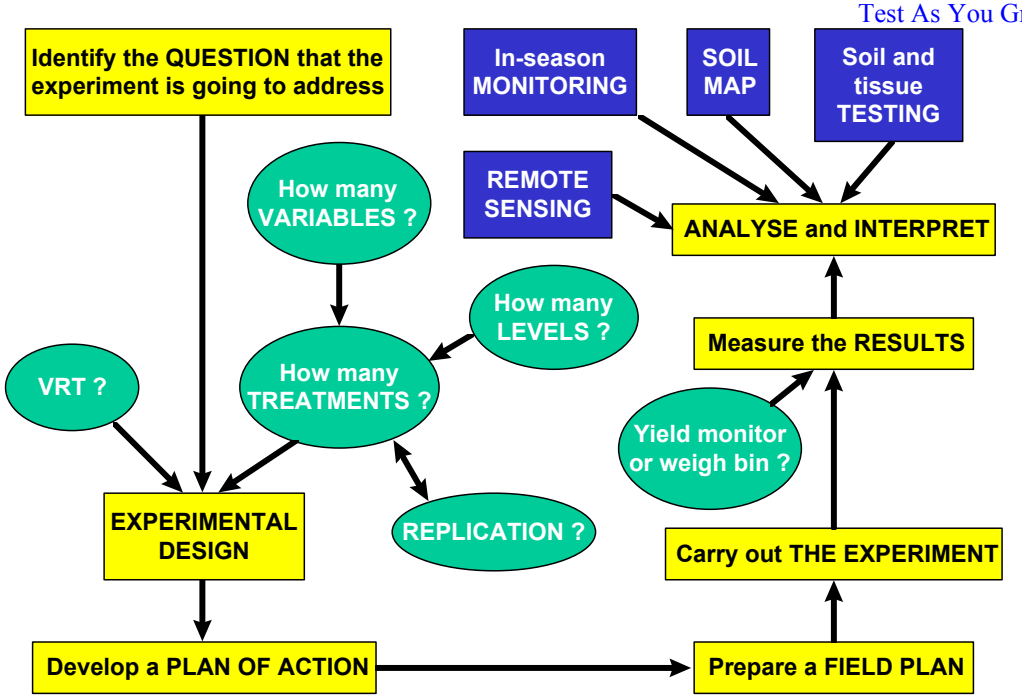


**Figure 13** Flowchart depicting the stages of conducting on-farm experiments. Essential actions are in yellow; optional extras are in blue. Note that many of the essential actions require consideration of some important questions (shown in green). Reproduced with permission from *On-farm Experimentation: A Farmer Guide to the Design of Farm-Scale Experiments Using Precision Agriculture Technologies* by RGV Bramley, SE Cook, ML Adams and RJ Corner, CSIRO Land and Water.

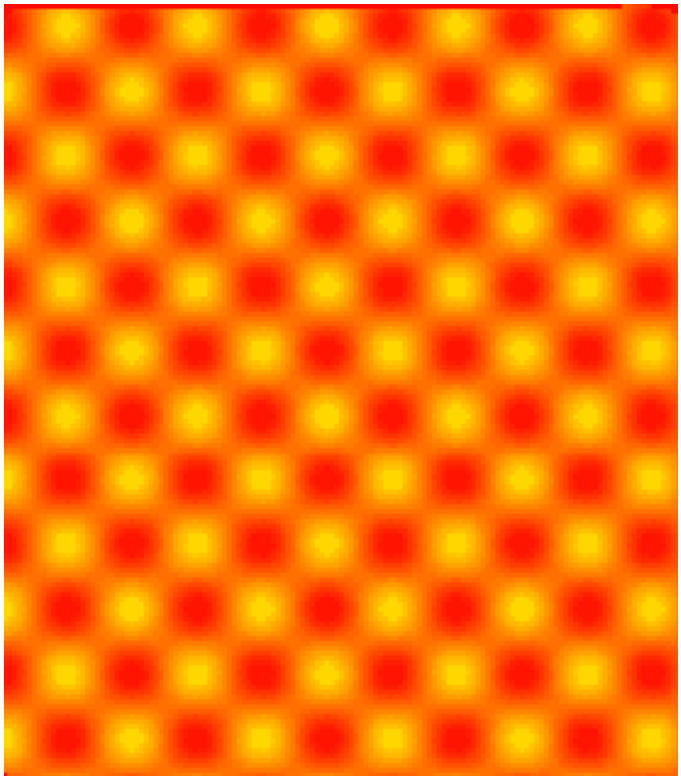

**Figure 14** Application map for a wave experiment. Reproduced with permission from *On-farm Experimentation: A Farmer Guide to the Design of Farm-Scale Experiments Using Precision Agriculture Technologies* by RGV Bramley, SE Cook, ML Adams and RJ Corner, CSIRO Land and Water.

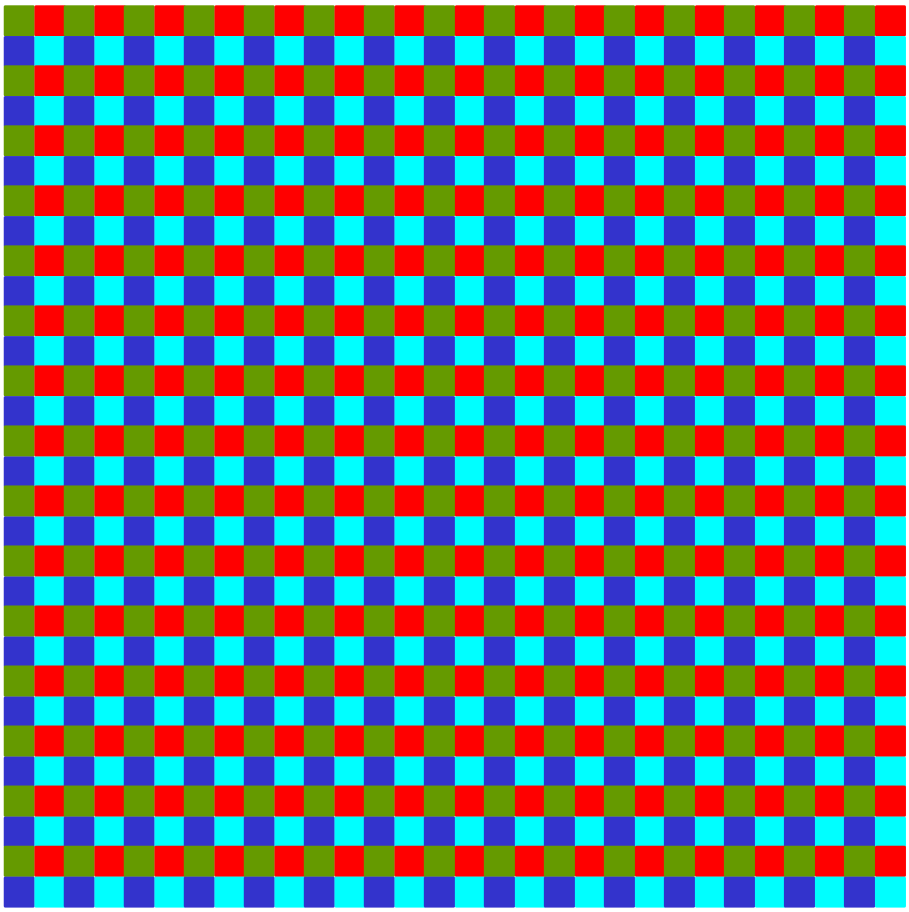

**Figure 15** A chequerboard design for an experiment with one variable, four levels and 225 replicates. Reproduced with permission from *On-farm Experimentation: A Farmer Guide to the Design of Farm-Scale Experiments Using Precision Agriculture Technologies* by RGV Bramley, SE Cook, ML Adams and RJ Corner, CSIRO Land and Water.

# Chapter Six – Obtaining Seed for Variety Comparisons

**Managing Seed Distribution**

Many on-farm tests are now done to specifically compare new varieties on offer to those already being grown. Where this is the case, seed sourcing and testing are necessary requirements to be done. Seed supplies need to be arranged well in advance to the test being done to avoid delays.

Seed sources
Simply obtaining seed from a number of places be they other farms or interstate can introduce error into the test. Ideally seed of the different varieties should come from the same location grown at the same time and treated the same way. This is difficult for an individual grower or grower group to do. Seed obtained from a location far removed from the source of other varieties may be greater or weaker in vigour, or nutrient content that may affect its performance.

Seed testing
A sample of each seed stock should be sent in for analysis well before seeding to obtain a measure of the germination percentage, seed size and where possible its vigour. This is done so that seeding rates for the varieties can be adjusted to give the same target plant number in each plot, unless the test is also to look at other agronomy packages.

Seed agreements
Due to Plant Breeders' "rights (PBR) of new varieties", contractual obligations are required for the use of new varieties for on-farm testing purposes. Where growers are exchanging seed for On Farm Testing purposes agreements are necessary between the growers involved and the seed licensee. AGWEST can assist in the supply of many named and experimental lines of seed through its CVT program. Agreements on what should happen to the grain from harvest of the Crop Test Sites may vary. Usually it is

**Option One**
- Grower group purchases seed.
- After harvest, all seed from the on-farm testing site is delivered to CBH.

**Option Two**
- Grower Group purchases seed, supplying a list of all of the involved members to the Seed Supplier
- The seed that is produced from the on-farm testing trial is equally shared amongst the involved members.

**Option Three**
- Grower Group purchases the seed.
- After harvest some of the seed is held by the group for the following years trials, all remaining seed is delivered to CBH

These are the preferred options. Keeping seed from the site as bulk up of a variety is **not recommended.** Apart from the legal requirements mentioned above, this seed cannot be kept pure enough from contamination by the other varieties in plots nearby. Contamination may

be in the form of cross-pollination between varieties of certain crops, and/or physical contamination in the harvester.

For members of grower groups, arrangements with some seed licensees can be made for the supply of seed for research purposes such as this. This may require a contract to ensure the seed is not held on farm after the test. Grower groups may like to explore their own arrangements with seed providers for similar purposes.

# Glossary of Terms

**Blocks** A part of the experiment where all of the treatments are represented in a uniform area.

**Broadscale test** Similar to an "On farm test" or farmscale test. An experiment conducted in which the farmer's own equipment is used to establish, manage and harvest the site. Ideally they should be used to just compare a few treatments only.

**Certainty** How sure or likely are you that this result can be repeated on similar paddocks and farms and seasons.

**Control** This is a standard treatment common amongst replications and / or farms. It may be the current popular variety or in the case of comparing fertilisers or herbicides be a nil (no) treatment.

**CVT** Crop Variety Test. These are intensive small plot experimental sites used to compare varieties of a similar crop species with a view to making recommendations as to the best variety a farmer should grow who is in a particular area.

**Experiment** A well designed test of different treatments.

**Plot** The area in which a treatment is placed. Preferably wide enough for harvesting to be taken out of the centre section, leaving the edges untouched.

**Randomisation** A mixing up in a random way of the treatments.

**Replication** A repeat of some or all treatments usually in a block.

**Site** The location of the on farm test. Ideally as uniform as possible.

**Small plot** Intensive research site. These usually contain a greater number of treatments than a broadscale test and are replicated a number of times.

**Treatments** One of the things that you want to test.