Field techniques manual

Department of Agriculture, Western Australia

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Field Techniques Manual
Vol. 1
Crop and Pasture Research

Western Australian Department of Agriculture
MAR 1981
INTRODUCTION

The Western Australian Department of Agriculture has responsibilities in the fields of regulation of the agricultural industries, extension of agricultural information and in agricultural research.

Research is one of the Department's most important responsibilities. It has many aspects, ranging from economic research, through the plant and animal industries to the processing and marketing of agricultural products. But all are concerned with increasing the productivity of Western Australia's agricultural industries.

The field of crop and pasture research covers the introduction and testing of new crop and pasture varieties, crop agronomy, tillage methods, crop rotations, testing pasture species under grazing, plant nutrition, weed control and plant diseases.

Technical staff play a vital role in all of these research programmes. By providing a guide to the techniques and equipment used in research we hope to improve both the training and job satisfaction of technical staff and the overall efficiency of the Department's research programmes.

The original aims set for the manual were to -

1. Provide the principles behind the techniques adopted.

2. Set down commonly used practices which experience has shown to be satisfactory.


4. Provide reference, where applicable, to sources of more detailed information.

Not all of these aims have necessarily been achieved in this edition of the crop and pasture research manual, but we hope that the manual will assist all staff concerned with field experimentation and provide a basis for improvement in the future.
### TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. THE SCHEDULE</td>
<td></td>
</tr>
<tr>
<td>A. Introduction</td>
<td>1.1</td>
</tr>
<tr>
<td>B. Making Up a Schedule</td>
<td>1.1</td>
</tr>
<tr>
<td>C. Handling Schedules</td>
<td>1.3</td>
</tr>
<tr>
<td>2. SITE SELECTION AND PREPARATION</td>
<td>2.1</td>
</tr>
<tr>
<td>A. Selecting Sites</td>
<td>2.1</td>
</tr>
<tr>
<td>B. Marking Out an Experiment</td>
<td>2.3</td>
</tr>
<tr>
<td>3. FENCING</td>
<td>3.1</td>
</tr>
<tr>
<td>A. Principles of Fence Construction</td>
<td>3.1</td>
</tr>
<tr>
<td>B. Fencing for Trial Sites</td>
<td>3.4</td>
</tr>
<tr>
<td>C. Practical Hints on Fence Erection</td>
<td>3.8</td>
</tr>
<tr>
<td>D. Electric Fencing and its Advantages</td>
<td>3.9</td>
</tr>
<tr>
<td>E. Fence Construction</td>
<td>3.10</td>
</tr>
<tr>
<td>F. Principles of Electric Fencing</td>
<td>3.11</td>
</tr>
<tr>
<td>G. Fence Design</td>
<td>3.13</td>
</tr>
<tr>
<td>H. Experimental Site Layout</td>
<td>3.14</td>
</tr>
<tr>
<td>4. SEED SUPPLIES FOR CROP AND PASTURE TRIALS</td>
<td>4.1</td>
</tr>
<tr>
<td>A. Seed Cleaning</td>
<td>4.1</td>
</tr>
<tr>
<td>B. Insect Control in Stored Grain</td>
<td>4.4</td>
</tr>
<tr>
<td>C. Seed Storage</td>
<td>4.6</td>
</tr>
<tr>
<td>D. Ordering and Despatch of Seed Supplies</td>
<td>4.8</td>
</tr>
<tr>
<td>E. Inoculation of Legume Seeds</td>
<td>4.10</td>
</tr>
<tr>
<td>5. PEDIGREE SEED PRODUCTION</td>
<td>5.1</td>
</tr>
<tr>
<td>A. Paddock Selection and Management</td>
<td>5.1</td>
</tr>
<tr>
<td>B. Cultivation</td>
<td>5.2</td>
</tr>
<tr>
<td>C. Seeding</td>
<td>5.3</td>
</tr>
<tr>
<td>D. Spraying</td>
<td>5.3</td>
</tr>
<tr>
<td>E. Roguing</td>
<td>5.3</td>
</tr>
<tr>
<td>F. Pre-harvest</td>
<td>5.3</td>
</tr>
<tr>
<td>G. Harvest</td>
<td>5.3</td>
</tr>
<tr>
<td>H. Seed Cleaning</td>
<td>5.4</td>
</tr>
<tr>
<td>I. Pickling</td>
<td>5.4</td>
</tr>
<tr>
<td>J. Sampling</td>
<td>5.4</td>
</tr>
</tbody>
</table>
### 6. PREPARING FERTILISERS FOR FIELD EXPERIMENTS  

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Introduction</td>
<td>6.1</td>
</tr>
<tr>
<td>B. Handling Bulk Fertilisers</td>
<td>6.2</td>
</tr>
<tr>
<td>C. Fertiliser Mixing</td>
<td>6.2</td>
</tr>
<tr>
<td>D. Properties of Common Fertiliser</td>
<td>6.8</td>
</tr>
<tr>
<td>E. Hand Topdressing</td>
<td>6.8</td>
</tr>
<tr>
<td>F. Time of Application</td>
<td>6.10</td>
</tr>
<tr>
<td>G. Application Problems</td>
<td>6.11</td>
</tr>
</tbody>
</table>

### 7. SEEDING EXPERIMENTAL TRIALS  

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Disc Drills and Combines</td>
<td>7.1</td>
</tr>
<tr>
<td>B. Working with Cone Seeders</td>
<td>7.4</td>
</tr>
</tbody>
</table>

### 8. PRINCIPLES OF WEED CONTROL  

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Introduction</td>
<td>8.1</td>
</tr>
<tr>
<td>B. Formulations</td>
<td>8.1</td>
</tr>
<tr>
<td>C. Mode of Entry</td>
<td>8.2</td>
</tr>
<tr>
<td>D. Classification and Activity of Herbicides</td>
<td>8.4</td>
</tr>
<tr>
<td>E. Mode of Action</td>
<td>8.7</td>
</tr>
<tr>
<td>F. Reasons for Selectivity</td>
<td>8.7</td>
</tr>
<tr>
<td>G. Fate of Herbicides</td>
<td>8.9</td>
</tr>
<tr>
<td>H. Residual Action and Breakdown</td>
<td>8.10</td>
</tr>
<tr>
<td>I. Persistence of Herbicides</td>
<td>8.11</td>
</tr>
<tr>
<td>J. Toxicity of Herbicides</td>
<td>8.11</td>
</tr>
<tr>
<td>K. Handling Experimental Chemicals</td>
<td>8.13</td>
</tr>
<tr>
<td>L. Hazards to Non-target Plants</td>
<td>8.14</td>
</tr>
</tbody>
</table>

### 9. CALIBRATION AND USE OF SPRAYING EQUIPMENT  

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Experimental Mini Boom</td>
<td>9.1</td>
</tr>
<tr>
<td>B. Other Boom Equipment</td>
<td>9.5</td>
</tr>
<tr>
<td>C. Terra Nozzle</td>
<td>9.6</td>
</tr>
<tr>
<td>D. Hand Lead Spraying</td>
<td>9.6</td>
</tr>
<tr>
<td>E. Misters</td>
<td>9.7</td>
</tr>
<tr>
<td>F. Practical Points in Spraying</td>
<td>9.7</td>
</tr>
<tr>
<td>G. Check List for Spraying a Trial</td>
<td>9.9</td>
</tr>
<tr>
<td>H. Essential Equipment</td>
<td>9.10</td>
</tr>
<tr>
<td>I. Metric Conversions</td>
<td>9.10</td>
</tr>
</tbody>
</table>

### 10. APPLICATION OF INSECTICIDES  

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Ground Application</td>
<td>10.1</td>
</tr>
<tr>
<td>B. Aerial Application</td>
<td>10.1</td>
</tr>
</tbody>
</table>

### 11. OBSERVATION, VISUAL ASSESSMENT AND NOTE-TAKING  

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Introduction</td>
<td>11.1</td>
</tr>
<tr>
<td>B. What to Record</td>
<td>11.1</td>
</tr>
<tr>
<td>C. Rating Plots</td>
<td>11.4</td>
</tr>
<tr>
<td>D. Taking Notes</td>
<td>11.4</td>
</tr>
<tr>
<td>Topic</td>
<td>Page</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>12. SOIL SAMPLING</td>
<td>12.1</td>
</tr>
<tr>
<td>A. Introduction</td>
<td>12.1</td>
</tr>
<tr>
<td>B. Sampling Method</td>
<td>12.1</td>
</tr>
<tr>
<td>C. Sample Handling</td>
<td>12.2</td>
</tr>
<tr>
<td>D. Sampling Equipment</td>
<td>12.4</td>
</tr>
<tr>
<td>E. Further Reading</td>
<td>12.4</td>
</tr>
<tr>
<td>13. PASTURE HERBAGE SAMPLING</td>
<td>13.1</td>
</tr>
<tr>
<td>A. Introduction</td>
<td>13.1</td>
</tr>
<tr>
<td>B. Herbage Yield</td>
<td>13.1</td>
</tr>
<tr>
<td>C. Botanical Composition</td>
<td>13.5</td>
</tr>
<tr>
<td>D. Chemical Composition and Quality</td>
<td>13.6</td>
</tr>
<tr>
<td>E. Sampling Consideration</td>
<td>13.7</td>
</tr>
<tr>
<td>F. General Procedures</td>
<td>13.8</td>
</tr>
<tr>
<td>14. PASTURE SEED SAMPLING</td>
<td>14.1</td>
</tr>
<tr>
<td>A. Introduction</td>
<td>14.1</td>
</tr>
<tr>
<td>B. Collection of Samples in the Field</td>
<td>14.1</td>
</tr>
<tr>
<td>C. Treatment of Samples in the Laboratory</td>
<td>14.2</td>
</tr>
<tr>
<td>15. HARVESTING</td>
<td>15.1</td>
</tr>
<tr>
<td>A. Commercial Equipment - Introduction</td>
<td>15.1</td>
</tr>
<tr>
<td>B. Harvesting Procedures</td>
<td>15.1</td>
</tr>
<tr>
<td>C. Working with Experimental Harvesters</td>
<td>15.3</td>
</tr>
<tr>
<td>16. USE OF COMPUTERS IN FIELD EXPERIMENTS</td>
<td>16.1</td>
</tr>
<tr>
<td>17. WORK SAFETY</td>
<td>17.1</td>
</tr>
<tr>
<td>A. Department of Agriculture Work Safety Policy</td>
<td>17.1</td>
</tr>
<tr>
<td>B. Safety with Machinery</td>
<td>17.2</td>
</tr>
<tr>
<td>C. Safety with Agricultural Chemicals</td>
<td>17.5</td>
</tr>
</tbody>
</table>
1. THE SCHEDULE

A. INTRODUCTION

B. MAKING UP A SCHEDULE

1. Experiment number and file number
2. Experiment title
3. Officers
4. Locality/property
5. Object
6. Soils, vegetation and previous history
7. Treatments
8. Responsibilities
9. Supplies
10. Experimental detail
11. The plan

C. HANDLING SCHEDULES

1. Reading the schedule
2. Distribution of schedules
1. THE SCHEDULE

A. INTRODUCTION

Schedules provide the link between research officers responsible for experiments and the personnel who will have responsibility for executing the experiments in the field.

A good schedule is therefore one which states clearly the aims of the experiment, defines the responsibilities of personnel involved and gives an unambiguous description of experiment layout, the way treatments should be applied and the way in which results will be recorded.

B. MAKING UP A SCHEDULE

Figure 1.1 illustrates the features of a well designed schedule.

PROJECT SHEET

1. Experiment number and file number

Experiment numbers are allocated to every experiment, describing the year, location (District Office or Research Station) and the number of the experiment at that location. Location codes used by the Department are listed in Table 1.1 and a yearly register of all experiments is kept by the Division of Plant Research. It is the responsibility of every officer making up a schedule to ensure that an experiment number is allocated and the experiment is entered into the register.

The file number is the reference to the departmental file concerned with the experiment.

2. Experiment title

The title should be explanatory. For example, 'Nitrogen rates x Times of application on wheat' is better than 'Nitrogen on cereals'.

3. Officers

List the officers responsible for the experiment and their telephone numbers and extension numbers. Should a query arise, it is imperative that field staff know who to contact and where they are located. The name and extension number of the research officer's technician should also be included.

4. Locality/property

This may have to be filled in later when a site has been selected.

5. Object

There should be a full, but concise description of the aim of the experiment, expanding on the experimental title.

6. Soils, vegetation and previous history

If a site has not been selected, this section should be filled in by field staff when the site has been decided.
7. **Treatments**

Describe the treatments; include a reference to the experimental design being used.

**DETAIL SHEET**

The detail sheet should include the following:

8. **Responsibilities**

Show clearly who is responsible for doing what - after checking that the person concerned is able to carry out the work.

9. **Supplies**

What materials are required and where they will come from.

10. **Experimental detail**

How the experiment is to be carried out. This section may include details on land preparation, weed control, seeding, fertiliser, how and when to apply treatments, observations to be made, sampling, harvest details, etc.

Use the margin of the sheet to record details of the treatments as actually applied and any changes to the schedule and the randomisation of the plots.

11. **The plan**

A straight-forward experiment may only require a listing **IN PLOT ORDER** of plot number, treatment number and the treatment to be applied. More complex experiments involving several factors should generally have a detailed plan drawn up showing the plot dimensions, main plot and sub-plot treatments, etc. How detailed the plan should be will depend upon how much work will be done on the trial and how many staff will need to locate the treatments correctly.

In order to standardise the design of experiments it is recommended that -

* The first plot always occurs on the bottom left hand corner of the page.

* Plots be numbered using the plant breeder system which includes the replicate number in the plot number. Thus, in a trial with 3 replications and 12 treatments, the plots in the first replicate would be numbered 1001 to 1012, the second replicate 2001 to 2012 and the third replicate 3001 to 3012.

* List the treatment number, and add a shorthand identification for the treatment.

* Buffer plots should be clearly indicated.
C. HANDLING SCHEDULES

1. Read the schedule - but use your initiative

All too frequently experiments are lost because someone did not read the schedule. Either treatments are missed, applied to the wrong plots or put on too late. Read the schedule and plan ahead.

At the same time, a schedule should not be followed blindly if it becomes clear that to do so will negate the aims of the experiment. For example, if there is a suspicion that a site is deficient in a trace element, then topdressing the site with plain superphosphate as specified in the schedule will be a waste of time. Check back if possible with the officer concerned and if this is not possible, consider the aims of the experiment and decide on the most appropriate course of action.

2. Distribution of schedules

Research Station Trials

For each trial conducted on a Research Station, four white, one pink and three green copies of the schedule should be prepared. These are distributed as follows:

4 White - 2 for the Research Station (one field and 1 office copy)
           1 for Division of Plant Production records
           1 for Information Branch

1 Pink - sent to the Research Station and passed on to the local District Office.

3 Green - 1 for the Research Station to be returned to the Research Officer with details of treatments, etc. written in
           2 for the personal use of the Research Officer and Technician.

The original copy should be placed on the relevant Head Office file.

District Office Trials

District Office based trials require five white and three green copies.

5 White - 2 for the District Office (field and file copies)
           1 for the farmer
           1 for Regional Services Division records
           1 for Information Branch

3 Green - 1 for the District Office to be returned to the Research Officer when all treatments are completed
           2 for the personal use of the Research Officer and Technician

The original copy should again be placed on the file.

It is most important that the green copy of the schedule intended for return to the research officer have all details of actual treatments (dates, rates of seed and fertiliser, seeding errors, etc.) recorded on it and that it be returned promptly to the officer concerned.
<table>
<thead>
<tr>
<th><strong>Research Stations</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal Breeding Research Institute</td>
<td>ABI</td>
</tr>
<tr>
<td>Avondale</td>
<td>A</td>
</tr>
<tr>
<td>Badgingarra</td>
<td>BA</td>
</tr>
<tr>
<td>Bramley</td>
<td>B</td>
</tr>
<tr>
<td>Chapman</td>
<td>C</td>
</tr>
<tr>
<td>Denmark</td>
<td>D</td>
</tr>
<tr>
<td>Esperance Downs</td>
<td>E</td>
</tr>
<tr>
<td>Gascoyne</td>
<td>G</td>
</tr>
<tr>
<td>Kimberley</td>
<td>KI</td>
</tr>
<tr>
<td>Medina Vegetable</td>
<td>MD</td>
</tr>
<tr>
<td>Medina Pig</td>
<td>MDP</td>
</tr>
<tr>
<td>Merredin</td>
<td>M</td>
</tr>
<tr>
<td>Mt. Barker</td>
<td>MT</td>
</tr>
<tr>
<td>Manjimup</td>
<td>MN</td>
</tr>
<tr>
<td>Newdegate</td>
<td>N</td>
</tr>
<tr>
<td>Northam</td>
<td>NR</td>
</tr>
<tr>
<td>Ord Regeneration</td>
<td>ORS</td>
</tr>
<tr>
<td>Poultry</td>
<td>PL</td>
</tr>
<tr>
<td>Poultry Broilers</td>
<td>PB</td>
</tr>
<tr>
<td>Salmon Gums</td>
<td>SG</td>
</tr>
<tr>
<td>Stoneville</td>
<td>S</td>
</tr>
<tr>
<td>Swan</td>
<td>SR</td>
</tr>
<tr>
<td>Wongan hills</td>
<td>WH</td>
</tr>
<tr>
<td>Wokalup</td>
<td>W</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>District Offices</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Albany</td>
<td>AL</td>
</tr>
<tr>
<td>Bridgetown</td>
<td>BR</td>
</tr>
<tr>
<td>Bunbury</td>
<td>BY</td>
</tr>
<tr>
<td>Busselton</td>
<td>BU</td>
</tr>
<tr>
<td>Carnarvon</td>
<td>CA</td>
</tr>
<tr>
<td>Location</td>
<td>Code</td>
</tr>
<tr>
<td>-------------------</td>
<td>------</td>
</tr>
<tr>
<td>Esperance</td>
<td>ES</td>
</tr>
<tr>
<td>Geraldton</td>
<td>GE</td>
</tr>
<tr>
<td>Harvey</td>
<td>HA</td>
</tr>
<tr>
<td>Jerramungup</td>
<td>JR</td>
</tr>
<tr>
<td>Katanning</td>
<td>KA</td>
</tr>
<tr>
<td>Kelmscott</td>
<td>KE</td>
</tr>
<tr>
<td>Kununurra</td>
<td>KU</td>
</tr>
<tr>
<td>Lake Grace</td>
<td>LG</td>
</tr>
<tr>
<td>Merredin</td>
<td>ME</td>
</tr>
<tr>
<td>Midland</td>
<td>SW</td>
</tr>
<tr>
<td>Moora</td>
<td>MO</td>
</tr>
<tr>
<td>Manjimup</td>
<td>MA</td>
</tr>
<tr>
<td>Narrogin</td>
<td>NO</td>
</tr>
<tr>
<td>Three Springs</td>
<td>TS</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
</tr>
<tr>
<td>Glasshouse (SP)</td>
<td>GL</td>
</tr>
<tr>
<td>Perth Plots</td>
<td>PB</td>
</tr>
</tbody>
</table>
EXPT. TITLE: RATES OF CYCOCEL GROWTH REGULANT X RATES OF NITROGEN ON WHEAT

OFFICERS: M. Perry (H.O. 367 0111, ext. 289)
           J. Allen (Moora D.O. 095 411 302)

Locality/Property: Wongan Hills Research Station
Postal Address: Wongan Hills

OBJECT: To assess the effects of Cycocel 750A growth regulant on wheat yields at two rates of nitrogen.

Soils, Vegetation and Previous History of Site.

Soils:

- Wongan loamy sand

Vegetation and Previous History of Site:

- Treatments:

  - Design: Randomised block - 5 rates of Cycocel x 2 rates of nitrogen x 4 reps = 40 plots

  - Treatments:

    | RATE OF CYCOCEL (l/ha) |
    |-----------------------|
    | 0 0.25 0.50 1.00 1.00 + 0.25* |

    Rate of Agran 34:0 kg/ha

    | 0 100 |
    | 0 1 6 |
    | 0.25 2 7 |
    | 0.50 3 8 |
    | 1.00 4 9 |
    | 1.00 + 0.25* 5 10 |

* Split application

Measurements: Plant height, grain yield, grain protein, grains/head, grain weight

Location and Orientation of Experiment (Detail Plan Reverse Side.)
EXPT. TITLE: Rates of Cycoceal x Rates of Nitrogen on Wheat

Specification of requirements for duration of trial in regard to supplies, treatments, land preparation, seeding, fertiliser application, grazing, sampling, note-taking, etc.

Notes on actual rates, dates, types of machinery and alterations to be entered in margin.

1. RESPONSIBILITIES

Research Stn: Seeding, spraying, harvesting
P.R.D.: Height measurement, head samples (500/plot) prior to harvest

2. SUPPLIES

Seed:
- 1 x 50 kg bag Miling wheat ex PRD

Fertiliser -
- Super: Research Station to supply
- Agran 34: 1 x 50 kg ex PRD
- Cycocel: 5 litres ex PRD
- Brominil M: 1 litre ex PRD
- Hoegrass: 1 litre ex PRD

3. EXPERIMENTAL DETAIL

a) Seeding

Select a site free of grass weed problems and work up according to standard station practice. Topdress Agran 34:0 onto treatments 6-10 immediately prior to seeding. Seed with Miling wheat at 50 kg/ha with 150 kg/ha plain superphosphate drilled. Seeding depth no deeper than 5 cm and use harrows behind the drill.

b) In-crop husbanding

i. Spray whole trial with a Brominil M/Hoegrass (1.4 l/ha + 1.0 l/ha) at the 4 leaf stage for broad leaf and ryegrass control.

ii. Cycocel application. Apply Cycocel by boom spray in 100 l/ha of water plus 0.1% non-ionic wetting agent (100 ml per 100 litres of mix).

Spray at the 5-6 leaf stage of the crop. Treatments 5 and 10 to receive a second spray of 0.25 l/ha at early stem extension (1 node detectable at the base of the stem). Run over all plots at the time of the second spraying.

Timing is important with Cycocel application. This will necessitate regular checking of the trial for growth stage so that spraying can be carried out on time. On the day of spraying, check at least 20 plants from each rep of the trial and record the actual growth stage on the schedule.

c) Harvest

i. PRD to sample plots for 500 heads prior to harvest. Samples to be threshed and grain number and grain weight to be determined.

ii. Research Station to harvest all plots (including buffers) and record grain yields.
2. SITE SELECTION AND PREPARATION

A. SELECTING SITES

1. Introduction
   - 2.1

2. The right site for the right experiment
   - 2.1

3. Uniformity
   - 2.1

4. When to select a site
   - 2.1

5. Checklist
   - 2.2

B. MARKING OUT AN EXPERIMENT

1. Marking out the experimental block
   - 2.3

2. Pegging the plots
   - 2.3
2.0 SITE SELECTION AND PREPARATION

A. SELECTING SITES

1. Introduction

There are two main considerations in selecting an experimental site:

* The site must represent the conditions for which the experiment was designed.
* The site must be as uniform as possible in all respects.

Once sites fulfill these criteria, other considerations are:

- accessibility, especially in winter
- possibility of vermin or stock damage
- proximity to a main road for extension purposes
- farmer co-operation

2. The right site for the right experiment

A good experiment begins with a good site and all officers should always be on the lookout for potential experimental sites.

Because an experiment is planned to answer a question, the site must be suitable to that end apart from its general suitability as an experimental site. Some examples are:

* Experiments to test fertiliser sources of phosphorus or nitrogen should only be done on phosphorus or nitrogen responsive sites. An unresponsive site will only mask the effects of the treatments.

* Herbicide experiments require relatively uniform weed cover.

* Experiments on clover regeneration may require a certain proportion of clover in a pasture. Too low or too high a clover content may obviate the aims of the experiment.

* For many experiments, site requirements may be quite specific, e.g. certain soil types or certain rotational situations such as 'second crop on light land'.

3. Uniformity

The site must be as uniform as possible in all respects. Assuming there will be some slight variations, those which will affect the growth of the experimental plants are the ones most to be avoided. A bad kind of variation is that which affects the growth of a particular treatment. For instance, if you know copper deficiency is affected by amount of gravel in the surface, copper experiments should not be put on sites where surface gravel varies.
It is difficult to list all the factors which may cause variability in a site. Some of the main ones are: changes in soil type, changes in depth to clay or gravel, sheep camps, fence lines which may have been ploughed for firebreaks, corners which will have been double sown, wet areas, and nearness to trees (which can have an effect either by shading or competition for moisture), etc. Another type of variability is that associated with differences in existing plant cover. This is very important for experiments on pastures, e.g. where there is an uneven cover of clover.

A type of variability which can occur on research stations, particularly, concerns past history. The history of previous treatments on the area should be known. If the site has uneven treatment of fertilisers which have a residual effect, such as superphosphate, or clover treatments causing different soil nitrogen, it should be totally avoided for experiments concerning the same factors. In some cases the site may be satisfactory after a number of years for treatment of a different type. For instance it may sometimes be safe to do nitrogen trials on old phosphate experiments if phosphate can be supplied at a non-limiting level. Even then it is safer to cross the plots.

4. When to select a site

Always be looking for suitable sites. Particularly with pasture experiments the site should be inspected the year before the experiment begins. By doing this, the experimenter has a good idea of pasture composition, especially uniformity.

A second time which has special advantage is when a paddock is first ripped up. Soil variation is much easier to see when the surface is freshly broken up.

5. A checklist

When selecting a site:

1. Consider the requirements for the trial.

2. Decide on possible sites - paddock or farm.

3. Check these sites for evenness of ground cover - crop, pasture, weeds or whatever is needed for the trial.

4. Soil sample the site with an auger to inspect the profile - depth to gravel, clay, etc. The number of auger holes will depend on the size of the trial area and should be enough to check variation in all directions.

In some cases, intensive and systematic sampling may be required (if specified) for chemical analysis prior to the commencement of the trial to determine the nutrient status of the site (e.g. nutrient trial - determine K levels before Potash Trial).
5. Shift the site along until the evenness over the trial area is acceptable. If there is any tendency for a uniform change in one direction, the plots should be placed along the direction of this change. If there is a slope and no other obvious variation the plots should run down the hill - there is a greater chance that any variation will be up and down the slope.

6. The site should then be adequately pegged. This may only require reference pegs on a nearby fence. However, if the trial is to be a continuing one it should be permanently pegged so that the site can be accurately located from year to year.

B. MARKING OUT AN EXPERIMENT

1. Marking out the experimental block

a. Mark out and peg the ends of the baseline for the experiment. Make sure that it is long enough to accommodate all plots and buffers for the experiment and add 0.5 m.

b. Mark the right angles for the sides of the block using either an optical square or a 3:4:5 triangle measured with the tape. Proceed in this manner until all four corners of the block are pegged. Check the diagonals to ensure the block is truly rectangular.

2. Pegging the plots

Twelve-row drills and combines have a wheel-to-wheel width of 2.50 m and plots are pegged on 2.5 m centres. Since the true sown width is 12 x 17.8 cm = 2.14 m, plots are separated by 0.46 m buffers.

Each end of the plots should be pegged on 2.5 m centres. The recommended method is to run out the tape and then draw it back until the 1.0 m mark on the tape is next to the corner post (Figure 2.1). The first peg is then placed on the 2.5 m mark and driven in. This peg is thus located 1.5 m (half a plot plus 0.25 m) from the corner. The extra 0.25 m is to allow the drill to be run down the plot without knocking over the corner pegs. Subsequent pegs are driven on the 5.0, 7.5, 10.0 ........ marks on the tape. 

FIGURE 2.1

```
  1.5 m  |  2.5 m  |  2.5 m  |
   A     | Plot centre pegs |

C     a = (Number of plots(including buffers)x2.5m)+0.5m
      b = Plot length
```
3.0 FENCING

A. PRINCIPLES OF FENCE CONSTRUCTION 3.1
   1. Strainer assemblies 3.1
   2. Posts and droppers 3.2
   3. Fencing wire 3.3

B. FENCING FOR TRIAL SITES 3.4
   1. How permanent must the fence be? 3.4
   2. What job is the fence intended to do? 3.4
   3. What materials are available? 3.5

C. PRACTICAL HINTS ON FENCE ERECTION 3.8

D. ELECTRIC FENCING AND ITS ADVANTAGES 3.9

E. FENCE CONSTRUCTION 3.10
   1. The fence line 3.10
   2. Strainer or end assembly 3.10
   3. Fence posts 3.10
   4. Length of strain 3.11

F. PRINCIPLES OF ELECTRIC FENCING 3.11
   1. Electric fence circuits 3.11
   2. Energisers 3.11
   3. Earthing 3.12
   4. Insulation 3.12
   5. Wire for electric fences 3.13

G. FENCE DESIGN 3.13
   1. The off-set wire 3.13
   2. Dry country layout 3.13

H. EXPERIMENTAL SITE LAYOUT 3.14
3. FENCING

A. PRINCIPLES OF FENCE CONSTRUCTION

Modern suspension fencing - characterised by wide post springs, long wire strains and high tensile wire - has largely replaced the traditional fence, which relied on closely spaced posts to provide support for the fence. Modern fence construction is based on engineering principles and an understanding of these will provide a sound background whether the fence constructed is to be of a permanent, semi-permanent or temporary nature.

There are three basic components to a fence:

* Strainer assemblies
* Posts and droppers
* Wire

1. Strainer assemblies

Strainer assemblies are the most important structure in any fence. They are the foundation and should they fail, the whole fence fails. It is therefore essential to ensure that assemblies are erected correctly and are strong enough to do the job.

The important factors governing the performance of a strainer assembly are:

a) Depth of set

The deeper the vertical members of the assembly are set in the ground the stronger the assembly. Table 1 shows that increasing the depth from 0.75 to 0.9 m more than doubles the load the assembly can carry. In contrast the size (diameter) of the strainer is of minor importance.

Table 3.1 - Effect of depth of set on strainer performance

<table>
<thead>
<tr>
<th></th>
<th>0.75 m deep</th>
<th>0.9 m deep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total load</td>
<td>20 kN</td>
<td>50 kN</td>
</tr>
<tr>
<td>Horizontal movement*</td>
<td>4 cm</td>
<td>2.5 cm</td>
</tr>
<tr>
<td>Vertical movement*</td>
<td>1.5 cm</td>
<td>1 cm</td>
</tr>
</tbody>
</table>

* At 13 kN = 3,000 lb

b) Driven posts

Posts driven into undisturbed soil will carry nearly twice the load of posts placed in holes and backfilled.
c) Assembly design

A horizontal box stay assembly (Figure 3.1) is more effective than a diagonal stay assembly but is also more costly and harder to erect.

Prefabricated steel assemblies with a diagonal stay are available and are quickly and easily erected.

2. Posts and droppers

Fence posts perform two functions - to hold the wires in position and to support the fence. Either steel or treated timber posts are recommended. Post failure is generally due to movement in the soil rather than to bending and the same principles of depth and driving rather than backfilling that apply to strainers also apply to fence posts.

It is important to understand that the wire and not the post forms the barrier and that the impact load of an animal hitting the fence is transferred by the wire to the strainer assemblies. The consequences of this are:

* Post spacings should be wide as possible (with droppers in between) as this reduces the load on the posts and thus the chance of post failure.

* Wires should never be tied tightly to intermediate posts as this stops the transfer of impact loads to the strainer assemblies.

Droppers act as spacers for the wire, distribute applied loads between the wires and act as a visible barrier. Droppers should not touch the ground and should be fixed to alternate sides of the fence. Spacings of 3 to 7 metres are generally used.
3. Fencing wire

a) Plain wire

Two types of wire are available for fencing - soft and high tensile. The latter is almost universally used as it is thinner, stronger, more elastic and cheaper than soft wire. It is, however, more difficult to handle and requires more careful straining. Table 2 lists the properties and uses of the major fencing wires available in Australia.

Table 3.2 - Properties of fencing wires available in Australia

<table>
<thead>
<tr>
<th>Wire</th>
<th>Recommended Tension kN</th>
<th>Min Breaking Force kN</th>
<th>Coil Length (m)</th>
<th>Coil Weight kg</th>
<th>Recommended Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft Wire</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.00 mm</td>
<td>2.75</td>
<td>4.8</td>
<td>500</td>
<td>49</td>
<td>General Purpose fencing</td>
</tr>
<tr>
<td>3.55 mm</td>
<td>2.00</td>
<td>3.8</td>
<td>600</td>
<td>47</td>
<td>as above</td>
</tr>
<tr>
<td>3.15 mm</td>
<td>1.50</td>
<td>3.0</td>
<td>750</td>
<td>46</td>
<td>as above</td>
</tr>
<tr>
<td>High Tensile</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.80 mm</td>
<td>3.00</td>
<td>8.0</td>
<td>1000</td>
<td>48</td>
<td>Cattle, top wire on all fences</td>
</tr>
<tr>
<td>2.50 mm Flexabel</td>
<td>1.50</td>
<td>8.7</td>
<td>1500</td>
<td>58</td>
<td>General purpose fencing</td>
</tr>
<tr>
<td>2.50 mm Tyeasy</td>
<td>2.00</td>
<td>5.4</td>
<td>1500</td>
<td>58</td>
<td>as above</td>
</tr>
<tr>
<td>2.00 mm</td>
<td>1.20</td>
<td>3.2</td>
<td>2000</td>
<td>50</td>
<td>Permanent electric</td>
</tr>
<tr>
<td>1.80 mm</td>
<td>1.00</td>
<td>2.6</td>
<td>2000</td>
<td>42</td>
<td>as above</td>
</tr>
<tr>
<td>1.57 mm</td>
<td>0.75</td>
<td>2.0</td>
<td>3000</td>
<td>48</td>
<td>Temporary electric</td>
</tr>
</tbody>
</table>

b) Barbed wire

Barbed wire is difficult to handle and its use should be avoided if possible.

c) Fabricated fencing

Hinged joint and ringlock fabricated fencing is available. In the former, vertical picket wires are attached to each line wire with a twist, whilst the ringlock picket wire is one piece, attached to the line wires with a ring.
Because of its security, ease of handling and speed of erection, fabricated fencing is especially suitable for fencing trial sites. A range of sizes is available and these are specified by the number of horizontal line wires, the height between the top and bottom wires and the distance between the vertical picket wires. For example, 7/90/30 hinged joint is a seven line, ninety centimetre high fence with 30 centimetres between upright wires. Table 3.3 lists the sizes currently available and their suggested uses.

Table 3.3 - Hinged Joint Fabricated Fencing

<table>
<thead>
<tr>
<th>Size</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/67/30</td>
<td>Adult Merino sheep</td>
</tr>
<tr>
<td>6/70/30</td>
<td>Sheep and lambs</td>
</tr>
<tr>
<td>6/90/30</td>
<td>Sheep and cattle, not lamb proof</td>
</tr>
<tr>
<td>7/90/30</td>
<td>All stock</td>
</tr>
<tr>
<td>8/90/30</td>
<td>All stock, more secure than 7/90/30</td>
</tr>
<tr>
<td>8/80/13</td>
<td>High security fence, suitable for pigs</td>
</tr>
<tr>
<td>8/115/30</td>
<td>All stock, including goats</td>
</tr>
</tbody>
</table>

B. FENCING FOR TRIAL SITES

Decisions concerning fencing for trial sites should include -

1. Permanency of the fence.
2. What the fence is intended to do.
3. What materials are available and how the fence will be erected.

1. How permanent must the fence be?

Fencing for trial sites is generally of a temporary (up to 1 year) or semi-permanent (1 to 3 years) nature. However, semi-permanent fencing should be constructed to the highest standard possible. Not uncommonly, trials (and their fences) are required to endure well beyond their planned life.

2. What job is the fence intended to do?

Fences are erected to either confine stock within an area or to exclude stock and vermin from the area. A sheep grazing trial may require a cattle (and sheep) proof fence if cattle are likely to be grazed around the area. Conversely, a cattle trial may require the fence to be sheep proof as well. The longer a trial is to last the more likely the fence will have to withstand both sheep and cattle.

a) Cattle

Where cattle alone are involved, electric fencing is preferred on the grounds of cost, ease of erection and efficiency.
b) Sheep

Prefabricated fencing is preferred for sheep. Many fence designs are satisfactory; six or seven line fabricated fencing should be used if lambs are to be run.

c) Sheep and cattle

A good general fence for trial use is 7/90/30 or 8/90/30 fabricated fencing with a single barb and one strand of plain wire above the mesh.

d) Kangaroos

Kangaroos are difficult to exclude but a plain wire strained 30 cm above the fence is reasonably effective. Electric fencing can also be used.

e) Rabbits

Rabbits are a frequent cause of damage to crop trials adjacent to uncleared land. Rabbit netting is very effective but must be buried at least 15 cm and the dirt re-packed and rammed around the netting.

f) Man

Human error is a frequent cause of trial failure and a single strand fence or even a line of posts can often prevent damage by farmers or staff unfamiliar with the trial area.

3. What materials are available?

a) Strainer assemblies

Horizontal box stay assemblies (Figure 3.1) are the most satisfactory for long term trials. However, they are time consuming to erect and are relatively expensive.

Prefabricated steel assemblies are quick and easy to erect and dismantle but are expensive.

Very satisfactory light steel assemblies can be made from 50 mm water pipe dropped over two steel posts. These have been found to be satisfactory for strains of up to 200 m. A frequent problem with pipe assemblies is a tendency to lift if the fence is tightly strained. This can be prevented by adding a base plate to the strut at the ground level or driving an angled peg through the back post. Figure 3.2 shows the construction of a pipe strainer assembly.

* Temporary strainers

For short term fencing needs three temporary strainers are shown in Figure 3.3. Their construction is self-explanatory.
b) Posts

Star steel posts are invariably used for trial fencing. For general purpose (sheep and cattle) fences, 165 cm posts should be used, driven to 45 cm depth. This will give a fence height to the top wire of 120 cm.

Because strains will not be as long as with permanent fencing, post spacing should be reduced to 6 to 10 m.

c) Wire

Figure 3.4 illustrates the construction of a 7/90/30 fence with one barb and a plain wire. This fence should be satisfactory for boundary fencing of all semi-permanent trials. Internal trial fencing may be of lighter construction if only sheep are to be run. For example, the plain wire and barb would be unnecessary.

FIGURE 3.2

FIGURE 3.3 Short pipe strainer assembly: must be braced with high tensile wire.
7/90/30 HINGED JOINT SUSPENSION FENCE
(cattle, sheep and lambs)

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tyeasy Fence Wire</td>
<td>½ coil</td>
</tr>
<tr>
<td>High Tensile Barbed Wire</td>
<td>2 reels</td>
</tr>
<tr>
<td>7/90/30 Hinged Joint</td>
<td>5 rolls</td>
</tr>
<tr>
<td>116 cm Galv. Steel Droppers</td>
<td>100</td>
</tr>
<tr>
<td>165 cm Star Steel Posts</td>
<td>48</td>
</tr>
</tbody>
</table>

Cost per km of materials: $447.00
Weight of all materials per km: 0.8 tonnes
C. PRACTICAL HINTS ON FENCE ERECTION

1. Use a wire spinner to play out wire, taking care to avoid kinking. Kinks caused by unravelling of the coil will be weak spots in the fence.

2. Tension the wire to the recommended tension using smooth-jawed wire strainers. Over or under tensioning will result in a poor fence.

3. Steel posts should be driven with the holes outward and the wire run on the outside of the post.

4. Never attach wire tightly to an intermediate post and don't run the wire through the holes. The post is there to space and support the wire but it should be able to move freely to transfer its load to the strainer. Running wire through the post holes is time consuming and damages the galvanised coating of the wire.

5. Knots. Like kinks, knots are weak points in wire. The figure of eight knot is the most satisfactory and should be used. A hair pin tie is also good, particularly if the wire is to be disconnected. Wires should be tied around strainer posts rather than the post being lassoed. These knots are illustrated in Figure 3.5.

6. Gates. Locate gates in corners for easy stock handling and ensure that the width is sufficient for machinery access. Gates should not be located in positions likely to waterlog.

7. Ensure that the bottom wire of any fence is 7 to 10 cm off the ground. This reduces corrosion through soil coverage, etc.

N.B. further reading

Literature produced by Australian Wire Industries Pty Ltd. gives a wide coverage of fencing techniques and materials.

FIGURE 3.5

Recommended knots for joining wire

![Figure of 8](image)

![Pin and Loop](image)

3.8
D. ELECTRIC FENCING AND ITS ADVANTAGES

The aim of any fence is to keep animals either in or out of a given site. This can be achieved now in two ways. The traditional manner is a mechanical barrier. The latest option in fencing is the electric wire.

In 1962 a New Zealander, Mr. D.S.M. Phillips, demonstrated two new principles in electric fencing. The new system was capable of maintaining high voltage despite large leakage from the fence. Now electrical pulses can be transmitted over long distances, overcoming many of the old transmission problems.

The advantages of electric fences over conventional fences are numerous. The electric fence stops all animals from penetrating it by fear rather than force. In fact, they get punished for trying.

1. The main advantage is that the fence is no longer a physical barrier, and the amount of materials required can be greatly reduced. The materials can also be lighter, wires and posts, etc.

2. If there are less materials in the fence it follows that less labour will be required to build it. Labour is usually 40 to 50 per cent of the cost of any fence.

3. As the fences are light and easily built and disassembled they are transportable, and materials can be used time after time - a most desirable feature for trial work. They can be used for strip grazing, for protecting small plots within treatments, equipment, etc.
E. FENCE CONSTRUCTION

This aspect has been covered, but not in terms of electric fencing.

Electric fences, because of the lighter construction, are the best engineered fences. They support the engineering principles far better.

1. **The Fence line**

The fence line should be cleared of vegetation (regrowth, rushes, logs, etc.) and the ground surface should be reasonably level. This will enable the fence to be easily and quickly built, and the wires can run parallel to the ground surface. The last point is the best test of a well built fence.

2. **Strainer or end assembly**

The strainer assembly for an electric fence can be either the double post type or the single post type.

For quick construction on an experimental site the single post is quite satisfactory. The post is braced using the 'bed log' system. The bed log should be sawn timber and at least half the length of the post. The strainer post should lean back several degrees, with the bed log placed in a cut trench.

**Bed - log system**

3. **Fence posts**

The selection of a fence post for an electric experimental fence will depend upon its site, the expected life of the trial, and the availability of materials.

For trials of short duration, steel posts are suitable, but they must be well insulated. (See Section on Insulation). Hand-driven wooden post systems are not being marketed, but wooden posts will, in general terms, be suitable for electric fences. For short lengths of fence such as required for experimental purposes, no further insulation will be needed.
Synthetic posts could well have a place in the future. Extruded fibreglass posts are now available in the U.S.A. and New Zealand. Further development is needed for permanent fencing in Australia. Even in their current form they would be suitable for experimental fencing.

4. **Length of strain**

The longer the strain of a fence the better the chance of maintaining wire tension. Wire is elastic, within certain limits.

The longer the length of wire the further it can stretch, so the less likelihood of damage to it.

Strains shouldn't be broken because of corners or angles. Gateways are a big factor in reducing strain length. Use modern gateway devices such as the 'Read Lift', 'Jack Lift', 'Drop Gate', etc. (See Bulletin 3957 or the Farmnote series).

5. **For short strains**, say 100 to 400 metres, tensioning wire springs should be used. They are required to maintain wire tension, and to help bear any impact loads, so the wire isn't damaged. Springs should be used on both earth and live wires.

Conventional gateways are the weakest section of an electric fence system. They should be electrified, especially for cattle trials.

F. **ELECTRIC FENCE PRINCIPLES**

1. **Electric fence circuits**

This subject is covered in the old Bulletin No. 3957 and the new Farmnote.

2. **Energisers**

There are only two basic types and these are the -

3.2.1 Impulse Wheel Inductance Energiser - Battery operated

3.2.2 Capacitor Discharge. They include the mains power, wet cell, 8 volt, 12 volt, 12 to 32 volt, solar units, and the dry cell type, usually 6 volt.

For trial work where mains power is available the latter is recommended.

On many sites power will not be available and battery units will be used. The difficulty is which unit to select. A guide to power output/length of fence is as follows:

- 6 Volt Dry cell - Strip grazing, 2 km live wire - Battery 4 to 8 weeks
- 6 Volt Wet cell - Strip grazing, 2 km live wire - Battery 25 weeks
- 12 Volt Wet cell - Permanent Fences, 10 km live wire - Battery 4 to 6 weeks

3.11
Solar Units - performance will range across these first 3 types - 

- Battery - continuous
- 12 to 32 Volt Wet cell - More powerful than many mains energisers.
- Short life battery - 1 week

Solar energisers would be suitable for most experimental sites, but they are expensive. The new wet cell energisers with long battery life would be suitable for most of the Department's trial sites.

3. Earthing

Earthing for electric fences is covered in the Bulletin and Farmnotes.

To achieve a satisfactory earth under Western Australian conditions is difficult, particularly in dry sandy soils, or even any dry soils in summer.

Finely textured soils with a large surface area (clays and loams) are generally easy to establish an earth in. Coarsely textured soils with smaller surface areas are likely to be difficult.

An experimental fence should have a high quality earth between the energiser and the fence. If a good earth can be established no other earth will be required.

A high quality earth point can be established by setting the earth electrode in a 75 mm hole with Bentonite and common salt, 1.2 metres deep. The ratio is 2 parts of Bentonite to 1 part of common salt.

The earth wires in the fence are just as important as the live wires, and should be given similar attention. In effect there should be electrical balance. The wire should be of similar quality and condition as the live wire. All joints in the earth wires should be clean and have good contact. Imbalance in the earth system in an electric fence is a major cause of poor performance and interference problems.

4. Insulation

This subject is again covered in Bulletin No. 3957 and Farmnotes.

Where the lower powered energisers are used more attention must be given to insulation. This is very important where steel posts are used. Porcelain insulators are the best insulators for electric fences. The quality is generally more reliable. Plastics can be good insulators, but the quality can vary a great deal, and they are subject to U.V. light damage. They are well suited where posts are regularly transported and porcelain insulators would be broken. Wood is the third insulator. Western Australian hardwoods make reasonable insulators where high powered mains energisers are used on short fences.

Creosote treated posts have improved insulation qualities over non treated posts.

3.12
5. Wire For electric fences

See Bulletin No. 3957 and Farmnotes.

Never use barbed wire.

Flexobel 2.5 mm high tensile wire would be the most readily available fence wire in Western Australia and is suitable for electric fences.

Small diameter high tensile wires can be used for small sites, in particular for cattle. For sheep, always use Flexobel or a 2.5 mm wire.

G. ELECTRIC FENCE DESIGN

There are three types of electric fences likely to be used in experimental sites. The off-set wire, the strip grazing fence, and permanent electric fences.

1. The off-set wire

This wire is sometimes referred to as an outrigger. The insulators can be attached to the posts - by wooden or wire supports or off-setter brackets attached to the wires. The off-set wire is usually set 250 to 300 mm out from the fence and generally 750 mm or so off the ground. It can rejuvenate a sheep fence where cattle are to run. For sheep the offset wire is usually placed 350 to 450 mm from the ground.

2. Dry country layout

With traditional types of fences there has been a need for strength; for permanent dry country electric fences, the major considerations are durability, visibility and profitability for trial work.

![Diagram of Electric Fence Design]

Energiser

Earth

Electrodes

6 metres Apart
On farms or sites where the stock aren't trained to electric fences, 6 wires should be used. Another earth and live could be added to the top of the fence. The heights would be from ground up, 100 mm, 250 mm, 425 mm, 850 mm, 1100 mm, E,L,E,L,E,L.

H. EXPERIMENTAL SITE LAYOUT

Perimeter Fences - Continuous strains.

Subdivision Fences - Short strains - using tensioning springs.

Gates - 'Read Lifts' - Stock. 3 to 4 metres high.

Posts - 10 metres sheep, 20 metres cattle.

Droppers - 2 to 4 for 'Read Lift' to prevent wire separation

Power Flow

Switch

For experimental fences the 'Billings' spiral and connectors would make excellent switches.
Read Lift' Gate

Dropper

20 to 50 m

Post

3 to 5 m

Lift Pipe or Wood

Dropper

3.15
A. SEED CLEANING 4.1
1. Introduction 4.1
2. Threshing 4.1
3. Seed cleaning methods 4.1
4. Using the clipper seed cleaner 4.3

B. INSECT CONTROL IN STORED GRAIN 4.4
1. Introduction 4.4
2. Principles of grain insect control 4.5

C. SEED STORAGE 4.6
1. Preparation of seed 4.6
2. Receipt of seed supplies 4.7
3. Seed in storage 4.7
4. Seed store fumigation for weevils 4.7

D. ORDERING AND DESPATCH OF SEED SUPPLIES 4.8
1. Ordering seed supplies 4.8
2. Weighing and packaging 4.8
3. Labelling and despatch of seed supplies 4.9

E. INOCULATION OF LEGUME SEEDS 4.10
1. Principles behind the practice 4.10
2. Methods of inoculation 4.11
3. Practical techniques 4.12
4. Inoculation of lupin seed 4.15
5. Seed treatment with systemic insecticides 4.15
6. Precautions to be taken when sowing field trials 4.15
4. SEED SUPPLIES FOR CROP AND PASTURE TRIALS

A. SEED CLEANING

1. Introduction

The aim of seed cleaning is the separation of various components of a sample. It may be seed from pods, seed of one type from another, seed from sand and rock or seed from burr. Generally only one component is required, usually seed from an unwanted fraction - chaff or foreign matter. The exception may be a mixture trial such as lupins grown with wheat, or peas with oats where both are required. Separation is carried out with the aim of minimum to zero contamination from the unwanted fraction with zero seed loss from the sample.

2. Threshing

If the seed is still contained within the pod, it must first be separated by some mechanical means. Very small clover samples are threshed out by hand, using a mat and block constructed from ribbed rubber material. Larger samples are threshed, using the Venables thresher. These machines use rubber beaters and concave and have a bottom screen through which the smashed pods and threshed seed pass. Adjustable air draught is provided to remove the bulk of the light chaff, leaving a sample of seed only lightly contaminated.

When using a Venables thresher, ensure that the screen fitted is of sufficient size to allow the seed to pass easily through while retaining entire pods for threshing. Wind adjustment should only be made to extract light chaff as a clipper is a better machine for the final winnowing process. Always ensure a bucket or suitable container is in place at the outlet of the thresher to retrieve the threshed sample.

3. Seed cleaning methods

There are seven basic methods used with seed cleaning operations:

1. Sieving  
   Air blast ) usually combined, i.e. clipper
2. Vibration or agitation - gravity table
3. Magnetic separation
4. Colour separation
5. Spiral separation
6. Floatation on a suitable fluid
7. Hand sorting

The system chosen is dependant on the purpose of the trial, the nature of the problem and size of the sample. The seed type and size must be compared against the unwanted fraction to assess the difficulty of separating the two. When the two fractions are of dissimilar size, shape and weight separation is easily achieved by sieving and air blast, using a clipper. If they have similar size, shape and weight, then some other technique would have to be employed, such as floating or gravity table.
(i) **Sieving and windblast**

The most commonly used machine for experimental purposes is the wooden clipper. It is suitable for samples of a few grams up to about 5 kg of seed. The principle of operation is:

**Top screen**

A large top screen removes all large and bulky trash while allowing all wanted seed to pass through.

**Bottom screen**

The bottom screen receives material from the top screen and is chosen to have holes or slots of the largest possible size without allowing any wanted component to pass through. This screen removes all material smaller in size than the wanted fraction.

**Wind blast**

The material from the bottom sieve is passed through a strong current of air which winnows the sample, removes all light material such as chaff, and allows the seed to fall into the collection tray at the bottom of the machine.

The M 2 B Clipper Seed Cleaner is the larger version of the wooden clipper and operates on exactly the same principle. This machine offers the facility of a grain auger and is used for samples of a bag or more.

The auger drive can be disconnected and seed recovered by a tray placed beneath the clipper. A sliding plate is opened at the base of the auger from which the cleaned seed is retrieved. When changing seed varieties care must be taken that all previous seed is cleaned from the machine. The grain hopper must first be checked and free of seed. The clipper is run until all flowing seed has passed through the machine. The bottom inspection plate is opened (if the auger was used) and cleaned out by turning the machine by hand, in reverse, to back auger all residual seed. When changing seed varieties, clean the machine's surroundings of all previous seed.

A large range of screens are available, making the clippers versatile machines. Screens can be slotted or round holed, ranging in size from 0.5 mm to 10 mm diameter holes. The machines are relatively simple to use and with the many setting combinations give good results.

(ii) **Gravity table**

Two sizes of the machine are available. A small laboratory gravity table, suitable for small samples of up to 1 kg and a large gravity table for bulk seeds. The larger gravity table is only suitable for large samples as the separation action is dependent on a continuous flow of seed over the table.

Gravity tables are used to separate material of similar dimension which cannot easily be screened out. The principle of operation is that seed flows down the inclined table by the action of agitation or vibration and
separates into various planes of flow according to weight and shape. At the edge of the table the seed types are diverted into various bins by baffles.

These machines are not easily set up and considerable experience may be required to achieve a desirable result.

(iii) Magnetic separation

The sample must first be mixed with a ferrous compound which will adhere to the rough surface of gravel, but not the smooth surface of seed. The sample is then passed over a magnetic drum which removes the dirt but allows the seed to fall into the collection bin. This method is rarely used.

(iv) Colour separation

This is a specialised machine, used by the plant breeders in separation of wheats. A colour separator is located at Wongan Hills Research Station.

(v) Spiral separator

This separator is used to separate seed of similar size and shape. The principle of operation has the seed flowing down a spiral as in a helter skelter, with heavier seed forced to the outside of the spiral.

A machine of this type is located at Mount Barker Research Station for the removing of wild radish from rape seed.

4. Using the clipper seed cleaner

Setting up the clipper

First ensure that the clipper is clean and free from all seeds from previous users.

The most likely screen sizes are selected and fitted to the clipper, ensuring they slide firmly in place and are held tight.

The correct screen sizes and wind settings are not always obvious so the recovery of all sample material is imperative until the clipper is correctly set up. This means placing containers under all outlets and ensuring the bottom seed tray is in place to catch the cleaned sample.

There are two trays to recover material separated by air blast. A top tray that fits over the air exhaust and a small sliding tray that fits into the back of the clipper immediately below the top tray. This tray catches material intermediate between being removed by wind and falling into the seed tray. Observation of this tray is a good guide to the wind setting, for once seed starts to collect in the tray, further increase will result in seed loss.

When clean seed is being recovered in the seed tray and there are no losses from the screen outlets or seed loss by wind, samples can then be processed in earnest.
Operating the clipper

a. Always ensure that the bottom seed tray is in place to catch the cleaned sample. This tray cannot be readily seen and it is a common fault to forget to replace it. Hint: never put the tray down on the bench after removing a previous sample, but always slide it back into the clipper.

b. Keep the clipper and its surroundings clean of all other seeds. If a spillage occurs, the sample can be recovered with no contamination from previous samples.

c. Always keep the label with the sample being processed. Place the label in the seed tray of the clipper while it is being cleaned.

d. Never have two separate samples with labels removed at the same time - this is getting ahead of oneself and leads to labelling errors.

e. Feed the sample over the clipper at a steady, even pace. A mass of material at once will not be screened properly. This will also affect the air blast separation, resulting in material falling into the cleaned sample and seed being carried by chaff into the top tray.

f. Check the security of the screens from time to time. A loose bottom screen will result in seed loss through the bottom screen chute with the fine trash.

g. If a mistake occurs with a sample, record the fact on the sample and note it down elsewhere.

h. Oil the bearings and all moving parts lightly during operation.

i. If the job is finished, don't leave the samples lying around. Put them away, even if you think you are coming straight back - you may be sidetracked. Someone else may want to use the machine while you are away. Other people may look at your samples as rubbish and they could become lost at the next garbage collection.

j. Always clean up the mess after you have finished or at the end of the day, whichever occurs first.

k. Don't leave screens lying around, put them back in a box. Screens are easily broken, expensive to buy and harder to replace. It also saves the next person from having to search the Department for the screen he requires.

ALWAYS BE TIDY.

B. INSECT CONTROL IN STORED GRAIN

1. Introduction

Cereal seeds are susceptible to infestation by a number of insect pests. Any bulk of grain can become infested.
The consequences of infestation can be serious. Large insect populations will destroy the germinating capacity of seeds, particularly cereals. A nil tolerance currently exists for insects in export grain; buyers can claim heavily for the presence of any live insects in cargoes. Grain containing insects is not acceptable for loading to ships and must be fumigated before becoming acceptable.

It is illegal to transport infested grain in any quantity; fines of up to $1,000 may be imposed for breaches.

Grain insect control in the past has been readily achieved using insecticides. The development of resistance since 1970 has forced changes in attitudes to weevil infestation.

2. **Principles of Grain Insect Control**

   **Hygiene**

   Weevils breed readily in spilt grain and old residues. The use of vacuum equipment and brooms is an essential part of successful weevil control. Consideration should be given to easy cleaning features when designing grain stores and seed handling buildings. Chemicals should not be relied upon to give satisfactory results when used in dirty situations. All machinery and storages should be thoroughly cleaned before using insecticides.

   **Chemical**

   Grain intended for human or animal consumption can be treated with malathion, which will give up to nine months protection against non-resistant insects.

   Machinery and storages can be sprayed with a fenitrothion solution after cleaning. Fenitrothion is effective against all strains of grain insects found on W.A. farms.

   Small seed lots can be treated with carbaryl or propoxur dust (Baygon) prior to sealing in bags or containers.

   **Fumigation**

   Phostoxin tablets can be used to disinfest grain bulks which are found to contain insects. Adequate sealing of fumigation rooms or vessels is essential for efficient fumigation. Phosphine (the active gas) is exceedingly toxic and exposure of personnel must be strictly avoided. Methyl bromide fumigation may be used under certain circumstances, but only in tightly sealed situations and by trained personnel.

   **Physical**

   A number of non-chemical methods are available for disinfesting grain and keeping it free of insects.

   - Heat disinfection
   - Aeration of large bulks
   - Refrigerated storage

4.5
Inert atmospheres  
Underground storage  
Hermetic sealing  

Refrigeration may be used to advantage in plant breeding programmes for insect control in grain parcels. Storage at or below 13°C will prevent insect build-up.

Storage of small grain lots in sealed plastic containers will ultimately cause death of insects due to a build-up of carbon dioxide.

Large bulks to be stored for long periods can be stored successfully in underground pits.

REFERENCES

W.A.D.A. Farmnote 141-79  
W.A.D.A. Farmnote 58-78  
W.A.D.A. Bulletin 3906  
W.A.D.A. Bulletin 3710  

C. SEED STORAGE AND DISPATCH OF EXPERIMENTAL SEED SUPPLIES

1. Preparation of seed

The aim of seed storage is the retention of seed for future use without the loss of seed viability.

. Clean seed

Seed should be free of all chaff and foreign matter which may lead to disease and mould as well as creating unnecessary bulk. All cracked and damaged seed should be removed so as not to attract insect pests.

. Insect pests

Seed must be free of any insect pests such as weevil. Grains susceptible to weevil attack should be pickled, using a suitable insecticide and details of the treatment marked on the bag.

. Moisture content

Seed with a high moisture content should not be stored. Generally, under the dry, hot harvesting conditions of Western Australia this is not a problem. If seed has a moisture content of greater than 14 per cent it should be oven dried at a temperature of 25°C to 30°C. Seed moisture content can be checked, using a grain moisture meter or by having a sample tested by the Seed Laboratory.

. Seed packaging

Seed should not be stored in plastic bags. The restricted air circulation may cause sweating within the bag and mould, causing seed deterioration. Seed should be stored in calico, jute or woven poly bags.
. Labelling

Bags should contain a label inside, in addition to the outside markings on the bag. Details on the label should give:

  a) Species and variety of seed or accession number.
  b) Date seed was harvested.
  c) Germination per cent
  d) Any seed treatment - pickled, scarified etc.
  e) Name of officer concerned.

2. Receival of seed supplies

1) Check the requisition against the seed received to ensure it is correct and complete in bag numbers.
2) Inform the officer concerned of its arrival.
3) Clearly label the date and officer's name on the bag.
4) Record the seed in the register.

3. Seed in storage

It is vital that the seed store is kept spotless. All seed spillages should be swept and vacuumed to remove seed between bags. Loose seed is an attraction to rodents which damage bags. Under no circumstances is any seed clippering to be conducted within the seed store. The door to the seed store is to be kept closed at all times to prevent dirt and chaff blowing in. All bags being stored should be sealed by tie wire or Fischbein bag closer. After taking seed from a bag, reseal the remaining butt; this prevents seed spillage.

Seed of no further use should not be left in the seed store. Space is at a premium and old seed has the chance of becoming weevilly. If seed is no longer required, it is either thrown out under the direction of the officer or, if suitable for stock feed, sent to a research station.

Insects and vermin are a major loss of seed in storage. A constant supply of fresh bait must be available for the control of rats and mice at all times. If bags of seed are discovered to be weevilly the bags must be promptly thrown out, or if it is necessary that the seed be kept, treated with an insecticide. This can be done by sealing the bags in a plastic liner with a phostoxin tablet and left for a week.

4. Seed store fumigation for weevils

The simplest method of fumigation is by using the C.I.G. Insectigas kits. For weevils control insectigas D is used. This contains Dichlorvos (or DDVP) at 5 per cent concentration.

The store is first swept and cleaned. All louvred windows are sealed with plastic and masking tape. This insectigas is released from the bottle, using the correct gun, which has a flow rate of 25g/sec. The gas stream is directed to all corners of the store and behind bags and benches. For both seed store rooms a total of 45 to 60 seconds is ample. The main door should be sealed after treatment with masking tape.
Place a large warning sign on the door for the night watchman with the words: Poison, Insectigas, the date and name and extension of officer concerned.

When using insectigas D use the respirator fitted with the correct filter cartridges. The best time for seed store fumigation is over the weekend so the store may remain sealed for at least two days.

**D. ORDERING AND DESPATCH OF SEED SUPPLIES**

1. **Ordering seed supplies**

   The circulars for ordering departmental pedigree seed lines are sent out as the end of October and should be returned to the Plant Production Division Clerk by mid-December. Late orders cannot be guaranteed of securing pedigree seed supplies as farmer orders are filled after January. Pasture and other seed species are requisitioned by the Division concerned for commercial sources. These supplies should be ordered so as to allow plenty of time for weighing and despatch to the various locations for planting.

2. **Weighing and packaging**

   When weighing seed use a balance which will give the degree of accuracy required by the trial. Weights of small clover lots can be critical with errors of a gram, resulting in large changes to actual seeding rates when related in terms of kg/ha.

   Always check the tare of a balance with each change of bag, envelope or container, etc. used for weighing.

   Ensure the correct line of seed is being weighed for the treatment as a variety trial may involve several bags being open at once. If doubt occurs as to where seed in a scoop originated, discard it. Never place it back in the bag or bin it may have come from.

   Place weighed seed into a bag of sufficient size to hold the quantity comfortably. This enables bag ties or elastic band to gain a better purchase around the neck of the bag.

   Small seed lots should ideally be railed in calico bags, securely tied. Plastic bags easily split and therefore are not the safest method of raling seed. If plastic bags are used, always use heavy guage plastic with double sealed bottoms. Place one bag inside another and seal separately by elastic bands or heated bag sealer. Prick a small hole in the bag to allow trapped air to escape. Superior rubber bands, size 28, are excellent for closing plastic bags. These bags should now be placed into jute sack for raling.

   Smaller and valuable seed lots should be crated in wooden pine boxes. These boxes are lined with bitumen paper on all sides and across the top. All free space must be packed to stop movement. The lid is nailed and the box strapped with plastic or metal bands.
All supplies of seed and fertiliser in jute bags, at risk of becoming wet, should have a plastic liner insert fitted to the bags. The liner neck is sealed, using a rubber band to ensure it is waterproof before closing the jute bag.

3. Labelling and despatch of supplies

Labels should be placed inside all bags, giving seed variety and trial number. The outside of the bag should be clearly labelled with the following information:

1. Destination or railing code
2. Trial number
3. Seed contents and treatment numbers

The markings on the outside of the bag should be bold, legible and written with waterproof ink such as die mark or felt nib pen. The rail code must be clearly separate from departmental information.

A record of despatch should be kept with the following information in the event of supplies becoming lost:

1. Date of despatch
2. Method of despatch - rail, post or delivered by Departmental Officer
3. Bag markings and contents
4. How it was addressed or consignee

All supplies despatched via rail must be accompanied by the correct consignment docket. Before delivering supplies to Kewdale for railing, check the current railing list for the correct goods receival, days for the intended destinations and its code letters.

Large lots of several bags can be stacked on pallets for handling with a fork lift. Ensure every bag is branded with the correct railing code for its destination.

Urgently required supplies may be send via passenger rail or bus. These supplies are taken to the Stores Branch and the appropriate consignment notes completed. Check with the Stores Branch driver when the supplies will be despatched and inform the consignee as to when and how they will arrive.

4.9
E. INOCULATION OF LEGUME SEEDS

1. Principles behind the practice

All plants require nitrogen for growth and although the air that animals and plants breathe contains nearly 80 per cent nitrogen gas it is not in a form that is in any way available for plant growth. Fortunately many agricultural plants are legumes - a group of plants that possess the ability to convert gaseous nitrogen from the atmosphere into a form that can be utilised by the plant. Because of this ability, properly functioning legumes do not require either soil nitrogen or fertiliser nitrogen in order to produce a productive pasture or crop.

The conversion process is known as nitrogen fixation and occurs in nodules on the plant roots (see Figure 4.1). The nodules are outgrowths of the roots and contain very specific bacteria (rhizobia) which interact with the nodule tissue and fix the nitrogen gas which reaches the nodules via the leaves. The fixed nitrogen is immediately available for the growth of the host plant and later most of it is incorporated in the soil as both plant and animal residues. The nitrogen containing protein in these residues is not available for plant growth until their microbial decomposition takes place in the soil. Following decomposition, much of the nitrogen is converted into nitrate and ammonia forms of nitrogen, both of which can be readily used by most plants.

Various estimates have been made of the amounts of nitrogen fixed by legumes. Species of clover and medics have been estimated to fix from 50 to 200 kg nitrogen/ha/year. In terms of absolute amounts of nitrogen this is equivalent to 150 to 600 kg of ammonium nitrate (Agran 34.0) fertiliser. However, because legume nitrogen is released for use by plants over a long period it is really of more value than an equivalent amount of fertiliser nitrogen.

Unfortunately legumes do not always nodulate when introduced to a soil. Even in those soils where rhizobia are present they may not be capable of nodulating the legume the farmer wishes to grow. If they can nodulate the plant they may not be very effective, i.e. they may not produce much nitrogen. If fully effective they may not be present in sufficient numbers to promote prompt and adequate nodulation. For these reasons it has been found necessary for the farmer to introduce rhizobia to the soil. This is done by adding them to the seed (inoculation) when the pasture or crop is sown.

Bacteria are classified the same way as plants into genera and species. Examples of some common combinations are listed below:

<table>
<thead>
<tr>
<th>Rhizobia</th>
<th>Genus</th>
<th>Species</th>
<th>Host</th>
<th>Genus</th>
<th>Species</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rizobium meliloti</td>
<td>Medicago</td>
<td>truncatula</td>
<td>Medics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhizobium trifolii</td>
<td>Trifolium</td>
<td>subterraneum</td>
<td>Sup clover</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhizobium leguminosarum</td>
<td>Pisum</td>
<td>arvense</td>
<td>Peas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhizobium lupini</td>
<td>Lupinus</td>
<td>angustifolius</td>
<td>Lupins</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The rhizobia for medics will only nodulate the medics and other closely related genera (Melilotus, Trigonella). They will not effectively nodulate any other genera - and the same holds as a general rule for all other genera. Even within the broad general groups marked specificities occur (Table 4.1, p. 16) which can have a marked effect on the usefulness of commercial inoculants for legumes used in agriculture. Table 4.1 shows the range of inoculants for use by farmers in Australia and it can be seen that there is more than one inoculant available for some plant groups. Within the clovers there are two groups, one for white clover, strawberry and red clover (Group B) and one for all subterranean, crimson, rose and cupped clovers (Group C). Similar special groups are found for medics (Group A, Rugosa Group and Polymorpha Group) and Lotus and soybeans.

2. Methods of inoculation

The inoculum consists of a pure culture of rhizobia in a nutrient broth that has been injected into a packet of dry and sterile peat. The rhizobia do not form spores or have any kind of resting or protective phase in their life cycle. As a consequence they must be protected from harsh chemical and physical environments - and it is the finely ground peat which provides some protection in the period between inoculant manufacture and purchase by the farmer. The inoculum survives over long periods (up to 6 months after release by the manufacturer) when stored under cool conditions. However, it does not survive for long once it has been applied to seed and storage of inoculated seed should be avoided, even when inoculated with the best available technique.

- **Dust inoculation** The peat inoculum is dusted over the seed. This is a lazy method in which relatively few rhizobia stay on the seed. It should only be used if the seed is immediately sown into moist soil.

- **Water slurry** The inoculum is made into a paste with water and mixed with the seed. This method has the same disadvantages as the dust method.

- **Gum slurry** The inoculum is made into a paste with a weak gum solution. This method is recommended where pelleting is not needed. The gum gives better retention of the inoculum on the seed and also has the added advantage of slowing the death rate of the inoculum on the seed.

- **Pelleting** Similar to the gum slurry method, except that a larger volume of a stronger gum solution is used to inoculate the seed, the wetted seed is then mixed with a finely powdered substance, usually lime, but sometimes in the case of tropical legumes rock phosphate is used. The adhesive used for pelleting improves survival (irrespective of the pelleting substance) and is used for sticking the pellet on the seed.

Lime pelleting is used in order to protect the sensitive rhizobia from the effects of acid superphosphate - particularly when the seed is to be mixed with the fertiliser before sowing.

- **Liquid inoculation** The peat inoculum is suspended in water and sprayed on to or into the soil. The simplest technique is to apply the inoculum through a watering can on to the soil surface (during rain) - this method may be used to inoculate small areas of non nodulated plants in problem sowings.
The technique is used on a large scale in Israel for inoculating peanuts at the time of sowing, it is also used on many sowings of soybeans in New South Wales. The main reasons for using the technique is when it is necessary for the inoculum to be placed away from seed that has been treated with chemicals (e.g. fungicides) that are not compatible with rhizobia.

Liquid inoculation has been successfully used with cone seeders by WADA Plant Breeders - where it has proved very convenient for inoculation of many small plots.

Granular inoculants - The inoculum is in the form of small granules or pellets that can be either mixed with the seed or drilled into the soil away from the seed. This is a recent innovation that has not yet been used in Western Australia.

3. Practical techniques

Adhesive solution

Gum arabic is the preferred adhesive but unfortunately it is not generally available. The most suitable alternatives are methyl celluloses such as methocel(R). To prepare one litre of adhesive solution:

Sprinkle 20 grams of the granulated powder on to 200 millilitres of near boiling water, stirring vigorously until the powder is dispersed.

Slowly add 800 millilitres of cold water still stirring vigorously until an even gel is produced.

WARNING - Do not add materials such as various alkalis to the mixture in order to hasten preparation of the adhesive solution.

Details of method

Calculate the quantities of materials needed for pelleting various legume seeds from the tables below. Note that the amounts given in Table 4.2 for large quantities are guidelines only. The operator should actually prepare trial batches, bearing in mind that pellet quality may vary with differences in such things as seed size and the method of preparing the pellet.

Mix the peat culture with the adhesive solution. Ensure that the adhesive solution has cooled before adding peat.

Pour the mixture over the seed and stir until all seeds are wet.
Table 4.2
Quantities of materials needed to inoculate large quantities of various legume seeds

<table>
<thead>
<tr>
<th>Type of Seed</th>
<th>Amount of seed (kg)</th>
<th>Adhesive solution (litres)</th>
<th>Lime (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small seed (white or strawberry clover, very small sub clover)</td>
<td>12</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Medium seed (subterranean clover, barrel medic, lucerne)</td>
<td>25</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Serradella (pre-moisten)*</td>
<td>12</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Large seed (lupins, pea, vetch)</td>
<td>25</td>
<td>0.5</td>
<td>3</td>
</tr>
<tr>
<td>Lupin (gum slurry)**</td>
<td>25</td>
<td>0.5***</td>
<td>Nil</td>
</tr>
</tbody>
</table>

Use inoculant recommended on packet for each type of seed.

* Superior pellets are formed if the serradella seed is pre-moistened with water, at 0.75 litres to 12 kg of seed. The seed should be wetted immediately before addition of the adhesive-inoculum mixture.

** Take care that seed is not too wet. If it is to be re-bagged directly after treatment it may be necessary to reduce the volume of the adhesive solution.

*** Half strength gum (i.e. 10 g in 1 litre of water). We had previously recommended the use of less of this gum solution. However, the higher quantity is preferred providing the seed is not bagged and stored with free moisture evident. If it is impractical to dry the seed then less gum should be used.

The recipes for small quantities are given in Table 4.3. Small amounts of pelleted seed are used in hand sown experiments where only a few rows of seed are sown. They are best made up in glass beakers, using glass rods for mixing/stirring.

WARNING - Where more than one strain of rhizobia is used it is important to safeguard against mixing strains by using clean and sterilised (or alcohol washed) equipment for each strain. Benches, hands and scissors/scalpels should be similarly treated. The same precautions apply when non-inoculated seed is being parcelled or prepared in the same area - particularly when pelleting non-inoculated seed.
Table 4.3

Quantities of materials needed to inoculate small lots of legume seeds*

<table>
<thead>
<tr>
<th>Type of Seed</th>
<th>Amount of Seed g</th>
<th>Adhesive Solution g</th>
<th>Lime g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>1</td>
<td>0.15</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>7.5</td>
<td>0.7</td>
<td>3.75</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>3.0</td>
<td>12.0</td>
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<tr>
<td>Medium</td>
<td>6</td>
<td>0.2</td>
<td>2.5</td>
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<td>170</td>
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<tr>
<td></td>
<td>300</td>
<td>6.6</td>
<td>38.0</td>
</tr>
</tbody>
</table>

* As an approximate guide lots of seed greater than 500 g should be treated in proportion to direction for large quantities.

Add immediately the required amount of finely ground limestone and mix until the seeds are evenly coated and well pelleted. Stop mixing as soon as the pellet has been formed.

Large amounts can be processed in a cement mixer by shovelling over on a cement floor, or by using a revolving drum or similar device (such as a large tractor tyre). A tarpaulin may also be used. The mixing or rolling of the seed is achieved by lifting alternate corners of the tarpaulin and walking forward. If thicker pellets are preferred, the same quantities of ingredients can be used for a smaller quantity of seed.

WARNING - Do not use builders' slaked or hydrated lime, they are too alkaline and will kill the bacteria.

Likely causes of poor pellets

- Powdery, soft pellets indicate either too much lime or uneven mixing, or both.
- Pasty-looking pellets with the seed surface showing indicates too much adhesive solution. This may be rectified by adding more lime.
- Clumps of small seed may be caused by excessive amounts of gum and may not break down after the addition of lime. The tendency to clumping can be minimised by rubbing the clumps against the side of the revolving drum.
Hard, glossy, smooth pellets indicate too little lime, or too much mixing after addition of lime, especially when revolving drum mixers are used. Such pellets appear darkish and have a tendency to crack and flake on drying, especially when handled.

Care should be taken with lucerne and medic seed which are very difficult to pellet. Do not mix too long after addition of lime.

4. Inoculation of lupin seed

Lime pelleting of lupin seed is only recommended where the seed is drilled with trace element fertilisers containing copper. There is no need to lime pellet if seed is drilled with manganese-superphosphate.

Where lupin seed is to be inoculated but not lime pelleted, a gum slurry inoculation is recommended. The technique involves mixing the correct amount of peat inoculant with half strength gum solution (10 g in 1 litre).

The mixture should be thoroughly mixed with the seed and preferably dried on a shed floor (out of sunlight) before bagging. If the seed is not too wet it can be bagged immediately. A small quantity of lime can be used to absorb excess moisture.

The gum slurry method gives the added protection of the gum as well as providing a means for the peat inoculant to adhere to the seed on drying. If too much gum is used, particularly if it is too concentrated, the seed will stick together on drying.

5. Seed treatment with systemic insecticides

Systematic insecticides or fungicides other than Thriam are not recommended where inoculation is necessary.

6. Precautions to be taken when sowing field trials

a. Always record the batch number and expiry date on packets used for inoculating seed. This practice ensures that operators use the correct inoculum and that it has not expired. It is also useful as a means of checking inoculant failures.

b. Where possible sow all non-inoculated seed before inoculated seed. This point should be covered in project sheets.

c. Avoid walking across plots so that rhizobia are not transferred from plot to plot.

d. Carry laboratory alcohol during sowing and sampling so that hands, and experiment equipment (where possible) can be swabbed. This particularly holds for hand sown trials where serious cross contamination can be easily caused during careless sowing and sampling operations.
Table 4.1

List of inoculants produced in Australia

<table>
<thead>
<tr>
<th>No.</th>
<th>Group</th>
<th>Host</th>
<th>Strain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>Medics, lucerne</td>
<td>U45</td>
</tr>
<tr>
<td>2</td>
<td>Paragosa</td>
<td>Medicago rugosa</td>
<td>W118</td>
</tr>
<tr>
<td>3</td>
<td>Circle valley</td>
<td>Medicago polymorpha</td>
<td>NA2290</td>
</tr>
<tr>
<td>4</td>
<td>B White clover</td>
<td>White, strawberry red clovers</td>
<td>Tal</td>
</tr>
<tr>
<td>5</td>
<td>C Sub clover</td>
<td>Sub, rose, cupped and crimson clovers</td>
<td>WU95</td>
</tr>
<tr>
<td>6</td>
<td>Semipilosum</td>
<td>Trifolium semipilosum</td>
<td>CB782</td>
</tr>
<tr>
<td>7</td>
<td>D Lotus</td>
<td>Lotus pedunculatus*</td>
<td>CC829</td>
</tr>
<tr>
<td>8</td>
<td>Corniculatus</td>
<td>Lotus corniculatus</td>
<td>SU343</td>
</tr>
<tr>
<td>9</td>
<td>Hispidus</td>
<td>Lotus hispidus</td>
<td>CC814b</td>
</tr>
<tr>
<td>10</td>
<td>E Pea</td>
<td>Pea, vetch, tares, broad bean</td>
<td>SU391</td>
</tr>
<tr>
<td>11</td>
<td>F. Bean</td>
<td>Tick beans, Tangier pea, lentil</td>
<td>CC511</td>
</tr>
<tr>
<td>12</td>
<td>G Lupin</td>
<td>Lupin, Serradella</td>
<td>WU425</td>
</tr>
<tr>
<td>13</td>
<td>H Soybean</td>
<td>Soybeans</td>
<td>CB1809</td>
</tr>
<tr>
<td>14</td>
<td>Hardee soybean</td>
<td>Soybean cv Hardee</td>
<td>CC709</td>
</tr>
<tr>
<td>15</td>
<td>I Cowpea</td>
<td>Cowpea, peanut, velvet bean, siratro, phasey bean, puero, calopo, glycine, style, Townsville stylo</td>
<td>CB756</td>
</tr>
<tr>
<td>16</td>
<td>J Dolichos</td>
<td>Dolichos lablab, D. uniflorus, D. axillaris</td>
<td>CB1024</td>
</tr>
<tr>
<td>17</td>
<td>Mung bean</td>
<td>Vigna radiata</td>
<td>CB1015</td>
</tr>
<tr>
<td>18</td>
<td>Centrosema</td>
<td></td>
<td>CB1923</td>
</tr>
<tr>
<td>19</td>
<td>Desmodium</td>
<td></td>
<td>CB627</td>
</tr>
<tr>
<td>20</td>
<td>Leucaena</td>
<td></td>
<td>CB81</td>
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<tr>
<td>21</td>
<td>Lotononis bainesii</td>
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<td>CB376</td>
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<td>22</td>
<td>Lotononis angolensis</td>
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<td>23</td>
<td>Fine-stem stylo</td>
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<td>CB1323</td>
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<tr>
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<td>Aeschynomene</td>
<td></td>
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</tr>
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<td>25</td>
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<td>CB2312</td>
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<td>26</td>
<td>Chickpea</td>
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<tr>
<td>27</td>
<td>Astragalus</td>
<td></td>
<td>CC1192</td>
</tr>
</tbody>
</table>

* = L. uliginosus
Non-inoculated seed

Soil

Rhizobia

Inoculated seed

Seed

Root

Rhizobia

Root hairs

Root Tip

Rhizobia in infection thread

Root hair curling

Multiplication of Rhizobia

Rhizobia in infection thread

Endodermis

Conducting Tissue

Old nodule

Bacteroid area packed with modified 'fixing' Rhizobia

Newly infected

Nodule growing point

Active N₂ fixation

Emergence of nodule from root

Infection thread

Inner cells of root cortex stimulated to divide (become nodule)

Nodulated plant
5. PEDIGREE SEED PRODUCTION

A. Paddock Selection and Management  5.1
B. Cultivation  5.2
C. Seeding  5.2
D. Spraying  5.3
E. Roguing  5.3
F. Pre-Harvest  5.3
G. Harvest  5.3
H. Seed Cleaning  5.4
I. Pickling  5.4
J. Sampling  5.4
5. PEDIGREE SEED PRODUCTION

Any pure seed scheme depends on the production of seed of a high standard. This high standard requires all personnel handling seed to use extreme care at all times to prevent mixing of different lines. Staff must be fully aware of likely problems, and have to develop an attitude of mind which accepts the need for a rigorous system.

Plant breeders are responsible for all stages of selection up to the production of Ped I seed. This is passed on to the Pedigree Seeds Officer, who uses this seed to plant the Ped II plots on the Wongan Hills Station. The Ped II seed from this particular variety is used to plant the Ped III block. Seed harvested from those blocks is used next season to sow the Basic seed crops for sale to farmers. This terminology can be represented diagrammatically in this way.

![Diagram of seed production process]

The following notes refer to the many aspects necessary to ensure the purity of seed required.

A. Paddock Selection and Management

Production of seed requires selection of paddocks of reasonable soil type, offering good prospects of satisfactory yields. Generally, these paddocks will have been sown to legume pastures for many years, and a major problem will be the control of grass weeds, such as ryegrass, bromes and silver grass. It is essential to have enough forward information of the likely area requirements for seed production so that management of crop paddocks can be put in hand at least the year before cropping.
Recommended treatments - which will necessarily differ from station to station - are based on the following:-

1. Winter spray (with sprayseed) and graze heavily through the growing season.

2. Spray top (grammoxone) when grasses have commenced setting seed (timing is most important as any mature seed is unacceptable).

3. Graze through summer to reduce pasture to the minimum by the break of season.

4. DO NOT HAND FEED in the paddock.

5. Control vehicle movement strictly - any vehicle entering the paddock must be swept clean of grain, and should move along fence lines, contour banks or permanent tracks rather than across cropping areas.

6. Cultivate shallowly (autumn tickle) in late summer to encourage maximum grass seed germination (this is an option).

7. Use Trifluralin (except for oats) before seeding where considered warranted.

N.B. This programme will effectively reduce the grass contaminant of crops to a very low level - but it will also remove grasses from the pasture. It is therefore practical as a long-term system only in those aras where clover-medic is an assured and effective component of pastures.

B. CULTIVATION

This should be the same as is practised normally, and may vary from year to year. In many situations, minimum or no tillage is currently being effectively used.

C. SEEDING

Both the demand for a particular variety, and the quantity of seed available affect the area to be sown. This has to be decided in conjunction with the other priority demands on available land, and is normally decided by manager and head office together.

Preferably, both Pedigree III and Basic (formerly called Ped IV) seed should be sown in the same paddock. Ped III should be sown in the longest runs practicable, preferably wheel on wheel to permit easy access for rogueing, and separated from the Basic crop by at least a 75 cm gap.

At seeding, vehicles entering the area must be scrupulously cleaned before use, and should transport only one variety at a time. Seeding machines must also be thoroughly cleaned before entering the area.

Use the following equipment for cleaning out seed drills:- air compressor, vacuum cleaner, whisk brushes. Be sure to check that tubes (especially the convoluted type), tynes and frame are free of grain.
D. SPRAYING

Weed control in pedigree seed crops is particularly important, even if control methods would be considered uneconomical in ordinary crops. Special care must be taken to ensure that the chemicals used, the rates and timing are correct for the crop. Selection of the chemicals should always be checked with the station manager, and there should always be two people to check spray settings, etc.

E. ROGUEING

Both Ped III and Basic seed lines should be rogued systematically, with extra time and care being taken with the Ped III.

* FIRST rogueing should be when the crop just commences earing - this allows removal of any early contaminants.

* SECOND rogueing should be when the grain is at the dough stage, allowing detection of late-maturing contaminants.

* THIRD rogueing is at maturity - colour-different and other off-types can be removed at this time.

Experience shows that rogueing is best done early in the morning, and the work should not extend for more than a 2 to 3 hour period. Rogueing should stop if wind causes the crop to move very much.

The number of times a crop needs rogueing at any stage is at the discretion of the manager.

F. PRE-HARVEST

Silos, bulk bins, sheds and all grain storage areas should be checked, and very thoroughly cleaned to ensure absolute cleanliness from grains and/or insects. All these areas should be sprayed with appropriate chemicals prior to harvest. GRAIN HYGIENE IS IMPORTANT AT ALL TIMES.

G. HARVEST

Before commencing harvest all harvesting machinery and vehicles should be checked to make sure that they are grain free.

Suggested equipment to assist in cleaning harvesting machinery between varieties:

1. Compressed air
2. Vacuum cleaner
3. High water pressure is undesirable because of risks of producing grain-residue "cakes" - and if used at all should be limited to the external parts of the harvester and should be the last thing used in the cleaning process.
The Basic seed line of a variety should be harvested first. When the Basic seed line has been completed, the harvester should be run for a while with all the elevators open to clear as much Basic seed as possible before commencing to harvest the Ped III line. Any grain split during the harvesting or storing operation should be disposed of immediately.

**H. SEED CLEANING**

The same stringent hygiene standards that apply during seeding and harvest operations also apply to seed cleaning.

Regular grain hygiene during the seed cleaning process is important.

When cleaning machinery between varieties use the following equipment:

- Compressed air
- Vacuum cleaner

Floor sweepings and spilt grain should be disposed of. Silos and bagged grain must have adequate labelling of a type not likely to be accidentally removed.

**I. PICKLING**

Pickling of grain should not commence until Basic seed sales and proposed cropping programmes have been calculated.

Care should be taken not to pickle grain in excess of requirements, as this leads to disposal problems.

Personnel involved with pickling must be aware of the safety requirements and application recommendations when using chemicals.

**J. SAMPLING**

Samples are to be forwarded as soon as possible after harvesting or grading of each variety.

Sampling at harvest and grading will be carried out in accordance with the standard departmental procedures on all Ped III and Basic seed lines. All samples are to be unpickled grain. Quantities required are:

**Harvest** - 2 kg forwarded to Seed and Inspection Services and 2 kg held at the Research Station - total sample required is 4 kg.

**Grading** - 2 kg forwarded to Seed and Inspection Services, 2 kg forwarded to Pedigree Seeds Officer at Wongan Hills Research Station, 2 kg held at the Research Station. 6 kg total sample required (the 2 kg sample forwarded to W.H.R.S. will be used to verify identification).

When samples are forwarded, staff are reminded that 2 kg only are required.
Samples being forwarded to Seed and Inspection Services are to be sent with the correct labelling.

**Labels required**

<table>
<thead>
<tr>
<th>From</th>
<th>Variety</th>
<th>Season</th>
<th>This is Harvester Sample</th>
<th>Paddock Crop History No.</th>
<th>Purity test to be provided</th>
<th>Is germination test required?</th>
<th>Yes/No</th>
<th>This is Grading Sample</th>
<th>Silo No.</th>
<th>Sample No.</th>
<th>Purity test to be provided</th>
<th>Germination test to be provided</th>
</tr>
</thead>
</table>

**OHMS**

To INSPECTOR IN CHARGE
SEED AND INSPECTION SERVICES
DIVISION OF PLANT PRODUCTION
DEPARTMENT OF AGRICULTURE
JARRAH ROAD
SOUTH PERTH W.A. 6151

URGENT
CEREAL INSPECTION
6. PREPARING FERTILISERS FOR FIELD EXPERIMENTS

A. INTRODUCTION 6.1

B. HANDLING BULK FERTILISERS 6.2
   1. Procedures at the South Perth fertilisers store 6.3

C. FERTILISER MIXING 6.2
   1. Mixing sheets 6.2
   2. Preparation of mixing 6.2
   3. Weighing out 6.3
   4. Mixing 6.4
   5. Fertiliser sample 6.4
   6. Packaging and labelling 6.4
   7. Despatch 6.5

D. PROPERTIES OF COMMON FERTILISER 6.8

E. HAND TOPDRESSING 6.8
   1. Introduction 6.8
   2. Small plot experiments 6.8

F. TIME OF APPLICATION 6.10

G. APPLICATION PROBLEMS 6.11
6. PREPARING FERTILISERS FOR FIELD EXPERIMENTS

A. INTRODUCTION

Fertilisers form an important part of most crop and pasture experiments. In many cases they may be applied as a basal treatment to give a uniform and adequate nutritional status to an experiment concerned with other aspects of crop and pasture production. In other cases the fertiliser itself may be the subject of the experiment.

It is important to realise that fertilisers may have effects other than to supply nutrients to the growing plant. For example, compound fertiliser (those containing more than one element - usually nitrogen and phosphorous) may affect the germination if sown in contact with some seeds. Many fertilisers are hygroscopic (absorb moisture from the atmosphere) and corrosive. These require careful handling and thorough cleaning of equipment after use. Some properties of common fertiliser are listed in Table 6.1.

B. HANDLING BULK FERTILISERS

Where commercial grade fertilisers are satisfactory, these can be ordered through South Perth or from the country fertiliser works located at Geraldton, Bunbury, Albany and Esperance. Table 6.1 lists the bag weights and number of bags per tonne for some common fertilisers.

1. Procedures at the South Perth Fertiliser Store

   a) Supplies. At the close of each season the Officer in Charge of the fertiliser store places a standing order to supply approximately 80 per cent of the next year's requirements for materials such as plain superphosphate, urea, and muriate of potash. He also orders limited supplies of other fertiliser and sufficient trace elements (bluestone, zinc oxide, etc.) to last the whole season.

   These estimates of fertiliser requirements are based on the previous year's usage and it is the responsibility of individual officers to notify the Officer in Charge of any marked changes in requirements before January 1, each year.

   Funds for fertiliser supplies come from the Division of Plant Research Budget and from individual officer's industry funds. Where other fertilisers are required such as special trace element mixes, compound fertilisers, etc. these should be ordered by the officer concerned after arranging the necessary funds. If these materials are to be handled through the fertiliser store the Officer in Charge should be informed when the order is placed.

   Supplies of cornsacks, plastic bags and liners, clean washed sand, wire ties, etc. are re-ordered each year and are available in the fertiliser store.

6.1
b) **Receiving stocks into store**

All officers using the fertiliser store are required to assist with unloading and stacking fertiliser deliveries.

* Mark the date and amount of each fertiliser received on the notice board provided.

* Stack fertiliser neatly in the marked storage areas for each type.

c) **Mixing.** For details of fertiliser mixing procedures refer to the later section. However, the following general rules should always be followed and the Officer in Charge of the fertiliser store has been instructed to ensure that all persons using the facilities maintain them in a satisfactory manner.

* Sweep out the mixing room at the end of each day and put sweeping in rubbish bins.

* Sweep up any split material immediately and put in rubbish bins.

* Keep the scales and scoops clean; wash if any residues adhere to the scale pan of scoops.

* Wash and scrub the inside of the mixing machine after each batch of mixing has been completed.

* Replace all items in allotted positions after use.

C. **FERTILISER MIXING**

Where fertilisers are required for nutritional experiments much greater care and precision is required in the preparation and handling of the fertiliser materials. This applies particularly to trace element research. The following procedures have been found to be effective in practice and should be followed at all times.

1. **Mixing sheets**

Details of the fertiliser mixtures required for each experiment should be written on a mixing sheet at the time the experimental schedule is prepared. Examples of mixing sheets are shown in Figures 6.1 and 6.2. Mixing sheets are available from the Division of Plant Research.

2. **Preparation of mixing**

a) Check that all materials and equipment required are available and that other officers are not occupying the mixing room.

b) Make sure that all equipment is absolutely clean. Scale pans, scoops, buckets, bins and the mixing machine should be washed thoroughly if there is any sign of fertiliser residue.

c) Check that the amounts of fertiliser material in store are sufficient to complete the mix with one, even line of each fertiliser needed.
It is extremely important that a single even line of each fertiliser is prepared for any one experiment. Different batches and even different bags within a single batch of fertiliser can vary significantly in composition and physical form. If undetected these differences can ruin an experiment. The texture of superphosphate, which is particularly variable, has caused a great deal of trouble. If the mixes for an experiment need more than one bag of super altogether, it is essential that bags be open before mixing so that sufficient super of similar consistency can be selected. Bags of fertiliser opened but rejected should be restacked neatly. Any lumpy material should be crushed up, particularly if for use in relatively small quantities. Fertiliser of different consistency will affect flow rate through the drill. Drills will be tested for different fertilisers - not for different bags of super. This means the consistency of all super must be identical.

3. Weighing out

a) Decide on the weights of material required for the mix.

(i) If the mixing sheet calls for several relatively small quantities or a few larger quantities of exactly the same composition these may all be prepared as one mix and weighed out into packets of the required weights after mixing.

  e.g. 20 packets each with 4 kg super + 2 kg ammonium sulphate. For this a single mix of 90 kg super + 45 kg ammonium sulphate would cover the 20 packets and allow a little excess for a sample. Twenty 6 kg lots would be weighed out after mixing.

  e.g. 5 packets each with 5 kg super + 50 g bluestone
  "    " "    " 10 kg " + 100 g "

  Here a single mix of 80 kg super + 800 g bluestone would provide sufficient for 5 packets of mixed material weighing 5.05 kg and another 5 packets of mix weighing 10 kg, plus excess for a sample.

(ii) For mixtures of total weight less than 20 kg it is necessary to provide for a little loss from residues left in containers and for the amount required for a sample.

  e.g. 2 packets each with 1 kg super + 0.5 kg muriate of potash + 15 g zinc oxide. A suitable mixture here would be 2.5 kg super + 1.2 kg muriate of potash + 37.58 g zinc oxide which provides for 2 packets each weighing 1.515 kg + excess.

Important - When amalgamating different mixing instructions or making additions to allow for sampling and wastage -

. be absolutely certain that the same ratio between the weights of different ingredients is maintained,

. check and double check your arithmetic.
b) Weight and composition of the weighed-out lot should be written on a tag which is placed on top of every lot of fertiliser held temporarily while other lots are weighed out. It is no good trying to memorise what each different lot consists of - write it down on the tag.

c) After weighing each lot of trace elements wash your hands before touching anything else. The commonly used trace elements are copper (as bluestone or copper ore), zinc, molybdenum, manganese, cobalt, iron and selenium.

4. Mixing

a) Method

(i) Mixes of total weight less than 1 kg: These are best mixed in a bucket or in a plastic bag. For mixing in a plastic bag the bag and its contents should be shaken and rolled around thoroughly for three to four minutes. In the bucket the mixture is stirred by hand. Particular care must be taken to mix material on the bottom and edges of the bucket with the rest.

(ii) Mixes of total weight 5 kg: These are best mixed in a bucket as in (i).

(iii) Mixes of total weight 5 kg plus: These should be mixed in the concrete mixer. Allow at least 4 to 5 minutes for each mix.

b) Make sure that nothing is missed out of the mix as you add the weighed out materials.

c) Clean, washed sand is supplied for mixing with very small samples. Use of soil or unwashed sand could result in significant contamination.

5. Fertiliser sample

A sample of each fertiliser used in each experiment is kept so the composition can be checked by chemical analysis if necessary. The sample is taken after mixing. Small handfuls or scoops are taken from three or more different parts of the mix to obtain a representative sample. This material is kept in screw-top jars which are numbered. The number of the jar containing the sample of the mix is immediately recorded on the mixing sheet in the space provided. Samples must be kept, as experiments have been ruined because of doubt regarding the composition of the fertiliser used. Few samples are ever needed but they more than justify the many kept and never used.

6. Packaging and labelling

a) Plastic bags are usually used for up to 5 kg, sugar bags lined with plastic bags are used for 20 kg. Cornsacks lined with plastic bags are used for 30 to 100 kg.
b) The total weights for each packet of each mix are calculated from the mixing sheet and, using appropriate scales, these amounts are weighed out into the bags. Each bag should be labelled with the experiment number and description shown on the mixing sheet.

c) Small plastic bags of mixtures are packed in cardboard or pine boxes for despatch. Waterproof, bituminised paper is used to line the boxes to minimise damage to the contents. The containers are labelled with the experiment number and an abbreviated description of the mixes. These details should be enclosed to avoid any confusion with the rail address which is also marked on the outside of the containers.

d) The names of the person/s mixing and sampling and the dates on which these were done should be recorded on the mixing sheet.

7. Despatch

Completed mixes should be despatched by the person/s mixing as quickly as transport can be arranged.

The weight of materials and experiment number for materials to be railed should be entered in a rail despatch book by the person who has done the mixing.

Copies of the consignment note should also be sent to the consignee (e.g. District Office, Research Station, etc).

Details of despatch should be recorded on the mixing sheet and, after despatch, the sheet should be filed for future reference if any query should arise.

Packages sent by rail should be clearly labelled.

D. PROPERTIES OF COMMON FERTILISERS

The following tables give some properties of common fertilisers and trace elements. These are correct as at January 1981 but bag weights and fertiliser compositions may change from time to time.

The list of registered fertilisers published periodically by the Department of Agriculture indicates manufacturers and composition of all fertilisers registered in Western Australia.
Table 6.1 - Properties of common agricultural fertilisers

<table>
<thead>
<tr>
<th>Fertiliser</th>
<th>Bag Wt Kg</th>
<th>Bags/t</th>
<th>Hygroscopic</th>
<th>Acidifying effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Rock Phosphate</td>
<td>83</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superphosphate</td>
<td>83/50*</td>
<td>12/20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double Super</td>
<td>71/50</td>
<td>14/20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triple Super</td>
<td>71</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonium Sulphate</td>
<td>71</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urea</td>
<td>56/50</td>
<td>18/20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonium Nitrate</td>
<td>62.5/50</td>
<td>16/20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muriate of Potash</td>
<td>83</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulphate of Potash</td>
<td>50</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agras No 1</td>
<td>71</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agras No 2</td>
<td>71</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAP</td>
<td>62</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DAP</td>
<td>62</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-1 Super Potash</td>
<td>83/50</td>
<td>12/20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-2 Super Potash</td>
<td>83/50</td>
<td>12/20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Where two figures are given, the first refers to woven polypropylene bags and the second to polythene bags.
Table 6.2 - Composition of common agricultural fertilisers

<table>
<thead>
<tr>
<th>Fertiliser</th>
<th>Per cent Composition*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% N</td>
</tr>
<tr>
<td><strong>PHOSPHATE SOURCES</strong></td>
<td></td>
</tr>
<tr>
<td>Ground Rock Phosphate</td>
<td>-</td>
</tr>
<tr>
<td>Superphosphate</td>
<td>-</td>
</tr>
<tr>
<td>Double Super</td>
<td>-</td>
</tr>
<tr>
<td>Triple Super</td>
<td>-</td>
</tr>
<tr>
<td><strong>NITROGEN SOURCES</strong></td>
<td></td>
</tr>
<tr>
<td>Sodium Nitrate</td>
<td>16</td>
</tr>
<tr>
<td>Ammonium Sulphate</td>
<td>21</td>
</tr>
<tr>
<td>Urea</td>
<td>46</td>
</tr>
<tr>
<td>Ammonium Nitrate (Agran 34:0)</td>
<td>34</td>
</tr>
<tr>
<td><strong>POTASSIUM SOURCES</strong></td>
<td></td>
</tr>
<tr>
<td>Sulphate of Potash</td>
<td>-</td>
</tr>
<tr>
<td>Muriate of Potash</td>
<td>-</td>
</tr>
<tr>
<td><strong>COMPOUND FERTILISERS</strong></td>
<td></td>
</tr>
<tr>
<td>Agras No. 1</td>
<td>17.5</td>
</tr>
<tr>
<td>Agras No. 2</td>
<td>12.0</td>
</tr>
<tr>
<td>MAP</td>
<td>12.0</td>
</tr>
<tr>
<td>DAP</td>
<td>18.0</td>
</tr>
<tr>
<td>5-1 Super and Potash</td>
<td>7.4</td>
</tr>
<tr>
<td>3-2 Super and Potash</td>
<td>5.3</td>
</tr>
</tbody>
</table>

* Prior to 1978 the proportions of phosphorus (P) and potassium (K) in fertilisers were expressed as phosphoric acid (P₂O₅) and potash (K₂O) respectively. These terms should no longer be used, but if they are encountered, the appropriate conversion is:

\[
1\% \text{ P}_2\text{O}_5 = 0.44\% \text{ P} \\
1\% \text{ K}_2\text{O} = 0.83\% \text{ K}
\]
Table 6.3 - Chemical composition and molecular weight of commonly used trace elements

<table>
<thead>
<tr>
<th></th>
<th>Formula</th>
<th>Molecular Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper Sulphate</td>
<td>Cu SO₄.5H₂O</td>
<td>249.7</td>
</tr>
<tr>
<td>Zinc Oxide</td>
<td>Zn O</td>
<td>81.4</td>
</tr>
<tr>
<td>Molybdenum Trioxide</td>
<td>MoO₃</td>
<td>144.0</td>
</tr>
<tr>
<td>Sodium Molybdenum</td>
<td>Na₂MoO₄.2H₂O</td>
<td>241.9</td>
</tr>
<tr>
<td>Manganese Sulphate</td>
<td>MnSO₄.4H₂O</td>
<td>223.1</td>
</tr>
<tr>
<td>Cobalt Sulphate</td>
<td>Co SO₄.7H₂O</td>
<td>281.1</td>
</tr>
<tr>
<td>Borax</td>
<td>H₃BO₃</td>
<td>61.8</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Mg SO₄.7H₂O</td>
<td>246.5</td>
</tr>
</tbody>
</table>

E. HAND TOPDRESSING OF FERTILISER

1. Introduction

Experimental plots should never be hand topdressed if it is possible to apply the fertiliser by machine. However, there are three main types of experiment where hand topdressing has to be used:

* Small plot experiments
* Time of application of fertiliser experiments.
* Experiments testing fertiliser that will not flow satisfactorily through a drill.

2. Small plot experiments

Procedure

a) Before going into the field, check the fertiliser to see that all packets are present.

b) At the plots, group all packets of each treatment together and arrange the treatments in numerical sequence to facilitate the placement of each packet on the appropriate plot.

c) Using the project sheet, and being careful to orientate north on the plan with north in the paddock, place all the packets on their respective plots. The packets should be placed well into each plot, not just alongside a corner peg. This reduces the chance of topdressing the wrong plot, e.g. topdressing a "nil" plot, for which there is no bag.

d) Check that each bag is on the correct plot. This should preferably be done by an operator who has not already used the project sheet to place the bags on the plots.
e) If possible, each block should be topdressed by the one operator. Operators vary in their efficiency but if each block is topdressed by the one operator all the treatments in a block are done in a similar manner.

f) The plot receiving the lowest rate of fertiliser should always be treated first, and the other treatments applied in ascending order of rate. This minimises the chance of topdressing part of the plot at too high a rate.

g) Tip half the fertiliser from one bag into a plastic bucket and carefully note the four corner pegs of the plot.

It is possible to mistake an adjacent plot peg for the corner peg of the plot being topdressed, particularly if the plots are narrow. If this happens two plots are mistreated.

h) All operators are not suited by the one method of hand topdressing but, as long as the fertiliser is spread evenly over the whole plot, any method can be used. The following method should be satisfactory for the right handed person.

Commence on the corner peg A looking along the long side of the plot to the corner B, with the plot to the left. Walk along a line parallel to AB but about 18 inches inside the plot. The natural swing of the arm should allow the edge of the plot AB to be sharply delineated. One handful of fertiliser should be released over a number of swings or flicks of the arm and never all at once. The fertiliser can be held fairly tightly in the hand and small amounts released past the extended thumb and index finger. When topdressing low rates take only a very small amount of fertiliser in the hand at any one time. With such low rates it is very easy to apply too high a rate for the first part of the plot.

The plot is completed by continuing around the plot and repeating the process commencing at a point E, etc.

i) Tip the other half of the fertiliser into the bucket and repeat the process. If the centre of the plot was treated a little lightly with the first half of the fertiliser, it is given a heavier rate with the second half. Always remember in each operation it is better to apply the fertiliser too lightly than too heavily.

j) On windy days the fertiliser must be released close to the ground. It is also sometimes preferable to mix the fertiliser with moistened soil. Soil for this purpose should only be dampened. Wet soil is difficult to spread evenly.
k) When very small amounts of fertiliser have to be applied they should be mixed with dry sand. If this hasn't been done previously it should be done in the field. If the fertiliser is coarse textured (e.g. coarse super granules), it is unsatisfactory to mix it with dry sand as it cannot be spread uniformly. In some cases, only moist soil may be available and if so, the fertiliser should be sprinkled slowly over the soil while mixing. An uneven mixture can result if all the fertiliser is poured into one spot of the moist soil.

Common errors in hand topdressing plots

a) Edges of the plots not sharply defined and the fertiliser not spread out to the edge of the plot.

b) Too much fertiliser spread along the edges with less towards the centre where practically none is applied.

c) Regular, uneven distribution over the whole plot – largely because the operator has not scattered the fertiliser but has tended to drop handfuls in small heaps all over the plot.

It is a good thing for new operators to write into a notebook the location of the plots they topdress so that any bad habit can be noted when the plots are viewed during growth.

F. TIME OF APPLICATION

If a number of "time-of-application" treatments of a fertiliser (to cereals) are being tested, it could be inconvenient to bring the drill to the plots each time a fertiliser treatment must be applied. Also, the passage of a Landrover or tractor down 12 row plots during the growth of the cereal can do considerable damage. It is therefore necessary to apply the fertiliser by hand. Hand topdressing also ensures that the same rate of application is applied each time. If a drill or combine is used each time it may not be possible to get the same rates of application (each time) because flow rate of fertiliser can vary from day to day with weather conditions.

Procedures are similar to those used for small plot experiments.

Considerable damage can be done to cereal plots by trampling during hand topdressing. It is advisable therefore to keep off the plot during the operation. This necessitates going around the plot in a clockwise direction, half the plot being covered in each run along the plot.

Remember that if the fertiliser rates have been calculated on a plot width of 2.1 metres, fertiliser should be broadcast on land extending about 8 cm beyond each outside row (i.e. row 1 and row 12). The width of a plot sown with a 12 run drill is 2.1 metres unless specifically stated otherwise on the project sheet.

When planting drill-sown plots there is a considerable over-run. Care must be taken not to topdress such sown areas which are outside the plot. The end of the plot can be delineated by placing a sighter peg on the corners of the experiment and one on the line joining these pegs. It often helps to drive a vehicle on line to mark the end of the plots.

6.10
G. APPLICATION PROBLEMS

Usually, fertiliser that is not free-flowing through a drill will be difficult to apply by hand, as it is finely ground and blows readily. Unless topdressing is done on a very still day such fertiliser is probably best mixed with damp sand before topdressing.

Procedures are similar to those used for small plot experiments.

Fertiliser spreading technique can be checked by pegging out an area on bare ground (e.g. 5 m x 5 m = 1/400th hectare), weighing out a packet of fertiliser (e.g. 500 gm = 200 kg/ha) and hand topdressing the plot. If a fertiliser such as ammonium nitrate is used, the white fertiliser can easily be seen on the bare ground and the evenness of distribution ascertained.

Figure 6.1

Fertiliser Mixing Sheet

Experiment No. 62GE9, 62GE10

Farmer or Research Station: C/- Department of Agriculture, Geraldton

Postal Address: Geraldton

Details of Despatch:

<table>
<thead>
<tr>
<th>Method</th>
<th>Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consignee</td>
<td>Department of Agriculture</td>
</tr>
<tr>
<td>Destination</td>
<td>Geraldton</td>
</tr>
<tr>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>Despatched by</td>
<td></td>
</tr>
</tbody>
</table>

Details of mixing:

| Mixing by |            |
| Date      |            |
| Sampled by |            |
| Date      |            |

Field officer to be notified:

<table>
<thead>
<tr>
<th>Treatment No.</th>
<th>Details of Mixtures and Packeting</th>
<th>Label Shown on Packet</th>
<th>Sample Bottle No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4,6</td>
<td>4 bags each with 50 kg urea</td>
<td>62GE9</td>
<td>Urea</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trs. 2,4,6</td>
<td>Repeat for</td>
</tr>
<tr>
<td></td>
<td></td>
<td>62GE10</td>
<td></td>
</tr>
</tbody>
</table>

6.11
Figure 6.2

Fertiliser Mixing Sheet

Experiment No.: 64KA1, 64KA6

Farmer or Research Station: C/- Department of Agriculture, Katanning

Postal Address: Katanning

Details of Despatch:

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<tr>
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</thead>
<tbody>
<tr>
<td>Consignee</td>
<td>Department of Agriculture</td>
</tr>
<tr>
<td>Destination</td>
<td>Katanning</td>
</tr>
<tr>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>Despatched by</td>
<td></td>
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</table>

Details of Mixing:

<table>
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<tr>
<th>Mixing by</th>
<th>Date</th>
<th>Sampled by</th>
<th>Date</th>
</tr>
</thead>
</table>

Field officer to be notified:

<table>
<thead>
<tr>
<th>Treatment No.</th>
<th>Details of Mixtures and Packeting</th>
<th>Label Shown on Packet</th>
<th>Sample Bottle No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 bag with 75 kg super Tr. 1</td>
<td>64KA1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1 bag with 15 kg super + 400 g bluestone</td>
<td>Tr. 2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1 bag with 15 kg super + 200 g zinc oxide</td>
<td>Tr. 3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1 bag with 15 kg super + 400 g bluestone + 200 g zinc oxide</td>
<td>Tr. 4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1 bag with 15 kg super + 400 g bluestone + 200 g zinc oxide + 17 g roasted molybdenite</td>
<td>Tr. 5</td>
<td></td>
</tr>
<tr>
<td>Basal</td>
<td>50 kg urea</td>
<td>Urea</td>
<td>Repeat for 64KA6</td>
</tr>
</tbody>
</table>

6.12
### 7. SEEDING EXPERIMENTAL TRIALS

#### A. DISC DRILLS AND COMBINES

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
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<tbody>
<tr>
<td>1. The Schedule</td>
<td>7.1</td>
</tr>
<tr>
<td>2. Testing the Drill</td>
<td>7.1</td>
</tr>
<tr>
<td>3. Pre-seeding Treatments</td>
<td>7.2</td>
</tr>
<tr>
<td>4. Seeding Depth</td>
<td>7.2</td>
</tr>
<tr>
<td>5. Checking the Drill</td>
<td>7.2</td>
</tr>
<tr>
<td>6. Reference Cards</td>
<td>7.2</td>
</tr>
<tr>
<td>7. Seeding the Trial</td>
<td>7.2</td>
</tr>
<tr>
<td>8. Keeping Records</td>
<td>7.3</td>
</tr>
<tr>
<td>9. Cleaning Out the Box</td>
<td>7.3</td>
</tr>
<tr>
<td>10. Other Seeding Systems</td>
<td>7.3</td>
</tr>
<tr>
<td>11. A Pre-seeding Checklist</td>
<td>7.4</td>
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#### B. WORKING WITH CONE SEEDERS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
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<tbody>
<tr>
<td>1. Introduction</td>
<td>7.4</td>
</tr>
<tr>
<td>2. Pegging Out the Trial Area</td>
<td>7.6</td>
</tr>
<tr>
<td>3. Planting a Trial</td>
<td>7.7</td>
</tr>
<tr>
<td>4. Some Disadvantages of Cone Seeders</td>
<td>7.9</td>
</tr>
</tbody>
</table>
7. SEEDING EXPERIMENTAL TRIALS

A. DISC DRILLS AND COMBINES

1. The schedule

Before going out to seed a trial, read the schedule carefully and be sure that the aims of the experiment and the methods to be used are fully understood. If any doubts arise, contact the officer concerned and clarify what is required - once out in the field it will be too late! While checking the schedule make up the reference cards listing the plots which will receive each treatment and the order in which they will be sown.

2. Testing the drill

If site preparation is satisfactory, test the drill to determine rates and drill settings.

A test run should firstly be measured and marked accurately. A twelve run drill usually has an effective sowing width of 2.1 m and, therefore, a run of 95 metres will give a test of one fiftieth of a hectare.

\[ 2.1 \text{ m} \times 95 \text{ m} = \frac{1}{50} \text{ ha} \]
\[ 20 \text{ gm of test run} = 1 \text{ kg/ha} \]

The sowing chart of the drill should be consulted and a rate close to that required should be chosen. The chart sets out the gear setting needed to give this rate. The appropriate change cog should be selected and the number of teeth on this cog checked. A check should then be made to ensure that the correct gear is used.

When a rate for either seed or fertiliser is to be tested the other drive should be taken out of gear. If the seed is being tested the seed box should be adjusted to either the fine or coarse side depending on which is required. All the stars in the fertiliser box should be turned back so they begin turning as soon as the machine is moved. The seed or fertiliser should then be placed in the drill.

The fertiliser has to be running right from the start of the test run so the drill should be put in gear when moving it up to the starting point. Check that fertiliser is running from each hose.

The hoses should then be taken out of the boots and the calico bags or testing canvas slung under the drill so that the ends of all the hoses empty into it. The calico bags or canvas should not be so high that the open ends of the hoses touch the bottom of the canvas, as this may cause a blockage in the hoses. If the canvas is too low there is a danger that the ends of the hoses may come out of the canvas during testing.

The drill is then ready for testing, but, before the run is started, all gear settings and the abovementioned steps should be run and a careful watch should be kept on the drill to make sure that it is functioning properly and there are no blockages in the tubes.

The drill is stopped at the end of the run and the bags or canvas carefully removed. The contents are poured into a bucket and weighed. By making allowance for the weight of the bucket, the amount of seed or fertiliser obtained from the run can be determined.
The rate actually put out by the drill is compared with that given in the table for the drill setting used. This will serve as a guide for settings for other tests to obtain the desired rates.

Watch for variation in fertiliser

There is often considerable variation in the texture of various batches of fertiliser which could greatly affect the rate applied by the drill at a particular setting. Therefore, fertiliser in a similar condition to that which will be applied on the experiment should be used in the tests. Batches of fertiliser with a high proportion of fine material will generally run at a much lower rate than more granulated forms.

The rate of flow of many fertilisers, such as urea, is also affected considerably by the weather conditions at the time. Dry urea will run at a much faster rate than urea which has taken up some moisture from the atmosphere. Test runs should therefore be made close to the time of application.

3. Pre-seeding treatments

Basal treatments, such as trace elements mixed with sand or an overall dressing of urea, should be applied across the direction of the plots prior to seeding.

Plot treatments not sown with the seed should also be applied prior to seeding wherever possible. Running a vehicle over the plots after seeding causes compaction which may affect germination and growth.

4. Seeding depth

The discs or points should be turned into the ground and the depth of seeding checked by making a short run with the drill. The seed should be dug up to estimate its depth.

5. Checking the drill

Before commencing each seeding treatment a number of checks should be made:

a) Check the drill setting.
b) Check that all gears are engaged properly.
c) Check that the hoses are not blocked and are in the boots.
d) Check that there is adequate fertiliser and seed, and that they are spread evenly.
e) These points should be double checked by another member of the team.

6. Reference cards

Reference cards should be made out for at least two members of the team indicating which plots should receive each treatment and the order in which these will be sown.

7. Seeding the plots

Ideally, there should be at least four members in the planting team - a driver for the tractor and to operate the drill, a member to ride on the back of the drill and to keep an eye on the working of the drill and one member at each end of the plots to attend the sight sticks. At the end
where the tractor and drill enter the plot a sight stick should be placed in the ground directly in front of the numbered peg for the appropriate plot. At the other end of the plot a sighter peg should be similarly placed with the numbered peg. A further sighter at this end should be placed some distance further back and lined up with the two sighters on the ends of the plot. These sighters should be vertical and placed in the ground firmly enough to prevent them being affected by the wind. By keeping these sighters in a straight line with himself, the tractor driver can sow a straight plot.

The drill should be put into gear some distance before entering the plot to make sure that it is sowing correctly when it actually enters the plot.

Teams of less than four members can effectively seed experiments, but where seed or fertiliser quantities are limited it is essential for one team member to ride on the drill to ensure even distribution to all cups. He should also keep an eye on all the hoses to make sure that they do not become blocked and that they are sowing correctly.

Each member of the team must know his own responsibilities and is encouraged to check for any mistakes made by other members of the team.

8. Keeping records

Date of seeding and all rates of fertiliser and seed actually applied to the plots should be recorded. All changes in the experiment or mistakes made should also be recorded on the schedule.

9. Cleaning out the box

When different fertiliser mixes are used in different treatments the fertiliser box should be cleaned out before each treatment. Particular care should be taken cleaning out between trace element mixes.

For those treatments where there is danger of contamination the treatments should be sown in a particular order which will minimise this danger. This order should be set out in the Project Sheet, e.g. with a trial including copper, zinc and molybdenum, the treatments without trace elements should be sown first. The copper treatments should then be sown, followed by the zinc treatments, followed by the molybdenum treatments. The reason for this is that only a small amount of molybdenum is needed to provide an adequate level and a small amount of contamination could affect the results.

10. Other seeding systems

Where other sowing systems are used, such as zero tillage (triple disc drill) or minimum tillage (combine with narrow points), the same basic principles apply as for conventional seeding methods described above. However, it is even more important to check seeding depths where the different systems are compared in the same trial.
11. Pre-seeding check list

Equipment

- Drill and prime mover
- Harrows
- Stars
- Change cogs
- Tools - grease gun, spanners, etc.
- Clean-out winder, brush and scoop
- Spare parts (hoses, shear pins)
- Cog chart
- Measuring tape
- Sight sticks
- Numbered pegs
- Corner pegs
- Prism square
- Knife
- Scales
- Calico bags or testing sheet
- Bucket
- Tarpaulin
- Schedule
- Reference cards
- Field note pad
- Pencil
- Supplies
- Seed
- Fertiliser
- Chemicals

B. WORKING WITH CONE SEEDERS

1. Introduction

Cone seeders have become increasingly popular in agricultural research because of their versatility. Cone seeders provide the opportunity to rapidly change seed type, rate of seed, fertiliser type and rate of fertiliser in the process of planting a trial. These changeovers can be done without stopping the machine between plots, allowing the experimenter to plant a trial systematically by plots rather than having to plant plots in treatment order. This means the trials can be planted very rapidly: In the plant breeding situation with plot lengths of 5 metres, trials can be planted at the rate of 1,000 plots per hour.

The basic component of these seeders is a cone (the process is best understood by reference to Figure 7.1). Seed is loaded into a funnel situated on the apex of the cone. At the start of a plot the funnel is lifted allowing the seed to distribute uniformly around the base of the cone. The seed is retained at the base of the cone by the vertical, flexible belt which (in the process of planting the plots) revolves with the cone to the site where the three rollers direct the belt away from the cone. This allows the seed at that point to drop from the cone down through a distributor and thereby through the seeding tyne into the soil.

The cone is geared to move through one complete revolution in the length of one plot. This means that every seed placed into the cone is seeded within a plot length-allowing for immediate reloading of the cone with seed of the next plot. Clean-out is unnecessary. While one plot is being planted the seed for the next plot can be loaded into the funnel so that immediately a plot has been sown seed can be dropped for the next plot. This allows seeding to proceed on a non-stop basis. Many cone seeders are capable of planting more than one plot at a time. Generally there is one cone on a machine for each plot planted.
Cone seeders operate most efficiently when planting plots which follow one another end-on-end. To avoid confusion, seed should be arranged into planting order before the trial is commenced. This is particularly so when the machine is planting more than one plot at a time. Planting orders can best be understood from Figures 7.2a and 7.2b which show the layout for trials planted with single and twin cone machines respectively. Seed is preferably placed in planting order during seed preparation in the laboratory. Planting orders can be complex, particularly in situations where two or more cones are used simultaneously, and there are computer programmes available to produce special labels to simplify this procedure. In all cone seeders currently used in the Department of Agriculture, seed is loaded into the cone from packets but in some equipment used in other organisations seed is loaded into the cones by magazine, seed-dispensing systems.

**FIGURE 7.2a Single cone seeder**

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**FIGURE 7.2b Twin cone seeder**

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<td>PL 4B</td>
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<tr>
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<td>PL 8A</td>
<td>PL 9A</td>
<td>PL 16B</td>
<td>PL 17A</td>
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</table>
2. **Pegging trial areas for cone seeders**

This is best understood by considering an example of a trial using twenty metre plots planted three plots deep and needing forty runs of a 2.5 metre wide cone seeder. The area required for such a trial, would be 60 metres deep by 100 metres wide. To this width of 100 metres normally 2.5 metres are added to allow room for marking pegs. Consider Figure 7.3.

To work out a trial to be planted by a cone seeder firstly decide on a base line. Normally the base line is the width of the trial, A1 to B1 on Figure 7.3. Once the location of the base line is established (e.g. 15 m from a fence line), a right angle can be taken on the corner peg A1. The depth of the trial can then be measured and pegs A2, A3 and A4 put in to mark the sections.
The base line A1B1 can then be measured with paper markers P1, P2 and P3 being placed every 25 m and B1 peg at the end. A right angle can then be taken on B1 and pegs B2, B3 and B4 may be measured and placed. The remaining unmeasured side A4B4 can then be measured with paper markers P4, P5 and P6 placed at 25 m intervals. The line A4B4 must be measured from the A4 end.

Drop lines can then be put in with vehicle between pegs A1 and B1, A2 and B3, A3 and B3, A4 and B4. These lines enable the cone seeder operators to know when to drop the next set of plots.

3. **Planting a trial**

Because of the opportunity to plant trials systematically there is a much reduced need to use sight pegs in planting trials. Many of the cone seeders in the Department use a run marking tool that scratches a mark in the ground for the following run while the current run is being seeded. Once the first run has been put in squarely with sight pegs, subsequent runs can be planted without further reference to sight pegs. Every 25 metres the driver has the opportunity to square up his driving using paper markers placed at the time of pegging up.

Before planting and during planting a number of items should be checked:

1. The machine must be geared to plant the correct plot length and tested under the soil conditions similar to those of the trial. Make sure the machine plot length is a fraction shorter, and definitely no longer, than the pegged-up length.

2. While plot length is being tested, the machine should also be tested for depth in that particular soil condition. It is important that this depth be tested with the numbers of operators on the machine that will be used during the planting of the trial.

3. If the machine is capable of planting a number of different plot types, then the machine should be checked to make sure that it is set up for the required plot type.

4. Depth should be regularly checked during planting so that the operators can adjust for any changes in depth of seeding that may occur due to changes in soil composition. It is absolutely essential that the 'electrics' be checked to ensure that they are securely connected to the power supply on the tractor and where multiple row plots are being planted that the electric spinners are operating. Spinners should be regularly checked throughout the course of planting a trial.

5. When loading seed on to the machine at the start of a trial, it is essential to check that the right packets are loaded with the right cone.

6. Trials should be planted at a rate which is comfortable for the operators to load the funnels, drop the seed, and grasp the packet for the next loading. Experience has shown that errors are more likely when the rate of operation is faster and slower than a
comfortable rate of seeding. Experience has also shown that errors are minimised when an operator does not remove the next seed packet from its holder until after the previous plot has been dropped from the funnel.

7. During the course of sowing a trial, periodic checks need to be made on tubes and boots to make sure that blockages have not occurred. Planting orders should be checked at least at the end of each run, and preferably during the runs.

8. If a mistake occurs in the process of planting a trial it is important that the machine not be stopped until the end of the current plot. This is absolutely critical in short plots where most of the plot can be lost by stopping in the middle, due to the delay in seed reaching the ground when seeding is re-started.

9. In most situations, trials are planted non-stop and this requires that timing for dropping seed into the cone be co-ordinated with the rate of sowing. Because there is a time delay between the seed dropping from the funnel and reaching the soil, it is necessary to drop the seed some distance before the intended starting point. How early the drop is made will depend on how fast the machine is travelling.

10. When using the run marker system, it is the driver's responsibility to ensure that he is not creeping on the trial width, and so avoid a situation whereby there is insufficient room to plant all the runs.

Errors due to operator mistakes can be of many types; the following procedures indicate how the three most common errors can best be minimised.

. Failure to drop seed at correct time

It is essential that the operator does not panic. Provided seed has not been dropped the operator should immediately signal the diver to stop the machine. The machine should then be taken out of gear, the tynes lifted out of the ground, and the machine reversed back to the position where the drop should have occurred. The machine should then be put into gear, the depth reset and the seed dropped as the machine commences operation again.

. Double loading of plots into cone

It is not possible to correct this mistake, as you have mixed two different lots of seed together in the funnel. It is important, however, at the end of the plot where this is detected, to stop the machine and take notes of the trial name and the plot numbers where this error has occurred. This error can best be minimised by adopting the procedures described previously.

. Failure to load a cone, particularly on a multi-cone machine

Provided this error is detected before the next lot of plots are dropped, this error can be overcome by hand seeding the plot that has been missed. Again this error is minimised by adopting the procedures described previously.
It is strongly advised that inexperienced operators be given the opportunity to practice on the machine in dummy runs, before a proper trial is undertaken.

Due to the system of continuous planting the demarcation between plots is not always obvious and it is considered an advantage to spray out narrow pathways between sections when the plots have germinated. This allows for easier note taking and subsequent application of herbicides and other treatment. Because these pathways are often used as the guide for spraying and subsequent trimming before harvest, it is imperative that they be sprayed accurately.

4. Some disadvantages with cone seeders

Cone seeders have both mechanical and electrical components, which means more than one source of machine failure. Some machines, particularly multi-cone machines, because of the number of options available on the machine, require care to make sure the correct combinations are in use.

Because of the principle of seed distribution on the cone, these machines are susceptible to rain, strong wind and, in some cases, severe slopes. The effects of weather conditions are usually minimised by building a weather-proof cab over the machine.

Very few of the cone seeders available within the Department are fitted with fertiliser boxes. Trial areas must be top dressed prior to trial seeding.

Because of the potentially rapid rate of sowing trials, errors which are not detected and recorded immediately can often go undetected. It is therefore strongly recommended that computing facilities available to simplify the setting up of cone seeder trials be used to minimise errors.

The machine needs to be frequently checked because if blockages occur, many plots can be lost.
FIGURE 7.2 a)
SIDE VIEW

FIGURE 7.2 b)
Top View

Direction of Rotation
# 8. Principles of Weed Control

## A. Introduction

## B. Formulations

## C. Mode of Entry

1. Contact
2. Foliage translocated
3. Root absorption

## D. Classification and Activity of Herbicides

## E. Mode of Action

## F. Reasons for Selectivity

1. Differential wetting
2. Location of growing point
3. Growth habit
4. Entry of herbicides into leaf
5. Movement within plants
6. Placement of the herbicide
7. Plant tolerance to herbicides

## G. Fate of Herbicides

1. Volatilisation
2. Photo-chemical breakdown
3. Chemical
4. Microbial
5. Leaching
6. Adsorption
7. Plant uptake
H. RESIDUAL ACTION AND BREAKDOWN

I. PERSISTENCE OF HERBICIDES

J. TOXICITY OF HERBICIDES

K. HANDLING EXPERIMENTAL CHEMICALS

L. HAZARDS TO NON-TARGET PLANTS
   1. Drift
   2. Volatility
   3. Soil residues
   4. Water bodies
B. PRINCIPLES OF WEED CONTROL

A. INTRODUCTION

A herbicide is a chemical used to kill plants. A selective herbicide is one which can be used to kill some plants, usually weeds, without killing others (crops or pastures). A non selective herbicide is one which has some effect on all plants with which it comes in contact.

A commercial herbicide product contains the active ingredient, which kills the weed, plus other inert constituents, such as emulsifiers, which enable the product to be applied with a convenient liquid carrier - usually water.

The chemical name describes the chemical structure of the active ingredient, such as 2,4-dichlorophenoxy acetic acid.

Every commercial herbicide has a chemical name which describes the chemical structure of the active ingredient, a simplifying common name and one or more trade names adopted by manufacturers of the product.

Some examples are:

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>Common Name</th>
<th>Trade Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,1'-dimethyl-4,4'-bipyridylium cation</td>
<td>Paraquat</td>
<td>Grammoxone</td>
</tr>
<tr>
<td>2,4-dichlorophenoxy acetic acid</td>
<td>2,4-D Ester</td>
<td>Estone 80</td>
</tr>
<tr>
<td>N'(3,4-dichlorophenyl)-N-methoxy-N-methylurea</td>
<td>Linuron</td>
<td>Alfalon</td>
</tr>
</tbody>
</table>

At present the common names of more than 70 chemicals and the trade names of more than 200 products (including mixtures of chemicals) are registered for use as herbicides in Western Australia.

The full list of herbicides, together with their common and trade names, is published in Bulletin 4061 "Herbicides Registered in Western Australia June 30, 1979". This is updated annually.

It is desirable to use the common name of a herbicide on experimental schedules and internal reports. The use of trade names should be restricted to when there is only one manufacturer of a particular herbicide, or where the use of the common name would cause confusion.

B. FORMULATIONS

1. Wettable powders. These are insoluble in water, but the particles are fine enough to allow them to form a suspension in water. The powder rapidly settles in water if left to stand, and constant agitation while spraying is needed to maintain the suspension, e.g. linuron, tribunil, diuron.

2. Flowable powders. These are a recent development where the addition of a dispersing agent to a wettable powder allows the powder to remain as a stable suspension when mixed with water as the carrier. Agitation during spraying is desirable, even though they settle out much more slowly than wettable powders, e.g. atrazine, diuron, simazine.
3. **Soluble powders.** These will dissolve in water to form a clear solution. Sufficient water must be used to completely dissolve the powder, e.g. 2,4-DPA. Soluble powders will evaporate readily and are less suitable for mister or aerial application.

4. **Water-miscible liquid.** Like the powder, this will mix with water to form a relatively clear, stable solution, e.g. 2,4-D amine, glyphosate. Liquids evaporate readily and are less suitable for mister and aerial application.

5. **Emulsifiable concentrates.** These are products which contain an active ingredient that is only soluble in oil or other organic solvents.

Emulsifying agents are added to disperse the oil in water to form a stable emulsion. These products can be mixed with either water, distillate or kerosene as the carrier. When mixed with water they form a milky solution. Emulsifiable concentrates are suitable for misting and aerial spraying because the oil particles containing the active ingredient do not evaporate readily.

They are more hazardous to non-target crops because the intact spray can drift for a greater distance than other formulations, e.g. 2,4-D ester.

6. **Invert emulsions.** These are products in which the active ingredient is dissolved in water which forms an emulsion when oil is added. As more oil is added so the product becomes less viscous, e.g. 2,4-D and 2,4,5-T for brush control. No invert emulsions are registered in Western Australia.

7. **Granules.** These contain the active ingredient on inert clay as a pellet which has a low solubility in water so that the herbicide is slowly released.

Granules are particularly suitable for some long term total vegetation control programmes (e.g. around power poles) and aquatic weed control. The high cost of the granule may be offset by the convenience of not having to use large volumes of water as the herbicide carrier, e.g. Hyvar X granules.

8. **Dusts.** These contain the active ingredient in an inert medium such as Kaolin. This formulation is more suitable for applying fungicides and insecticides.

C. **MODE OF ENTRY**

There are three ways a herbicide can enter a plant.

1. **Contact**

The herbicide lodges on the leaves, and after entering the leaf there is little or no further movement within the plant. The toxic reaction occurs at the point where the herbicide first contacts the plant, e.g. paraquat, diquat, bromoxynil.
2. **Foliage translocated**

The herbicide lodges on the leaves, enters the leaf and is translocated throughout the plant (including the roots) by way of the vascular strands. Thus the toxic reaction may occur away from the point of entry of the herbicide into the plant, e.g. 2,4-D, dicamba, glyphosate, 2,2-DPA.

3. **Root absorption**

After being sprayed on to the soil the herbicide enters the plant through the roots or an emerging shoot where it may act directly or be translocated to the rest of the plant and act away from the point of entry, e.g. bromacil, diuron, dacthal, trifluralin.

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**Practical implications**

- Contact herbicides need sufficient water to cover the target plant but not so much that run-off occurs.

- Contact and foliage-translocated herbicides may wash off the plant and be ineffective if rainfall occurs within three to six hours of spraying.

- Complete coverage of the plant is not essential with foliage translocated herbicide so they can be effective in low water volumes.

- Moderate rain after spraying root-absorbed herbicides can hasten the entry of the product into the soil and so improve its activity. Some root-absorbed herbicides require rain or mechanical incorporation to prevent their loss from the soil by photochemical breakdown or volatilisation. However, if heavy rain causes flooding and surface movement of water after spraying then the results may be poor and non-target plants away from the sprayed area may be killed.
D. CLASSIFICATION AND ACTIVITY OF HERBICIDE

The table below shows the relative importance of the three methods of herbicide entry into the plant

1 = most important
2 = secondary importance
3 = minor importance
- = does not occur at all.

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<tr>
<td>Aromatic</td>
<td>dicamba</td>
<td>1</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Carboxylic acids</td>
<td>chlorthal; DCPA</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Phenols</td>
<td>DNBP; dinoseb</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>pentachlor phenol</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Uracils</td>
<td>bromacil</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>terbacil</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>lenacil</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Benzonitriles</td>
<td>dichlobenil</td>
<td>-</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>ioxynil</td>
<td>2</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>bromoxynil</td>
<td>2</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Chemical Group</td>
<td>Common Name</td>
<td>Foliage Translocated</td>
<td>Root-Absorbed</td>
<td>Contact</td>
</tr>
<tr>
<td>----------------</td>
<td>----------------------</td>
<td>----------------------</td>
<td>---------------</td>
<td>---------</td>
</tr>
<tr>
<td>Aniline</td>
<td>oryzalin</td>
<td>-</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Derivatives</td>
<td>penoxalin, pendimethalin</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>trifluralin</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>benefin</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Organic</td>
<td>MSMA</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Arsenicals</td>
<td>DSMA</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>cacodylic acid</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>amitrole</td>
<td>1</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Organic</td>
<td>picloram</td>
<td>1</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Compounds</td>
<td>diclofop-methyl</td>
<td>1</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>bensulide</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>acrolein</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>glyphosate</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>flamprop-methyl</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>hexazinone</td>
<td>2</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>bentazon</td>
<td>3</td>
<td>2</td>
<td>1</td>
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<tr>
<td></td>
<td>pyrazon</td>
<td>2</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>tetrapion</td>
<td>2</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Inorganic</td>
<td>arsenicals</td>
<td>1</td>
<td>1</td>
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<td>Compounds</td>
<td>borates</td>
<td>-</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>sodium chlorate</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>ammonium sulphamate</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
E. MODE OF ACTION

After a herbicide has entered a plant there are several ways it can cause the plant to die.

- **Interference with photosynthesis** - This inhibits the reaction between CO₂ and water to form carbohydrates, e.g. bromoxynil, bromacil, paraquat and diquat.

- **Interference with respiration** - This inhibits the metabolism of carbohydrate into energy sources required for plant growth, e.g. trifluralin, bromoxynil.

- **Interference with cell division** - The herbicide attacks the growing points in roots and shoots where cells are dividing most rapidly, e.g. amitrole, 2,4-D, 2,2-DPA.

- **Interference with cell elongation** - Affects the metabolism of plant nutrients and/or protein synthesis so that plants become stunted or distorted, e.g. 2,4-D, dicamba.

- **Multiple effects** - These include action such as physically blocking the movement of mobile products in the plant and rupturing cell walls, etc., e.g. amitrole, 2,4-D.

F. REASONS FOR SELECTIVITY

No herbicide is completely selective under all conditions. The conditions under which selectivity is at a maximum have been established from a great deal of experimentation and research. Recommendations given by the Department of Agriculture, and those on the herbicide product label, should be read and followed if the herbicide is to be used selectively. The following notes summarise some of the factors affecting selectivity.

1. **Differential wetting**

Broad leaves are easier to wet than narrow leaves. Horizontal leaves are easier to wet than upright leaves. Non-waxy leaves are easier to wet than leaves with a waxy cuticle. Leaves with flat surfaces are easier to wet than corrugated leaves.

Many herbicides that require a wetting agent contain it in the formulation; others may lose selectivity if a wetting agent is added. Check the label before adding wetting agent.

2. **Location of growing point**

The part of the plant which is producing new growth is the most vulnerable to many herbicides. Broad-leaved plants have an exposed growing point usually at the end of stems whereas grasses have a protected growing point usually at the base of stems. Thus a herbicide may selectively kill broadleaf weeds in a grass crop.
Some shoots develop a protective cap as they emerge through the soil. Weed shoots that don't form a cap are vulnerable, therefore, especially if herbicide is placed in the soil so that weed seeds germinate in a herbicide band, e.g. chlorthal and pronamide.

3. Growth habit

Some perennial crops, such as lucerne, have a dormant period during which they are less susceptible to herbicides. They are also able to withstand damage to above ground parts far better than annual weeds. Selectivity is lost if such crops are sprayed during active growth periods.

4. Entry of herbicides into leaf

If a herbicide finds entry into the plant difficult, it will not be as toxic to that species as when entry is easily obtained. The ability of a herbicide to penetrate the cuticle is a characteristic of the chemical and will govern the selectivity of the herbicide between different types of plants.

5. Movement within plants

Some herbicides are able to move through particular plants more readily than others. Even though some 2,4-D is absorbed by grasses it is not translocated to the growing tips and this makes grasses extremely resistant, whereas movement is relatively easy for 2,4-D in broad leaved plants.

6. Placement of the herbicide

Herbicides can be applied to row crops so that the weeds are treated but not the crop. This is done with vegetables, orchards, and row crops such as cotton and sorghum.

7. Plant tolerance to herbicides

Some plants are able to degrade a herbicide and thus render it non-toxic which gives them resistance. Plants which are unable to do this are killed. Weeds such as docks and doublegees readily absorb 2,4-D but are not killed, because they degrade the herbicide.
G. FATE OF HERBICIDES

The processes which can take place to remove the herbicide from the environment after it leaves the spray nozzle are illustrated below.

1. Volatilisation
The herbicide vapourises from the leaf and soil surface after application, or from open containers, and may be hazardous to non-target plants, e.g. 2,4-D ester.

2. Photo-chemical breakdown
The herbicide reacts with sunlight and is degraded into harmless chemicals. These products are usually sold in dark containers and should not be transferred to clear containers for storage. Some require soil incorporation as soon as possible after application, e.g. trifluralin, picloram, diuron.

3. Chemical
The herbicide reacts with other salts or ions in the soil to form inactive chemicals. This can occur very rapidly with some herbicides, e.g. paraquat, diquat.
4. **Microbial**

The herbicide is metabolised by soil micro-organisms (fungi, algae, bacteria). Breakdown can be very rapid in soils that have a high organic matter content or have had recent applications of the same herbicide. Products that are not leached readily are most susceptible to this type of breakdown which usually occurs near the soil surface. Temperature and moisture levels are important in determining the rate of microbial breakdown, e.g. 2,4-D, linuron, diuron, simazine.

5. **Leaching**

The herbicide may move out of the immediate root zone of target plants and therefore seem to have a low persistence. A relatively soluble herbicide that is not rapidly broken down before leaching occurs may still be herbicidally active when picked up by more deeply rooted plants, e.g. picloram.

6. **Adsorption**

The herbicide becomes bound to clay particles and organic matter. This renders it unavailable for plant uptake. Herbicides fixed in this way often need higher rates of application on heavy soils to leave enough herbicide for uptake by the weed roots, e.g. linuron, simazine, diuron.

7. **Plant uptake**

Herbicides taken up by plants generally break down in the plant. After the plant dies, any remaining herbicide is subject to the factors affecting herbicide life in the soil as discussed above.

H. **RESIDUAL ACTION AND BREAKDOWN**

Herbicides break down in a manner similar to nuclear degradation, so that the rate of herbicide breakdown can be described in terms of its half-life. This is the time taken for a herbicide to lose half of its activity. In more practical terms, herbicides are considered to have high or low persistence, judged by the period over which they can continue to kill susceptible plants at normal rates of application.

Industrial weed control generally requires herbicides of high persistence whereas, for agricultural weed control, low persistence products are preferred so that crops in rotation are not affected by herbicides applied to a previous crop.
### I. PERSISTENCE OF HERBICIDES

<table>
<thead>
<tr>
<th>Persistence Level</th>
<th>Time Period</th>
<th>Herbicides</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low persistence</td>
<td>less than four weeks</td>
<td>paraquat, diquat, endothal, acrolein</td>
</tr>
<tr>
<td>Low persistence</td>
<td>four weeks - six months</td>
<td>2,4-D, 2,2-DPA, amitrole, bromoxynil</td>
</tr>
<tr>
<td>Medium persistence</td>
<td>less than one year</td>
<td>diuron, linuron, dicamba, trifluralin, atrazine</td>
</tr>
<tr>
<td>High persistence</td>
<td>greater than one year</td>
<td>bromacil, diuron - high rate, picloram</td>
</tr>
</tbody>
</table>

Factors affecting herbicide persistence

The persistence of a herbicide in the soil is affected by all the factors already covered on pages 9 and 10. However, these are a few generalisations that can be made:

- Highly soluble herbicides are usually less persistent than less separate soluble products,
- Persistence is greater at lower soil temperatures,
- Persistence is greater at low soil moisture levels, i.e. lower rainfall districts,
- Persistence is greater in soils high in clay and/or organic matter.

### J. TOXICITY OF HERBICIDES - LD50

The oral toxicity of a herbicide is determined by feeding it to groups of animals at various doses. The amount of chemical (in milligrams of active ingredient per kilogram of body weight) required to kill 50 per cent of the animals tested determines the LD50. The figures used in the table refer to the acute oral LD50 for rats (LD = Lethal Dose).

Chemicals can be broadly grouped as follows:

<table>
<thead>
<tr>
<th>LD50 (rats)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely toxic</td>
<td>5 or less</td>
</tr>
<tr>
<td>Very toxic</td>
<td>5-50</td>
</tr>
<tr>
<td>Moderately toxic</td>
<td>50-500</td>
</tr>
<tr>
<td>Slightly toxic</td>
<td>500-5000</td>
</tr>
<tr>
<td>Almost non-toxic</td>
<td>5000-15000</td>
</tr>
<tr>
<td>Non-toxic</td>
<td>greater than 15000</td>
</tr>
</tbody>
</table>
LD50 of some well known compounds

<table>
<thead>
<tr>
<th>Compound</th>
<th>LD50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caffeine</td>
<td>150</td>
</tr>
<tr>
<td>DDT</td>
<td>420</td>
</tr>
<tr>
<td>Aspirin</td>
<td>750</td>
</tr>
<tr>
<td>Penicillin</td>
<td>1000</td>
</tr>
<tr>
<td>Salt</td>
<td>3300</td>
</tr>
<tr>
<td>Petroleum oils</td>
<td>1000-10000</td>
</tr>
</tbody>
</table>

The acute oral LD50's (rats) given for herbicides commonly used in Western Australia are compiled from published information, manufacturers' technical bulletins and data from the Toxicology Department, Chesterfield Park Research Station, Essex, U.K.

**TABLE 2 The LD50 of Herbicides**

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>LD50</th>
<th>Herbicide</th>
<th>LD50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrolein</td>
<td>46</td>
<td>Propachlor</td>
<td>1200</td>
</tr>
<tr>
<td>DNBP (Dinoseb)</td>
<td>58</td>
<td>Alachlor</td>
<td>1200</td>
</tr>
<tr>
<td>Ioxynil</td>
<td>110</td>
<td>Sodium chlorate</td>
<td>1200</td>
</tr>
<tr>
<td>Parquat</td>
<td>100</td>
<td>Pendimethalin (Penoxalin)</td>
<td>1250</td>
</tr>
<tr>
<td>Bromoxynil</td>
<td>190</td>
<td>Barban</td>
<td>1300</td>
</tr>
<tr>
<td>Pentachlorophenol</td>
<td>210</td>
<td>Cacodylic Acid</td>
<td>1350</td>
</tr>
<tr>
<td>Diquat</td>
<td>230</td>
<td>Methazole</td>
<td>1350</td>
</tr>
<tr>
<td>Thiazafluron</td>
<td>278</td>
<td>Propanil</td>
<td>1384</td>
</tr>
<tr>
<td>2,4-D</td>
<td>375</td>
<td>Ametryne</td>
<td>1400</td>
</tr>
<tr>
<td>Diallate</td>
<td>395</td>
<td>Triallate</td>
<td>1675</td>
</tr>
<tr>
<td>TCA (acid)</td>
<td>400</td>
<td>Hexazinone</td>
<td>1690</td>
</tr>
<tr>
<td>Difenoquat</td>
<td>470</td>
<td>DSMA</td>
<td>1800</td>
</tr>
<tr>
<td>2,4,5-T</td>
<td>500</td>
<td>Nitratin</td>
<td>2000</td>
</tr>
<tr>
<td>Diclofop-methyl</td>
<td>580</td>
<td>Asulam</td>
<td>2000</td>
</tr>
<tr>
<td>2,4,5-TP (Fenoprop)</td>
<td>650</td>
<td>Metribuzin</td>
<td>2200</td>
</tr>
<tr>
<td>MCPB</td>
<td>680</td>
<td>Terbutryne</td>
<td>2400</td>
</tr>
<tr>
<td>MCPA</td>
<td>700</td>
<td>Methabenzthiazuron</td>
<td>2500</td>
</tr>
<tr>
<td>Bensulide</td>
<td>770</td>
<td>Dicamba</td>
<td>2900</td>
</tr>
<tr>
<td>MSMA</td>
<td>900</td>
<td>Chloroxuron</td>
<td>3000</td>
</tr>
<tr>
<td>Mecoprop</td>
<td>930</td>
<td>Chlorothal-dimethyl</td>
<td>3000</td>
</tr>
<tr>
<td>Diphenamid</td>
<td>970</td>
<td>Karbutilate</td>
<td>3000</td>
</tr>
<tr>
<td>Betazone</td>
<td>1100</td>
<td>Pyrazon</td>
<td>3030</td>
</tr>
<tr>
<td>Aminotriazole (amitrole)</td>
<td>1100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8.12
## K. HANDLING EXPERIMENTAL CHEMICALS

It is reasonable to treat all herbicides as moderately toxic and observe the following precautions:

- They should not be mixed with bare hands.
- After handling, operators should not eat, or smoke, before they have washed their hands.
- Fumes should not be inhaled.
- The spray drift should be avoided.
- Gloves, masks and protective clothing should be worn when chemicals having low LD50 ratings (e.g. DNBP) are being used.
- Operators who only wear shorts and thongs are not adequately protected against skin absorption.
- In the event of accidental spillage on to clothing, remove the clothing and have a shower.
- If herbicide contacts the skin, wash it off immediately with water.

The above precautions are basically common sense and if followed, herbicides can be used quite safely when spraying trials.

No herbicide is released for general or experimental use if it cannot be used safely, observing the above precautions. Before a herbicide is eligible for sale it must be screened by the Pesticides Committee and registered under the Health Act.

---

### Table of Herbicides and Toxicities

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Toxicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrofen</td>
<td>3050</td>
</tr>
<tr>
<td>Atrazine</td>
<td>3080</td>
</tr>
<tr>
<td>Dichlobenil</td>
<td>3160</td>
</tr>
<tr>
<td>TCA (sodium salt)</td>
<td>3200</td>
</tr>
<tr>
<td>Metoxuron</td>
<td>3200</td>
</tr>
<tr>
<td>Diuron</td>
<td>3400</td>
</tr>
<tr>
<td>Monuron</td>
<td>3600</td>
</tr>
<tr>
<td>Linuron</td>
<td>4000</td>
</tr>
<tr>
<td>Glyphosate</td>
<td>4320</td>
</tr>
<tr>
<td>Ethidimuron</td>
<td>5000</td>
</tr>
<tr>
<td>Napropamide</td>
<td>5000</td>
</tr>
<tr>
<td>Propazine</td>
<td>5000</td>
</tr>
<tr>
<td>Simazine</td>
<td>5000</td>
</tr>
<tr>
<td>Terbacil</td>
<td>5000</td>
</tr>
<tr>
<td>Bromacil</td>
<td>5200</td>
</tr>
<tr>
<td>Pronamide</td>
<td>5620</td>
</tr>
<tr>
<td>Siduron</td>
<td>7500</td>
</tr>
<tr>
<td>Fluometuron</td>
<td>8000</td>
</tr>
<tr>
<td>Phenmedipham</td>
<td>8000</td>
</tr>
<tr>
<td>Picloram</td>
<td>8200</td>
</tr>
<tr>
<td>Dalapon-Na (2,2-DPA)</td>
<td>9330</td>
</tr>
<tr>
<td>Benefin</td>
<td>10000</td>
</tr>
<tr>
<td>Oryzalin</td>
<td>10000</td>
</tr>
<tr>
<td>Trifluralin</td>
<td>10000</td>
</tr>
<tr>
<td>Lenacil</td>
<td>11000</td>
</tr>
</tbody>
</table>
HAZARDS TO NON-TARGET PLANTS

Herbicide sprays can affect non-target plants by drift, volatility, soil residues and through water bodies.

1. Drift

All herbicides are subject to drift, that is, the physical movement (through the air) of spray droplets from the target area. How important it is depends on -

- Height from the ground
- Droplet size (depends on pressure, nozzle, etc)
- Wind speed and direction
- Herbicide formulation

Spray drift can be minimised by:

- Increasing droplet size by using large volumes of water
- Using coarse nozzles and using low pressures
- Ceasing ground spraying when wind reaches 19 km/h and aerial and Mister spraying when wind reaches 11 to 13 km/h
- Spraying at the minimum height necessary

2. Volatility

The phenoxy herbicides, picloram, dicamba and any others which can be formulated into esters are particularly volatile. Volatility is the tendency of the chemical to vapourise or give off fumes. The volatility of amines is nil (or nearly so), but that of esters is much higher. Conditions which favour volatilisation of an ester are:

- The type of ester
- High temperatures
- High wind
- Smooth, exposed, sprayed surfaces

The following chemicals are in decreasing order of volatility - 2,4-D; 2,4,5-T; MCPA; Dicamba and Picloram.

For each of these herbicides, the formulations available in decreasing order of volatility are - H.V. esters, L.V. esters, and the practically non-volatile sodium and amine salts.

Volatility can be minimised by:

- Using herbicides of low volatility
- Avoiding the use of volatile sprays in hot conditions. Herbicides of low volatility may be hazardous in high temperatures
- Spraying in early morning or evening when wind is negligible and convection currents are downwards
3. **Soil residues**

Soil herbicide residues can be a significant means of killing non-target plants by:

- Careless application, over the root zone of desirable plants. A safe rule of thumb is never to apply residuals closer to a desirable tree than 2.5 times its canopy diameter.

![Diagram of tree canopy diameter]

- Planting susceptible trees in previously sprayed areas.

- Movement of chemical through the soil. A few herbicides will move laterally, especially downhill. Bromacil is a good example.

4. **Water bodies**

Careless or accidental spraying of irrigation channels, creeks, rivers, lakes, dams, etc. can lead to herbicide damage elsewhere. This depends on the herbicide, the quantity used, the amount of dilution, the speed of the water, and the use of the water. In many cases of accidental spraying, the dilution factor alone would rule out the possibility of non-target damage. In addition, the rate of breakdown of many herbicides in open water is much greater than in soil.

One potential danger is the deliberate pollution of water bodies in order to dispose of unwanted herbicide residues or to wash out dirty spray equipment.
9. CALIBRATION AND USE OF SPRAYING EQUIPMENT

A. EXPERIMENTAL MINI BOOM
   1. Cleaning nozzles
   2. Adjusting the height of boom and spray pattern
   3. Testing nozzles
   4. Calibrating output of the equipment
   5. Gas pressure
   6. Speed of spraying

B. OTHER BOOM EQUIPMENT

C. TERRA NOZZLE

D. HAND LEAD SPRAYING

E. MISTERS

F. PRACTICAL POINTS IN SPRAYING
   1. Blocked equipment
   2. Leaking equipment and loss of pressure
   3. Cleaning equipment
   4. Nearby susceptible crops
   5. Weather conditions

G. CHECK LIST FOR SPRAYING A TRIAL

H. ESSENTIAL EQUIPMENT

I. METRIC CONVERSIONS
9. CALIBRATION AND USE OF SPRAYING EQUIPMENT

When using herbicides it is necessary to apply the exact rate or quantity of chemical evenly. This can be done by using different types of equipment such as a single (Terra) nozzle, a hand lead, a boom spray or mister.

A. EXPERIMENTAL MINI BOOM

The experimental mini boom is most suitable for applying treatments to plots sown by drill.

The essential steps in spraying experiments with a boom spray are:

- Clean and test the output of all nozzles
- Adjust the height of the boom and spray pattern
- Calibrate the output of the boom
- Determine the correct speed of the vehicle on the area to be sprayed

1. Cleaning nozzles

The output of new nozzles can vary by up to 20 per cent and used nozzles can vary by even more.

Check that each nozzle is clean before testing. The only way to clean nozzles is to remove nozzles and filters from the boom and wash both in clean water. Blow air through the jet. Metal objects should not be poked through the jet as this is likely to cause permanent changes to the output of the nozzle.

2. Adjusting the height of boom and spray pattern

The boom should be at a height that allows the fan of each nozzle to overlap exactly half the adjoining fan at the surface to be sprayed. This surface may be ground level or the top of a crop.
Each nozzle should be at a slight angle to the boom so that overlapping fans do not merge.

3. Testing nozzles

The output of all nozzles should be checked regularly as corrosion and abrasive (powdered) herbicides can change the size of the jets and thus alter the output.

All nozzles in the boom should be of the same type; nozzles of similar 'size' produced by different manufacturers tend to vary in output.

With the nozzles placed in the boom, run some water through the equipment before starting the test. At the same time check that all nozzles are spraying evenly, and that the overlapping spray pattern is satisfactory. With the pressure set at 200 kPa collect and measure the amount of the water from each nozzle for exactly one minute. Select the nozzles that are closest in output and discard nozzles that vary by more than 10 per cent from the average of the selected nozzles.

4. Calibrating output of the equipment

Jets on the experimental boom are 40 cm apart (check this before using the following method of calculation) and each jet sprays 1/187.5 ha in one minute at eight km/h.

Having now tested each nozzle and fitted the boom with nozzles that are closest in output, calculate the average output of a nozzle in ml for one minute.

i.e. total output of nozzles fitted to the boom (ml in one minute) / No. of nozzles

9.2
The output of the boom in litres per hectare can then be calculated from the following formula:

Output (litres/ha) = average output of a nozzle in one min × 0.1875

Example  Average output per nozzle in one min = 500 ml

Output from boom = 500 × 0.1875 = 93.75 litres/ha.
5. **Gas pressure**

A pressure of 200 kilopascals is a convenient operating pressure.

A new treatment should not be commenced if the pressure in the compressed air bottle falls below 700 kPa as the operating pressure may drop before the treatment has been finished.

The pressure regulator on the compressed air bottle should not be altered during the spraying of an experiment. Gas pressure should only be cut off by using the key on the main tap below the pressure regulator. This maintains the same pressure for all plots. The output of the boom should be calibrated if any adjustment is made to the pressure regulator or if a fault is suspected.

6. **Speed of spraying**

The tachometer or speedo on the spraying vehicle should only be used as a means of maintaining a constant speed along a plot. The accuracy of the gauge should be checked by running the vehicle over a measured distance on a level surface. The guiding indicator on the tachometer or speedo should then be set at the speed required for spraying. Eight km/h is a convenient speed for most conditions.

<table>
<thead>
<tr>
<th>Length of plots (metres)</th>
<th>Time taken to travel along plot at 4 km/h (secs)</th>
<th>6 km/h (secs)</th>
<th>8 km/h (secs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>18</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>40</td>
<td>36</td>
<td>24</td>
<td>18</td>
</tr>
<tr>
<td>60</td>
<td>54</td>
<td>36</td>
<td>27</td>
</tr>
<tr>
<td>80</td>
<td>72</td>
<td>48</td>
<td>36</td>
</tr>
<tr>
<td>100</td>
<td>90</td>
<td>60</td>
<td>45</td>
</tr>
</tbody>
</table>

The vehicle should accelerate and decelerate outside the plot, i.e. it should enter the plot at the correct speed and not slow down until it has left the plot. The time taken to spray a plot should be checked several times during the course of spraying an experiment by using a stop watch. Any irregularities must be noted against that treatment on the schedule.
The output of spray units that have a bulk tank and motorised pump is tested by collecting the water from all nozzles for one minute, with the pump operating at the pressure to be used for spraying.

Any change in pressure of the pump will change the output of the boom.

General formulae for calibrating all types of boom equipment are:

1. Output in litres/ha at eight km/h = litres water used in 1 minute x 75
   length of boom (in metres)

This formula is derived from the fact that each metre of boom travelling at eight km/h sprays 1/75 hectare in one minute. The length of the boom is the swathe width.

2. Output in litres/ha = litres used in a 100 metre run x 100
   width of swathe in metres

The speed at which the test is done must be the same as the speed of spraying.

This formula can also be used for a stationary calibration of equipment that is to be used at a known speed.

The speed-of-spraying table shows the time taken to travel 100 m at several speeds.

Litres used in a 100 m run can be found from:-

- at 4 km/h = 90 sec. test
- 5 km/h = 60 sec. test
- 8 km/h = 45 sec. test
C. TERRA NOZZLE

There are two types of Terra nozzles available:

- M27 (45) designed to cover a swathe of eight metres (27 feet) and to deliver relatively low volumes, e.g. 50 to 60 litres per ha.
- M12 (5) designed to cover a swathe of 3.6 m (12 feet) and to deliver higher volumes, in the order of 300 to 500 litres per ha.

The Terra nozzle may be mounted on the front or rear of a vehicle, preferably on an extension pipe.

From ground or target level, heights are - M12 (90 cm), M27 (105 cm).

A terra nozzle can be used with either compressed air or a motorised pump. It is tested by measuring the water sprayed in one minute. The formula to use is:

\[
\text{Output in litres/ha at eight km/h} = \frac{\text{litres water used in 1 minute} \times 75}{\text{width of the spray swathe in metres}}
\]

The terra nozzle is not satisfactory for spraying experimental plots but can be used where accuracy is not so important.

D. HAND LEAD SPRAYING

When experiments are to be sprayed by hand lead, the exact area of each plot must be known. Generally, plots are smaller than for boom sprays, usually no greater than 20 square metres.

It is advisable to mark the edges of each plot with tape or string, or at least have the corners of each plot pegged. It is just as necessary to accurately calibrate hand lead equipment as it is to calibrate boom sprays and misters.

Procedure

1. With the tap in the full "on" position spray a plot with water (test run). Measure the exact time taken and the amount of water used.

   Because it is necessary to spray each plot twice to ensure even coverage then the time taken and the water used in the test-run must be doubled when the treatments are applied.

2. For each treatment mix sufficient chemical with sufficient water to cover each plot twice, plus that required to fill the hoses and hand lead.

3. Spray the whole treatment, covering several plots, using a stop watch to ensure the correct time is spent on each plot.

4. Note on the schedule any changes in rate due to miscalculation or mis-timing.
E. MISTERS

A mister is suitable for applying general basal treatments to trial areas or large plots but is not suitable for applying treatments to small drill-sown plots, or wherever accuracy is required.

Misting machines are designed to apply very low volumes of liquid. Although water may be used as a carrier and diluent, the main carrier is air.

They are not suitable for applying wettable powders or contact herbicides (e.g. paraquat and diguad). They are more efficient when spraying oil-based herbicides than water-based herbicides.

Calibration procedure

1. Fill the tank with water and mark the level.

2. Open metering jet to desired setting. Once set, this must remain fixed unless re-calibrated, as it determines nozzle discharge rate.

3. Nozzle orifice must be at 45° angle and pointing upward.

4. Measure discharge over one minute at operational revs by refilling tank to the mark.

5. Determine speed of travel. Misters should not be operated at over eight km/h as spray pattern is adversely affected.

6. Determine swathe width. For oil-based herbicides a maximum of ten metres and for water-based herbicides - 7.5 metres.

7. Apply measurements to formula:-

   \[ \text{Output in litres/ha at 8 km/h} = \frac{\text{litres water used in 1 minute} \times 75}{\text{distance between each run in metres}} \]

   \text{NOTE:}

   The distance between each run should be spaced so that the spray swathe is overlapping the previous swathe by 1/2 to 2/3.

   Do not operate misters in calm conditions or when the wind speed is greater than 11 to 13 km/hour.

F. PRACTICAL POINTS IN SPRAYING

1. Blocked equipment

   Wettable powders are more likely to block spraying equipment than water soluble chemicals. When applying herbicides it is therefore preferable to apply all liquid herbicides first unless otherwise stated on the schedule. If obvious blocking occurs with any treatment, a note to this effect should be made on the pre-schedule, and the whole boom cleaned before attempting to apply the next treatment.
At the end of a trial in which wettable powders have been used the boom output should be calibrated immediately after the last treatment (before cleaning the nozzles), by collecting the spray mixture from each nozzle for one minute.

Any changes in output of the boom or blockages should be recorded on the trial schedule.

2. Leaking equipment and loss of pressure

Constant checks are needed to rectify leaks in hoses or changes in pressure on the pump or gas cylinder. Leaks or pressure changes will alter the output of equipment.

3. Cleaning equipment

Equipment should be rinsed with clean water each time between different chemical treatments.

If it is necessary to de-contaminate spray equipment, the following procedures should be used for water soluble liquids and powders (2,4-D and 2,4,5-T amine and sodium salts)

1. Flush sprayer with water and rinse tank lines, screens, pump and nozzles. Drain all water from the equipment.

2. Fill tank with water (warm if available) and add washing soda (1 kg per 100 litres) or household ammonia, 1 litre per 100 litres (2 lbs/25 gals).

3. Agitate in tank and spray out a small amount of solution and leave the remainder in tank overnight.

4. Drain out cleaning solution and rinse a few times with hot, soapy water. The rinsing should be thorough and washings disposed of away from plants and water.

5. Discard any leather washers or rubber hoses and replace.

For emulsifiable concentrates (2,4-D and 2,4,5-T esters), rinse first with kerosene and then follow the procedure outlined above.

Even if these procedures are followed carefully, some chemical may remain in or on equipment.

Replacing all non-metallic parts is the only way of ensuring complete decontamination.

Wash down any vehicles that have been used in spraying operations, including vehicles that have only transported machinery and chemical. This is especially important where chemical spillages have occurred; or where the vehicle is to be parked or stored near susceptible plants. This is important when 2,4-D, 2,4,5-T, MCPA and picloram have been used.
4. **Nearby susceptible crops**

Excess chemical should not be run out on crops surrounding plots but on buffer areas, against a fence or on a track where spray damage to a crop or pasture is not likely to occur.

Crops such as tomatoes, grapevines, lupins, vegetables, rape and linseed are very susceptible to a wide range of herbicides, particularly phenoxy herbicides, and can be affected by spray drift or subsequent vapourisation after spraying.

5. **Weather conditions**

Experiments should not be sprayed on windy or exceptionally hot, dry days. Strong wind will obviously cause spray drift on to adjoining plots and crops. Both strong wind and very hot weather will increase evaporation of spray mixture leaving the boom.

Rain which may wash the herbicide off the foliage will reduce the effectiveness of the treatment. It is desirable to have at least four hours free of rain after a herbicide has been applied. Residual type herbicides may be aided by rain washing the chemical into the soil.

G. **CHECK LIST FOR SPRAYING A TRIAL**

**Example:**

A trial with plots 100 metres long is to be sprayed with 2,4-D at 3 litres/ha using the experimental boom. Three plots are to be sprayed for each treatment.

<table>
<thead>
<tr>
<th>Essential steps</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Clean and test the output of all nozzles</td>
<td>The boom should have clean nozzles that are known to deliver a similar rate of water.</td>
</tr>
<tr>
<td>2. Adjust the height of the boom and spray pattern</td>
<td>Check that each fan is overlapping by half, is not interfering with adjoining fans and that unused nozzles and joints are not dripping.</td>
</tr>
<tr>
<td>3. Calibrate the output of the boom and calculate the quantities of water and chemical to be mixed</td>
<td>With the pressure at 200 kPa the boom is found to deliver, say 70 litres/ha. Mix sufficient chemical to spray 0.1 ha, i.e. mix 0.3 litres 2,4-D in 7 litres water and transfer to the spray tank.</td>
</tr>
</tbody>
</table>
4. Check the speed of the vehicle. On the outside of the trial drive the vehicle down the length of the 100 metre plots in second gear low range at approximately 1500 RPM on the tachometer. Repeat this if necessary so that it takes exactly 45 seconds (see page 21) to cover the 100 metre plot and re-adjust the tachometer indicator.

5. Spray the plots Cut the gas by using the key when the last plot is finished.

6. Clean the equipment for the next treatment Excess chemical should be run out away from the trial where damage to crops or pasture won't occur. Flush the whole unit with clean water.

H. ESSENTIAL EQUIPMENT

The following items are considered essential equipment for spraying jobs:

- Safety gear, including rubber boots, rubber gloves, overalls and face shield and respirator.
- Measuring cylinders (100 ml, 250 ml, 500 ml).
- Litre jug (graduated), funnel and filter.
- Regulator (compact) and air hose, air cylinders.
- Buckets (10 litre) with volume indicators (at least 6).
- Stop watch, optical square.
- Whirling sycrometer wind meter and compass for recording details of weather at trial site.
- Tool box including two sized crescents, hammer, screwdrivers, pliers, spare nozzles and filters, tape, marking pegs, pocket calculator

I. METRIC CONVERSIONS

N.B. These should not be necessary. Adopt the metric system.

Pressure (PSI - kPa)

![Pressure Conversion Chart](chart.png)

9.10
Solid rates (1 lb/ac - kg/ha)

![Solid rates graph]

Liquid rates (gal/ac - litres/ha)

![Liquid rates graph]

Approximate conversion factors

<table>
<thead>
<tr>
<th>Imperial to Metric</th>
<th>Metric to Imperial</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length</strong></td>
<td></td>
</tr>
<tr>
<td>1 in = 25.4 mm</td>
<td>1 cm = 0.394 in</td>
</tr>
<tr>
<td>1 ft = 0.305 m</td>
<td>1 m = 3.28 ft</td>
</tr>
<tr>
<td>1 yd = 0.914 m</td>
<td>1 m = 1.09 yd</td>
</tr>
<tr>
<td>1 mile = 1.61 km</td>
<td>1 km = 0.621 mile</td>
</tr>
<tr>
<td><strong>Mass</strong></td>
<td></td>
</tr>
<tr>
<td>1 oz = 28.3 g</td>
<td>1 g = 0.0353 oz</td>
</tr>
<tr>
<td>1 lb = 454 g</td>
<td>1 kg = 2.20 lb</td>
</tr>
<tr>
<td>1 ton = 1.02 t</td>
<td>1 t = 0.984 ton</td>
</tr>
<tr>
<td><strong>Area</strong></td>
<td></td>
</tr>
<tr>
<td>1 in² = 6.45 cm²</td>
<td>1 cm² = 0.155 in²</td>
</tr>
<tr>
<td>1 ft² = 929 cm²</td>
<td>1 m² = 10.8 ft²</td>
</tr>
<tr>
<td>1 yd² = 0.836 m²</td>
<td>1 m² = 1.20 yd²</td>
</tr>
<tr>
<td>1 ac = 0.405 ha</td>
<td>1 ha = 2.47 ac</td>
</tr>
<tr>
<td>1 sq mile = 2.59 km²</td>
<td>1 km² = 0.386 sq mile</td>
</tr>
<tr>
<td><strong>Volume</strong></td>
<td></td>
</tr>
<tr>
<td>1 in³ = 16.4 cm³</td>
<td>1 cm³ = 0.061 in³</td>
</tr>
<tr>
<td>1 ft³ = 0.0283 m³</td>
<td>1 m³ = 35.3 ft³</td>
</tr>
<tr>
<td>1 yd³ = 0.765 m³</td>
<td>1 m³ = 1.31 yd³</td>
</tr>
<tr>
<td>1 fl oz = 28.4 ml</td>
<td>1 ml = 0.0352 fl oz</td>
</tr>
<tr>
<td>1 pt = 568 ml</td>
<td>1 l = 1.76 pt</td>
</tr>
<tr>
<td>1 gal = 4.55 l</td>
<td>1 m³ = 220 gal</td>
</tr>
<tr>
<td>1 acre foot = 1.23 Ml</td>
<td>1 Ml = 0.811 acre foot</td>
</tr>
<tr>
<td><strong>Pressure</strong></td>
<td></td>
</tr>
<tr>
<td>1 psi = 6.89 kPa</td>
<td>1 kPa = 0.145 psi</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td></td>
</tr>
<tr>
<td>1 hp = 0.746 kW</td>
<td>1 kW = 1.34 hp</td>
</tr>
</tbody>
</table>

9.11
10. APPLICATION OF INSECTICIDES

A. GROUND APPLICATION
   1. Principles of misting
   2. Advantages
   3. Disadvantages

B. AERIAL APPLICATION
10. APPLICATION OF INSECTICIDES

A. GROUND APPLICATION

a) BOOM - see section on herbicide application - the same principles apply to using insecticides.

b) MISTER

1. The principle of misting

Misters differ from conventional sprayers in that the insecticide is not sprayed directly from the nozzle to the target. A mister has a large fan which produces a powerful blast of air. Insecticide is injected via a nozzle into this high velocity air stream.

The force of the air blast atomises the insecticide particles and carries them towards the target. The ambient wind is utilised to complete the journey of the insecticide to the pest.

Misters can be either a backpack or mounted on a vehicle. Some vehicle-mounted misters are designed to apply neat insecticide formulations. The application of insecticide without the use of water as a carrier is termed the ULV (ultra low volume) application technique.

2. Advantages

Compared with boom or single nozzle spray equipment, much wider swathes can be obtained with misters, resulting in reduced damage to mature crops and considerable saving of time.

3. Disadvantages

As this technique relies on the wind to carry the insecticide to the target, and as wind speed varies, so insecticide distribution is variable. With large swath widths, unfavourable conditions, e.g. very high temperatures causing evaporation of carrier, the kill may be patchy.

B. AERIAL APPLICATION

Insecticide can be applied from the air quickly, with excellent coverage over difficult or distant fields; its only disadvantages are cost and availability of the plane in a situation such as an army worm outbreak, where every farmer wishes to spray at the same time.
11. OBSERVATION, VISUAL ASSESSMENT AND NOTE TAKING

A. INTRODUCTION 11.1

B. WHAT TO RECORD 11.1
   1. Basic Details 11.1
   2. Environmental Conditions 11.1
   3. Response of Experimental Materials 11.3
   4. Errors in the Establishment of the Experiment 11.3

C. RATING PLOTS 11.4

D. TAKING NOTES 11.4
11. OBSERVATION, VISUAL ASSESSMENT AND NOTE TAKING

A. INTRODUCTION

Observation and visual assessment of trials is an important but all too frequently ignored facet of trial work. Harvest results without any observations are bare bones which may be meaningless or even misleading. For example, suppose weed or some other extraneous factor - rather than the treatments - determines the results obtained. Unless this is observed, written down and filed with the results and other details of the experiment, the results may later be interpreted incorrectly.

Results supplementary to those obtained from other methods of measurement can be obtained by visual assessment. It is seldom possible to mechanically sample an experiment more than once or twice in a season, but differences between treatments can be appraised several times visually. This permits the compilation of a complete record of the treatment effects throughout all stages of the growth of the crop or pasture.

Sometimes, visual assessments may be the only results obtained if the experiment is destroyed or harvesting is impossible.

B. WHAT TO RECORD

The following is a checklist of what could be recorded during a visit to an experiment.

1. Basic details

These should ALWAYS be recorded at the head of any notes.

   i) Experiment number and title
   ii) Location
   iii) Date
   iv) Observer's name

2. Environmental conditions

Note any uneven distribution of conditions over the experimental site and use diagrams to record zones of differences. Rate plots (as outlined below) to record differences between plots.

   i) Edaphic conditions

* Soil profile. Describe the colour and texture of different horizons down to 50 cm for at least 5 sites covering the experimental area. Additional levels will be necessary to determine soil type boundaries on uneven sites.

* Position of site in landscape, e.g. on top of hill or breakaway, valley floor, mid-slope, on pedimont below breakaway, etc.

* The amount and direction of any slope.
* Drainage conditions.
  1. Internal- ease of passage of water through profile.
  2. External- surface movement of water on to or off experiment.

* Condition of the surface soil, e.g. caked, cemented, powdery, cracked, friable.

* Soil moisture conditions to, e.g. waterlogged, wet, moist, dry.

(ii) **Climatic conditions**

* Date of germinating rains.

* Rainfall  1. Previous 24 hours
  2. Previous 7 days
  3. Since previous inspections.

* Temperatures  1. Generally since previous inspection
  2. Frosts since previous inspection.

* Any damage caused by weather, e.g. floods, drought, frosts.

(iii) **Biotic conditions**

* Viral, bacterial and fungal diseases.
  1. Name diseases. If unknown, collect and forward for identification.
  2. Estimate number and percentage of economic plants affected.
  3. Describe distribution over the area.

* Weeds and natural regrowth
  1. Name species. If unknown, collect and forward for identification.
  2. Estimate weed density - number of plants per unit area or percentage of the plant community.
  3. Describe distribution.

* Harmful lower animals (insects, eelworms)
  1. Name species or collect and forward for identification.
  2. Estimate population if possible - number per unit area and also the number and percentage of affected plants.
  3. Describe distribution.

* Harmful higher animals (wild or farm stock; including birds).
  1. Name
  2. Estimate damage to plants
  3. Describe distribution of damage.
* Damage caused by man, his vehicles or implements (old firebreaks, headlands, tracks, plough lines)
  . Estimate the extent of damage
  . Describe the position of affected areas

3. Response of the experimental materials

Measure and rate each plot.

i) Depth of seeding.
ii) Density - number of plants per unit area or per unit length of drill row
   1. At germination
   2. Established plants throughout season.
iii) Height
iv) Colour
v) Deficiency symptoms on leaves, stems, nodes, floral parts or seed.
vi) Toxicity symptoms on above-ground parts and roots
vii) Growth habit
viii) Root development
ix) Nodulation (for legumes)
x) Growth stages, e.g. number and percentage of wheat ears in anthesis, number of tillers per plant and per unit area, number of clover burrs set per unit area.

4. Errors in the establishment of the experiment

Possible errors are sections or rows of some plots not sown, crossed plots, sown too deep, uneven fertiliser application, plots apparently incorrectly treated, wrong varieties sown.

Wherever possible use absolute measurement, e.g. use a ruler to measure the height of plants; count the number of plants in a measured area from four or five sample sites per plot for each estimate of the density of establishment, damage or deficient plants; count the number of insects wherever practical; measure the dimensions of sections of any part of the experiment uniformly damaged by vermin, erosion, machinery, etc., or patches of weeds and different soil types.

Objectivity, accuracy and reliability are essential. Regardless of the status of anyone with you, make your own independent assessments and record your own observations.

The following aids to objectivity should be adopted:

i) Always measure, or use the system of rating, described below.
ii) Use precise, definitive words. Avoid extravagant, sweeping or meaningless words.
iii) Question what you are writing down. Do the words say what you want them to? Do they describe the aspect of the experiment truly and accurately?
iv) Don't look at the randomisation plan of the experiment until you have finished comparing plots and recording your observations.
v) Tell anyone with you to keep their opinions to themselves until you have completed the job. Ignore any comments they let slip. Likewise keep quiet until they finish. Compare and discuss notes when all observers are ready. Don't alter your original notes after discussion with others. Any modified opinion may be recorded as an additional note.

C. RATING PLOTS

(a) Choose your scale. More than ten grades are rarely advisable and where there is no numerical background more than five grades can be disastrous because they cannot be kept distinct in the observer's mind.

(b) Make a preliminary survey of the plots to fix the grades to levels of the factor to be observed. Grade 1 is always ascribed to the plot showing the worst or smallest level of the factor. The highest grade is ascribed to the plot showing the best or largest level of the factor. The middle grade is ascribed to the plot showing a level of the factor midway between best and worst.

(c) Grade each plot in the whole experiment and record this grade. Refer back to the original plots to establish the points on the scale as often as is necessary to refresh your mind of the whole scale.

(d) Only rate for one aspect at a time. Don't be influenced by any factor other than the particular one you are rating. The tendency is to give a higher grading, for say colour, to plots which are denser or taller. This tendency must be avoided.

(e) Always relate the grades to absolute measurements where possible.

NOTE: For experimental designs in which every treatment is repeated in each block, it is permissible to rate each block individually, establishing a grading scale for each different block. This may be advantageous for very wide experiments.

D. TAKING NOTES

Notes should be clearly and neatly set out. Illegible notes are useless. Don't cram everything together and make full use of diagrams. Use carbon paper to make a copy of each page of notes.

Keep the carbon copy and place on your own file so that you build up a complete record of all your observations. In the event of the other copy going astray, reference to your record will be necessary, so keep it safe. From your own copy tabulate the results of your observations and summarise your conclusions.

The original copy of your notes together with a copy of your tabulations and conclusions should be forwarded through the correct channels to the Research Officer in charge of the experiment.
# 12. SOIL SAMPLING

## A. INTRODUCTION

## B. SAMPLING METHOD

1. Site Characterisation
2. Soil Nutrient Status

## C. SAMPLE HANDLING

## D. SAMPLING EQUIPMENT

## E. FURTHER READING
12. SOIL SAMPLING

A. INTRODUCTION

Sampling is frequently the most limiting factor to successful measurement of a soil property, e.g. soil nutrient status. A hectare to a depth of 10 cm contains about 1.3 million kg of soil so that a 10 g sub-sample used by the laboratory represents only one part in 130 million! As a consequence, extreme care is needed to ensure that representative samples are collected.

Variation in soil properties in the soil occurs as a result of soil type differences or management effects. Most soils in Western Australia are not very uniform and many soil types can usually be found in one paddock. Because of this, soil properties (including soil nutrients) are unevenly spread throughout the paddock, particularly where leaching is important. Even if the paddock is located on one soil types, stock can spread soil nutrients unevenly through urine and dung. The management history of the paddock can also cause concentration or spread of nutrients through clearing, burning and hay cutting.

As the aim of soil sampling is to obtain a representative sample it is important to use information on soil variability to calculate the number of samples or cores required. Depth control is also important.

B. SAMPLING METHOD

The actual method used to sample a field, plot or sub-plot depends on the properties that need to be measured.

1. Site characterisation

Plant growth is a function of climate and soil factors and this latter property should be measured at most experimental sites, especially nutritional trials.

a) Use auger to obtain ten cores/rep 0 to 10, 10 to 30, 30 to 60, 60 to 100 cm depths for cropping trials and 0 to 10, 10 to 30, 30 to 60 cm for pasture trials.

b) Bulk cores for each depth on each rep., mix thoroughly in bucket and sub-sample. Sub-sample size should be approximately 500 g. Dry sub-sample in glasshouse or outside in sun, sieve through 2 mm sieve. The 2 mm fraction should then be quartered with one half of the sample stored for future use and the other half forwarded to Government Chemical Laboratories for analysis. All samples must be labelled with Experiment No., Depth, Date Sampled, Location.

2. Soil nutrient status

The purpose is to collect samples as an aid to diagnosis of nutrient deficiencies and as a guide to fertiliser usage.
a) Diagnostic sampling

Samples are taken from the affected area with an equal number from a nearby normal area of the same soil type. Depending on the size of the area 20 cores 0 to 10 cm need to be collected from each area.

b) Monitoring or fertiliser prediction

If the paddock is predominantly of one soil type take 40 cores, each to a depth of 10 cm in a zig-zag pattern throughout the paddock.

Where there is more than one soil type in the paddock 20 cores should be taken from each of the major soils. The cores should be bulked, thoroughly mixed, and sub-sampled. This will provide a 500 g sample of each soil type for forwarding to the laboratory along with information sheets.

c) Depth of sampling

Ideally the whole root zone should be sampled. However, in most soils the nutrients are concentrated in the plough layer, so that only the top 10 cm is sampled. For mobile nutrients, such as nitrogen and for potassium and phosphorus in situations prone to leaching, sampling to this depth will not accurately assess nutrient availability. Depth control is essential, as in most soils the concentration of nutrients such as P and K decreases rapidly down the profile. Most sampling tools are marked or have an attachment to regulate the depth of penetration.

d) Time of sampling

Extractable nutrient levels in the soil vary markedly during the season as a result of plant accumulation, decomposition and changes in soil moisture. If soil samples are collected in spring a large percentage of available nutrients are in the plant which, following decomposition or recycling, will be available for the subsequent crop or pasture. Most calibration levels are based on mid-summer (January to March) sampling.

e) Special purpose sampling

When sampling for a special purpose, such as for soil moisture determinations or monitoring of soil properties during the growing season, sampling technique is more intensive and the depth sampled depends on the aims. Full details cannot be provided for each technique but these should be discussed fully with the appropriate officer.

C. SAMPLE HANDLING

No matter how carefully a soil sample is taken from a site, it is useless if the properties which are to be measured are destroyed by thoughtless handling. The subject of sample handling can be best treated by giving a few examples.
a) When sampling for physical characteristics such as water stable aggregates, great care must be used in sampling and handling to avoid modifying the soil. The water content at sampling time greatly influences results.

b) Water content samples must be adequately sealed to prevent water loss.

c) Care must be taken to avoid contamination. Sampling implements should be free of any elements under study. Galvanised iron sampling tubes would be useless when sampling for zinc. Brass or copper implements would be equally useless for copper samples. Most soil sieves are made of brass or copper; these should not be used for copper work.

Contamination from fertilisers easily occurs. Sampling bags and equipment should be kept out of the fertiliser store and fertilisers or other chemicals should not be handled in a room where samples are being stored or prepared.

d) In some special cases, contamination can take place through the adsorption of gases such as ammonia. This problem does not arise often but precautions should be taken to minimise chances of such contamination when samples are being transported and stored.

e) Often, chemical properties of samples depend on moisture content and microbial activity. Sulphur can be made more or less available depending on wetting and drying processes. The availability of phosphorus and potassium can be affected in a similar way. These effects are best overcome by standardising preparation and preservation procedures. Rapid air drying is recommended for most samples. Temperatures above 70°C should not be used as these can cause unwanted chemical changes.

Special attention must be given to the treatment of samples which are to be analysed for various nitrogen fractions. When only total N is to be determined, rapid air drying is adequate. However, special measured are required when incubational N, NO₃ nitrogen, and NH₄ nitrogen factions are measured. Firstly, incubation is required as soon as possible after sampling; secondly, reagents such as toluene should be applied to prevent microbial nitrification.

f) Sub-sampling in the field is often required to save transport and handling of large volumes of soil. This operation should give every part of the sample a chance of being included in the final sub-sample. After thorough mixing the sample should be formed up into a cone and divided vertically into quarters. If a smaller sample is required the process may be repeated on the quarter. The mixing and quartering is best done on a flat ground sheet, as dead pockets of soil readily form in buckets. Once the soil has been thoroughly mixed it is either coned and quartered or spread out flat and repeated grab or spoon samples taken (if there are too many samples or insufficient time for coning and quartering). Care should be taken to prevent contamination at this stage.
D. SAMPLING EQUIPMENT

As there are many requirements and methods of soil sampling, there are many different implements which can be used. The equipment not only varies with the requirements of the sampling programme but also with the condition of the soil to be sampled.

Good sampling implements have three basic properties:

a) They give an uncontaminated sample

b) They give a sample of uniform cross-section (so that there will be no bias with depth)

c) Successive samples are of the same size and depth interval

There are several types of sampling implements:

a) Blades - trowels, spades, shovels, spoons and knives

b) Tubes - open sided, constricted tip and uniform bore. Sometimes the tube is a small cylinder enclosed in a core sampler

c) Augers - wood-bit, post-hold, sheathed, and those enclosing a sample cylinder

These implements have different values under different conditions. Fine bore tube samplers are difficult to use on gravelly soils and are next to useless on wet, heavy soils and dry, sandy soils. Some blade tools give accurate samples if great care is taken to ensure all samples are of uniform surface area and depth. A pit is needed to obtain samples down the profile. Sheathed augers of various gauge are useful in obtaining rapid imprecise profile samples. Wood-bit type augers are handy in solid clay and rocky conditions.

Taking undisturbed profiles at six to nine feet has been difficult in the past. Power-driven equipment with hydraulic jacks and split core tubes is now available, allowing rapid, accurate samples to be taken.

Undisturbed core samples needed for physical measurements, such as hydraulic conductivity, are taken using removable metal sleeves, in which the samples are returned to the laboratory.

E. FURTHER READING

13. PASTURE HERBAGE SAMPLING

A. INTRODUCTION

B. HERBAGE YIELD
   1. Non-pick-up machines
   2. Pick-up machines
   3. Calibration cutting methods
   4. Non-cutting methods

C. BOTANICAL COMPOSITION
   1. Plant counts
   2. Point quadrat
   3. Line transect
   4. Visual score assessment
   5. Dry weight basis

D. CHEMICAL COMPOSITION AND QUALITY

E. SAMPLING CONSIDERATIONS

F. GENERAL PROCEDURES
   1. Field procedure when cutting pasture
   2. Layout of samples
   3. Sampling
   4. Determination of quantity
   5. Sample drying
   6. Weighing and recording
13. PASTURE HERBAGE SAMPLING

A. INTRODUCTION

Pastures are sampled to estimate herbage yield, botanical composition, chemical composition and quality. Rarely is it possible, practical or even desirable to take all the pasture from a plot because of limitations in time, handling facilities, or the need to make sequential measurements on the same plot. Sampling of a representative area is the approved way of obtaining results.

B. HERBAGE YIELD

Herbage yield is usually measured in terms of dry matter (kg/ha). Methods that utilise at least some cutting are favoured because although time consuming they usually give reliable results. In addition to ease and speed of use, there are three important considerations related to any cutting equipment:

a) How close to the ground do they cut? This depends on the cutting width and the type of cutting mechanism, in association with the eveness of the ground.

b) The condition the cutter leaves the sample in. This determines degree of soil contamination, the ease with which individual species can be identified and the ease of drying.

c) The conditions of pasture and weather the cutter can operate under efficiently, e.g. some machines can cut low but not high pasture; others cannot be used under wet conditions.

1. Non-pickup machines

* Autoscythe - the motorised autoscythe has a reciprocating knife blade and cuts a 900 mm wide strip. It samples large areas very quickly. Although it can be adapted to pick up material the adaptions are cumbersome and generally unsatisfactory.

Disadvantages are that the height of cut is difficult to control and it cuts too high, particularly on rough or uneven ground. Most autoscythes are large and difficult to manoeuvre.

* The electric hedge trimmer - this is very similar in principle to the autoscythe but has a narrower cut. However, it still cuts too high except on smooth ground. It can be used for cereals and lucerne but the teeth are too wide for fine pasture.

* Shearing handpiece - using New Zealand combs a 75 mm cut is possible with a shearing handpiece. The handpiece can be driven by a flexible tube, electrically or by compressed air. The handpiece cuts closely to the ground under most conditions but is still unsatisfactory for heavily grazed prostrate species. Although short pasture can be cut it is often difficult to pick up. It is widely used when making calibration cuts (see Section 3). Pasture growth following cutting is very poor.
* Handshears, scissors - this method can do a good job but is tedious, and picking up the cut pasture can be a problem. Short pastures can only be successfully sampled using scissors and cutting a large number of very small quadrats. The results need to be very valuable to warrant the effort.

For dry pastures a straight handknife is the best and fastest method. Under good conditions a sharpened shovel can be used effectively.

2. Pick-up machines

* Reel mower - an adapted lawn reel mower has been used. Modifications necessary to improve the mower's performance have been height adjustment, wheels on the roller, variable-sized cutting cylinders to suit pasture conditions and a four cutter bar assembly.

The mower samples rapidly and does not cut up the material excessively. While it can cut almost as closely as the shearing handpiece on swards higher than 50 mm, on shorter pastures it leaves a lot of herbage. A big disadvantage is that soil contamination can be high, particularly on wet, sandy soils or loosely surfaced soils. Also, on long pasture, the wheel height adjustment is unsatisfactory and causes variability in cutting height.

* Forage harvester - this does very much the same job as a reel mower but cuts on a flail principle instead of using a cutter bar. Again, machine wheels control the cutting height and the height can be variable when travelling on uncut pastures.

Forage harvesters used up to the present have shown more tendency to mash up pasture than the reel mower. This makes the material unsuitable for sorting into species components. However, it is able to sample higher pastures than the reel mower.

* Rotary mower - provided they are fitted with large wheels and a strong motor the rotary mower can be used, particularly on small plots. Because the material is macerated, care has to be taken when drying the samples and the cut material cannot be sorted into its species. High pastures, particularly in spring, though hard to collect, are not as difficult as with the reel mower.

3. Calibration cutting methods

Because cutting methods can be very demanding in terms of time and facilities, other ways to measure pasture yield have been devised. They utilise either various components of pasture yield, e.g. height, density of plant material or characters associated with yield. Such measurements are non-destructive and are simply and quickly taken. This reduces the workload and/or increases the accuracy of sampling. All such methods involve the cutting of a limited number of samples to calibrate the results against actual yield.
A height measurement - direct measurement of a crop has been used to express experimental differences. Height has been shown in many cases to be closely related to total production but only on certain crops and pastures. Erect species, such as lucerne and cereals, have given the most reliable result.

Electronic pasture meter - essentially, the meter measures electrical capacitance. Green herbage placed between its probes changes the capacitance of the system - the change is measured at a radio frequency and used as an indicator of the mass of herbage. Water has been shown to be the major influence on meter reading. While the correlation between the weight of water in the sample area and meter reading is usually very good there can also be a reasonable relationship between dry matter yield and meter reading.

Soil moisture has little or no effect on the reading but surface moisture will cause an increase. Where pasture had been trampled or lodged reliability is reduced.

The slope of the linear relationship between pasture meter reading and yield varies with pasture type and days. Calibration has therefore to be done with separate species and on each experiment and each day it is used. No one regression can be used; calibration is always necessary.
Many readings are taken from the trial and the range of average plot readings estimated. Ten calibration cuts are taken to cover the range found. To calibrate, a meter reading is taken, a cutting frame is placed around the meter and the herbage carefully cut, using a shearing hanapiece or handshears; the meter is placed back on the area to obtain a residual reading. The sample is then dried.

The major limitations to the use of the meter include its sensitivity to changes in botanical composition, its unreliability under wet conditions, a lower limit of yield estimate of about 1,000 kg per hectare, and that pastures must be green and probably containing at least 40 to 50 per cent moisture. Also a reasonable amount of care must be exercised in using the meter to avoid breakdowns.

* Plate meter (Ellinbank) - the height above the ground of a plate resting on the pasture is affected by the height, density, pasture species and the weight of the plate. The Ellinbank plate meter has been found to be suited to yield measurements provided botanical composition does not vary greatly and there is at least 1,000 kg per hectare of pasture present. Readings are simply and rapidly taken. Little experience is required. The plate is more robust than the electronic meter.

Plate meter readings are calibrated as previously described for the electronic pasture meter. Compared with the electronic meter, the plate is more robust and less affected by weather conditions.

* Visual assessment - instead of using a meter to assess pasture quantity a visual estimate can be made and then calibration cuts used. The method is well adapted for use in large grazing trials where cutting of each plot would be difficult or nearly impossible. The "Morley" method involves the selection of sampling positions to represent most of the range in yield composition of the trial (10 to 30). Three trained observers estimate some 40 sites per plot in addition to the selected areas. The selected quadrats are then harvested and used to construct the calibration curve from which the yield of each plot can be assessed.

While good calibrations can be consistently obtained on green pastures, on dry pastures poor results are usual, unless some intensive training is carried out.

In contrast to the electronic or Ellinbank meter much lower yields can be estimated using the Morley method.

For very short pastures the Hutchinson technique can be used. While similar to the Morley method it replaces the selected quadrats with five cores of pasture covering the range of yield and composition. The cores are carried around by the observer to assist in the rating. The cores are finally cut, dried and used to construct the calibration curve.
4. Non-cutting methods

* Rating or ranking - plots can simply be rated or ranked without any associated calibration to give relative production.

* Use of animals - assessment of pasture quantity is possible by using animals if experiments are designed for this purpose. However, animals also reflect other factors of the pasture including its composition and quality.

Animal parameters used are body weight, wool weight, lamb production and milk production. Body weight can be very sensitive to changes in pasture available to the animal. Animal measurements are not as sensitive as pasture measurements but it may be easier to assess winter production using animal body weight than to cut and pick up the small amounts of plant material available at that time.

There are four important aspects to consider if animal body weight is used to measure the amount of pasture available -

i) Rate of gain varies with the amount of feed available - depending on the type of sheep, rate of gain in sheep body weight increases up to about 2,000 kg/ha dry matter of pasture. At this point the rate of increase falls off rapidly with increases in feed available. Therefore, if weight changes are used to assess differences on small paddock treatments, the maximum amount of feed of any one treatment should not exceed 2,000 kg/ha. Similarly, on large grazing trials body weight differences are more related to treatment in winter than in spring.

ii) Importance of compensatory gain - similar animals of low body weight gain more rapidly than heavier animals. Heavy animals will show smaller differences and are not the best to use for this type of experimental work.

iii) Stocking rate - too heavy a stocking rate can cause overgrazing of the plots and over a long period can reduce the response and growth of pasture under various treatments. Overstocking must therefore be avoided if amounts of pasture available are small or the period of grazing is long, unless the experiment uses various stocking rates to determine pasture "crash point".

iv) Feed quality - feed quality rather than quantity can be the controlling factor in body weight changes. This is most likely in late spring and during the summer months.

C. BOTANICAL COMPOSITION

Composition can be expressed on a plant basis, leaf area basis or a dry weight basis.

1. Plant counts

Plants must be removed to obtain accurate counts unless plant density is low. For high density pastures, counting can be facilitated by taking cores, e.g. 100 mm diameter.
2. **Point quadrat**

The point quadrat method relies on the principle that a large number of small quadrats rather than a few large quadrats increases the reliability of the results. With this technique a frame with projecting points is used and a large number of observations made by recording the species touched by the points. The results are usually expressed on a per cent area basis.

3. **Line transect**

The number of plants occurring along a line or the length of line occupied by the species is recorded as a score. Estimates are made on a per cent basis. This method is more suited to measuring change of composition over a period of years in low density pastures.

4. **Visual score assessment**

- The per cent score for various species constituting a pasture is estimated by many observers. This is a statistically valid technique and computer programs are available to process the results. It is similar to the rating technique for pasture production and the more observers the greater the accuracy. Considerable training of observers is required to give accurate results.

- Dry weight rank - in a number of randomly placed quadrats an observer estimates which species takes first, second or third place in terms of dry weight. Where one species is dominant ranks may be bulked. The data is tabulated to give the proportion of quadrats in which each species received first, second and third place. The proportions are then multiplied by the factors 70.2, 21.1 and 8.7 respectively and added to find the dry weight percentage of each species. The quadrat size used is usually 0.25 of a square metre but this can be increased for very sparse pastures. The method can give an accurate estimate of botanical composition on a dry weight basis. Much less training is required to use the technique than for the direct estimation of composition. In addition no cutting or hand sorting is required.

5. **Dry weight basis**

Many small samples of equal area are taken or, alternatively, sub-samples may be obtained from samples taken for dry matter. Such samples, either fresh or dry, are sorted by hand. Sorting while fresh is easier and desirable but there is limited time before the samples deteriorate. Storage time can be increased by placing the samples, in sealed plastic bags, into a refrigerator.

**D. CHEMICAL COMPOSITION AND QUALITY**

Sampling plants for chemical analyses and quality requires a knowledge of which constituents are to be determined. Such knowledge influences sample size, choice of plant part, importance of soil contamination and choice of drying facilities, e.g. for analysis of minor elements the ovens must be of a different material.
Important aspects which can influence the feed quality and level of plant constituents include:

* Differences between species and cultivars. Generally, samples should be restricted to one species or separated into species components before analysis. For quality determination it is usually the value of the mixed herbage which is important so separation may not be required.

* The plant part. Where possible samples should be of specific plant parts, e.g. leaf only or leaf plus petiole.

* Surface contamination. Washing is not desirable but will be necessary if samples are contaminated with soil. Contamination can occur in a number of ways such as from sampling equipment, bags, soil or during sorting.

* Grazing management.

* Time of sampling (which part of growing season). The date of sampling must always be recorded so that the physiological age of the plant can be estimated.

E. SAMPLING CONSIDERATIONS

Type of sample - The sample taken to represent the plot needs careful consideration. The unit is referred to as a quadrat and is generally delineated by a sampling frame. Some notes on the factors determining the size, shape and number of quadrats cut in a plot are listed below:

a) Size of quadrat - quadrats usually range in area from 0.1 to 0.5 square metres, but actual size depends on two factors - convenience and the variability of the site to be cut. Quadrat size may be determined by the convenience of converting to other units, e.g. grams per quadrat to kilograms per hectare or by convenience in handling, e.g. width of cutter.

Very variable sites are most satisfactorily sampled by a large number of small samples, but if the stand is sparse, quadrats should always be large enough to include a number of plants.

Where plants are in rows, the quadrat width must be a multiple of the row spacing so that the same number of rows are sampled each time.

b) Shape of sampling quadrat - for upright species in rows, e.g. cereals, frames with one end open are best. They cause little or no damage to plants when the frame is slid into position.

Most quadrats used for cutting are rectangular in shape. Such quadrats are convenient to see and are more effective than squares as they sample across patchy variation. Very long narrow quadrats can increase errors due to large edge effects.

When doing visual estimates, a square quadrat of 0.25 sq. metres is usually the most convenient to use, but after some experience the quadrat can be dispensed with.
For calibration cuts the quadrat used should be of the same shape as the area assessed - usually square. In the case of the electronic pasture meter and the visual estimate, it is the same size as the area assessed. For the Ellinbank plate meter, the plate area is only 0.1 sq. metre. A larger quadrat (0.25 sq. metres) is used to overcome the large edge effect which would result from the use of a smaller quadrat.

c) Number of quadrats - the number of quadrats will depend on the magnitude of the differences expected, the reliability and precision needed in estimating them, the variability within a plot and the number of further samples which will be taken from the plot. Statistical techniques are available to estimate the number of samples required. It is recommended that where more than one sample per plot is taken, that for at least one plot per trial and preferably one plot per replicate all samples should be individually processed. On other plots they could be bulked. The research officer can then use the individual data to assess the adequacy or otherwise of the sampling intensity being used.

F. GENERAL PROCEDURES

1. Field procedure when cutting pasture

The type and number of sampling units, and the system used for sampling, is determined after the plots have been inspected to assess variation and the differences it is desired to record. Before starting to sample an experiment the officers concerned should:

a) Have a clear understanding of what to cut and the purpose, methods and details of samples needed.

b) Have all bags labelled prior to sampling and checked as they are placed on plots. Internal bag labels must be used at all times.

While the sampling is proceeding officers must:

a) Watch for operator error in cutting.

b) Avoid perimeter edge effects and edge effects within pasture cages.

c) Cut at a constant height above ground. If more than one person cuts the experiment they should each cut separate replications. Alternatively each person should cut the same number of quadrats from all plots.

d) Avoid excess soil, stones and sticks.

e) Check labelling with plan.

f) When transporting samples, count them in and out of vehicles and check that all have been accounted for.

2. Layout of samples

The aim of a layout of sampling frames is to prevent bias. To obtain a representative sample of the plant material on a plot the sample layout can be -
a) Random - Random location is not often used. If random throwing is used the frame must have an equal chance of landing on any part of the plot. This requires very wild throwing and the frame often lands on adjacent plots. A planned random layout could be prepared but is very time consuming.

b) Systematic - When more than one sample per plot is taken they can be laid out systematically. The sample sites are arranged in a regular and predetermined manner to give maximum dispersion over the plots. Unconscious bias in selecting sample sites is prevented by strictly following the system. Ideally, strings are laid out to pin point sampling positions but usually the positions are determined by distances or paces from the plot edge of the last sample.

c) Selected areas - Sampling areas must not be selected. However, if cow-pats, stumps, etc., which have no possible connection with experimental treatments, fall within a sample area, the sample can be discarded. If this is done another sample should be taken from a random or systematically chosen area.

Some research workers cut areas which they select as being representative of the plot. The selection is open to bias.

No matter what system is used the margin of the plot should always be avoided. An edge effect, due to the adjacent plot or buffer, is often presented.

3. Sampling

Sub-samples are required for dry matter determinations, botanical composition estimates, quality and chemical analysis. Often separate samples are taken for the latter two purposes because of the special precautions needed. (See section on chemical composition).

The sub-sampling method will depend upon the length of the material cut. A representative sample can be obtained with greater reliability from short pasture than from tall spring pasture.

a) For samples of one species or short pasture (less than 50 mm high)

Grab samples.

Mix the material thoroughly, spread it out and take small equal amounts from several places. The number of places should be at least six, but it is better to take more if sub-sample size is not critical.

Another method is, after a thorough mixing, to plunge the hand into the sample and trim off excess material with handshears.

b) For long, mixed pasture samples

Quartering

Mix the pasture thoroughly by teasing it out, then make a cone-shaped pile. By cutting, remove a one-quarter segment and discard the three-quarters. Mix the one-quarter fraction as before and cut to one quarter of that. Repeat until the sample is the desired size.
4. **Determination of quantity**

The amount of plant material can be estimated or expressed in four ways:

a) **Fresh weight** - Fresh weight has the disadvantage of being variable throughout the day and season. It limits conditions under which samples can be collected, i.e. it is most unreliable with dew or rain.

b) **Dry matter** - Dry matter is the weight of all plant material, oven dried to a constant weight at 80°C. It is the most reliable means of expressing the amount of plant material.

c) **Fresh weight plus sub-sampling for dry matter estimate** - When drying facilities are limited fresh weight can be recorded and a weighed sub-sample taken for per cent dry matter. Sub-samples are taken in plastic bags to prevent moisture loss until they are accurately weighed.

d) **Air dry hay yield** - This is generally unsatisfactory because large weight losses can occur during the drying process.

**Reasons for using dry matter basis are:**

i) Because of continuing respiration, the loss of dry matter during air drying can be as high as 30 per cent if not oven dried within about four days of sampling.

ii) The uniform basis of expressing data prevents errors due to different levels of soil or plant water.

iii) Dry matter expresses the amount of actual plant material produced.

iv) Any qualitative data on mineral constituent levels is falsely elevated by the loss of weight during air drying. Oven drying is the only reliable basis on which to express qualitative data.

5. **Sample drying**

Loss of dry weight due to tissue respiration is continuous so that the sample must be dried as soon after cutting as possible. Samples left wet and confined too long heat rapidly. Such samples lose weight very rapidly and are unreliable and unsatisfactory for any purpose. To overcome this, samples must be loosely stacked and kept as cool as possible until drying. Ideally, samples should be dried at 80°C, but drying at 60°C is satisfactory. All samples should be dried with forced draught.

6. **Weighing and recording**

Samples should be weighed from the oven so that they are completely dry, yet they should be cool to avoid weighing errors. The best compromise is to weigh after a standard period of cooling. This entails removing samples in small batches at regular intervals and weighing them in order. It should always be possible to weigh to a greater accuracy than one per cent. Results should be tabulated as they are weighed so that gross errors can be recognised before samples are discarded.
14. PASTURE SEED SAMPLING

A. INTRODUCTION

B. COLLECTION OF SAMPLES IN THE FIELD
   1. Indirect method
   2. Direct method

C. TREATMENT OF SAMPLES IN THE LABORATORY
14. PASTURE SEED SAMPLING

A. INTRODUCTION

Nearly all pasture seed sampling is aimed at estimating seed yield, i.e. weight of seed per unit area, usually expressed as kilograms per hectare. More detailed information on seed distribution, seed numbers per plant, seed size, seed above and below ground, and so on, may occasionally be required for a particular experiment. Such detailed aspects will not be dealt with here.

B. COLLECTION OF SAMPLES IN THE FIELD

Seeds generally occur in natural groups in pastures, in seedheads or burrs. Estimates of seed yield are usually arrived at by collecting seedheads or burrs using one of two sampling methods. The samples are then treated in the laboratory to determine their seed content.

1. Indirect method

In this method a specified number of burrs or heads is collected and the average weight of seed per head calculated. The plots are then sampled further by making a number of counts of heads per unit area. The seed yield can then be calculated by multiplying the number of heads per unit area by the weight of seed per head.

This method can be used for rose and cup clovers and annual medics. With some modification it can be used for nearly all annual legumes excepting subterranean clover.

Its most important advantage is that it reduces to a minimum the amount of plant material which must be handled when a large number of quadrats needs to be taken.

The steps involved in the use of the method in the field are:

a) Seeds per head

- Heads are collected from a number of sites (e.g. from 20 sites) to give a total sample of 500 burrs. The exact numbers will depend on plot variability, the purpose of sampling and the time available.

- If sufficient time is available the number of burrs required can be counted and collected in the field. Alternatively a large number can be quickly collected for later counting in the laboratory. If the heads have a tendency to break up they must be counted in the field.

- The burrs collected should be a representative sample of the burr population in the field. To avoid choosing the largest burrs or those that stand out most, either collect all burrs within a set area or collect all burrs along a short line.
b) Head or burr counts per unit area

For large plots in grazing trials, between 50 and 100 quadrats is usually a satisfactory sampling intensity. For smaller drill-sown plots the sampling procedure is similar to that described for the direct method.

Quadrat size is usually chosen to give less than 50 heads per quadrat. Operator fatigue is lessened if only small numbers are counted at a time.

Any burr or head that is more than half within a quadrat is included in the count; any more than half out is excluded.

2. The direct method

In this method seed is collected from a percentage of the area of the plot. For small plots, all but a buffer area could be sampled. This gives a direct expression of yield usually in grams per square metre; this is easily converted to kilograms per hectare. The method is generally used for estimating seed yield of subclover as those plants bury their burr and it is extremely difficult to count such burrs in the field. The method has the disadvantage of being laborious and resulting in a large bulk of samples.

Steps involved for collecting subclover are:

a) The burr must be dug up. Usually a sharpened spade is used to first cut around the edge of the quadrat and then to dig up the burr-containing soil. Depth of sampling is determined by depth of burrs - in first year pasture this may be as small as 10 mm but in cultivated paddocks it could be as much as 100 mm. The top material is usually brittle and cuts easily. The burr and soil can either be sieved on the spot to get rid of fine material or can be taken back to the laboratory. To break up burrs a larger sieve, e.g. 15 mm can be placed on top of the main sieve. The smaller sieve obviously must retain all burr and any seed which may have fallen from the burr.

Care must be take in placement of the quadrat, e.g. in drill-sown trials the outside rows should be left and the quadrat placed at right angles to the rows.

Burr can also be collected during winter using a similar procedure, although field sieving is usually impractical. Cores can also be used to sample for seed during winter.

C. TREATMENT OF SAMPLES IN THE LABORATORY

Ensure that the samples are dry - this may require placing them in a drier. Often dry burr samples cannot be dealt with for several months. If this is the case the sample bag should be placed, firmly tied, in clearly labelled bags and protected from vermin.
When samples are threshed and winnowed a method should be chosen which results in a minimum loss of seeds. If small amounts of material are involved they are usually threshed by hand using a corrugated rubber mat, rubbing block and hand winnowing. If large amounts are involved a number of machines are available. Chemicals such as "Perciene" can also be used to give a clean seed sample.
A. COMMERCIAL EQUIPMENT - INTRODUCTION

B. HARVESTING PROCEDURES
1. Prepare thoroughly
2. Inspect the plots
3. Cutting back
4. Setting up for harvest
5. Harvesting procedure

C. WORKING WITH EXPERIMENTAL HARVESTERS
1. Introduction
2. The one-man system
3. Conclusion
A. COMMERCIAL EQUIPMENT - INTRODUCTION

The aim of cereal plot harvesting is to obtain an accurate measure of the amount of commercially available grain produced. Equipment currently in use includes MF 31 and Claas self-propelled harvesters fitted with 1.8 m combs or reels which harvest 10 rows from a 12 row (nominal 2.5 m) plot.

The advantages of commercial headers over equipment designed for small experimental plots is that the machines are more robust and easier to operate. They also have the facility to re-thresh material unthreshed on its first passage through the drum and are therefore less sensitive to harvesting conditions than small plot harvesters.

The disadvantages of commercial equipment are that it is difficult to clean thoroughly (an important factor in pedigree seed production) and that because of its size, small grain samples may be 'lost' in the machine. In general, plots shorter than 20 m are unsuitable for harvesting with commercial 1.8 m cut harvesters.

B. HARVESTING PROCEDURES

1. Prepare thoroughly

Read the schedule and check with the officer concerned if any point is unclear. Are there any special requirements such as harvesting the whole plot instead of 10 rows, or retaining all grain from the plot?

Check that bags are available for harvested grain, grain samples (if required) and for discarded grain once harvesting is completed.

Prepare the experimental results sheets by filling in the experimental detail, plot numbers and treatment numbers. This should be done as neatly as possible and double checked. The original should be returned, when completed, to the officer responsible for the trial without transcription.

2. Inspect the plots

Are they ready to harvest?

Make a note of anything unusual, e.g. lodging, shedding, vermin damage, etc. If some difference is pronounced, it may be worth rating the plots for that factor.

Check the experimental plan and make sure that you know the location of plot 1. Are there 0, 1 or 2 buffers before the first plot? How many buffers are there between each replicate block?

3. Cutting back

If necessary, measure out and cut the experiment back to the length to be harvested. On research stations this is usually done well before harvest time, but on farmers' properties, the harvester may have to be used to cut
back the plots. Measure accurately, and if any plots are short (e.g. seed ran out during seeding) measure them individually and note the length so that the yield can be calculated.

4. Setting up for harvest

Ensure that the machine has the correct screens for the grain being harvested and that the drum speed and concave clearance are set according to conditions. Check also that the comb width is correct; for harvesting 10 rows the comb should have an effective width of 17.8 cm \times 10 = 178 \text{ cm}.

Harvest a buffer plot first. This fills the auger bottoms and other spaces in the machine which would otherwise be filled by the first sample. Check behind the machine for grain and unthreshed heads and look at the grain sample for unthreshed material and for excessive cracked grain. Re-adjust the machine as necessary.

Only when the machine is properly set should harvesting begin.

5. Harvesting procedure

a) Direction. Harvest into the wind or against the lean of a crop and always harvest in the same direction. At the end of the plot, keep the machine running and reverse back along the plot. If the machine is turned and run back, there is a risk of harvesting outside rows from previously harvested plots.

Keep the machine running until only a few grains are being delivered into the bag. Check the first few plots for correct machine adjustment.

b) Weighing. The bag of grain should be dropped on the end of the plot it was harvested from. It should then be weighed after taring the balance for the bag weight and either returned to the plot or carefully laid out in plot order adjacent to the balance. This is to allow later checking should an error be detected. The weight should be carefully recorded on the original and book copy of the results sheet.

c) Sampling. If grain samples are required for quality testing, it is most important that they be -

* representative of the plot
* as free of contamination as possible

To these ends, samples should be taken mid-plot as the grain is entering the bag. Bags should be labelled inside and out.

d) Post harvest operations. When all plot have been harvested, check the results for unusually high or low figures. Re-weigh any doubtful plots. Only when all operators are satisfied that all weights are correct should grain be bulked for transport from the site.

Check the site and remove any pegs, rubbish, etc.

Always count sample bags into the vehicles to ensure that none are left on the plots.
C. WORKING WITH EXPERIMENTAL HARVESTERS

1. Introduction

There are three types of experimental harvesters operating within the Department of Agriculture, namely the Hege 125 series, the Wintersteiger Seedmaster and the Wintersteiger Nurserymaster. Although these machines vary somewhat in their appearance and many of their facilities, they are all based on a fairly similar principle. The machines are simple in design, in that they do not have facilities for returning unthreshed grain for re-threshing. This means the machines are as self-cleaning as possible to reduce cross contamination, which is important for experimental work. However, it also means the machines are more sensitive to variations in temperature and weather conditions than commercial harvesters.

Experience has indicated that these harvesters are much less robust than commercial harvesters, require care in operating, regular maintenance and regular checking during operation, to ensure that components aren't being damaged due to malfunction.

Machines supplied by the manufacturers are designed for two operators. One person drives the machines, the other walks beside the machine and empties samples from the sample bin. Most machines in the Department are now modified to single person operation, using a system designed within this Department.

2. The one-man system

The modification has the advantage of reducing the number of operators to one without affecting the rate of harvest of the plots. Obviously, by removing the need for the operator to walk beside the machine, operator comfort is greatly improved. Samples are stacked directly into bins on the side of the machine. This allows the whole harvesting operation to be carried out much more efficiently as there is no need for individual samples to be collected in the field after the plots have been harvested.

The main disadvantage of the system is that samples are stacked into the bins in harvest order. Where plots are planted in blocks behind each other, they are usually harvested in this order — in a different order therefore to plot order (Figure 15.1). This means that when samples are processed later for weighing and sub-sampling, etc., they have to be handled in the harvest order. Using computing facilities and programmes available, this need not be a restriction, as materials can be readily weighed in harvest order, the data analysed and samples then processed again in harvest order for future work.

To make the one man system operate most efficiently, there are a number of things to keep in mind. For plots of about 5 metres in length (the usual plot length with plant breeding trials) the harvesting time for a plot is about 30 seconds. Approximately five seconds of this is taken up actually harvesting the plot, for the remainder of the time the grain moves through into the sample bag, and the operator folds and stacks the sample into the bin. The machine cleanout time and the operator's folding and stacking time should be concurrent to maintain the best harvesting rate. To achieve this, the operator should delay folding and stacking the sample just harvested until after the next plot has been harvested, so while the machine is cleaning that sample into the harvest bag, the previous sample can be folded and stacked.
Samples must be stacked into the bin systematically, so when they are processed later they can be retrieved in a systematic order. The machines are normally fitted with a bin rack that allows two bins to be placed on it. When one bin is filled, samples are put into the second bin until the machine is at the centre of the block being harvested. The full bin is then placed on the ground, and the supplementary bin is moved into its position. A new empty second bin is then shifted on to the bin holder. This results in all the bins being stacked in order across the middle of the trial block, which greatly improves the orderly collection of bins when harvest is completed.

Operators obviously must get off the machine when changing over sample bins. They should take that opportunity to walk around their machine, and check that all components are operating satisfactorily. This often alerts the operator to problems before they progress beyond repair and therefore keeps the machine operating more efficiently.

The one man system provides a useful means of warning operators of grain blockages that may be occurring in the machine.

The grain is readily heard as it enters the cyclone of the system; even small amounts of grain are audible. Operators should notice if grain is trickling through the machine after the initial cleanout is completed. Such noise indicates that there is a blockage in the machine.

It is imperative that operators continually check to make sure that they are harvesting the right plot into the right sample bag. In plant breeding trials sample bags are labelled with computer labels in harvest order prior to harvesting. Labels have sufficient information on them for the operators to check that they are harvesting the correct plot. Any errors made in the harvesting procedure should be written on to the harvest bag, in large writing near the label, so that errors can be allowed for during the weighing process back in the office. It is essential that operators record on the bags any inconsistencies and discrepancies that may occur, for future checking by staff at weighing and subsequent processing.

3. Conclusion

The one-man system allows an extremely efficient harvesting procedure. With plant breeding trials, operators can harvest between 800 and 1,000 plots a day, provided they harvest consistently and keep their machine in good condition. It is important that operators are alert, check their work, and make sure that material is being processed and harvested in its correct order and is placed into its correct bag. All errors must be recorded to ensure that subsequent analyses are accurate and truly reflect the results of the trial.
FIGURE 15.1

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Harvest Number H

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Start Harvesting

Finish Harvesting
16. USE OF COMPUTERS IN FIELD EXPERIMENTS
16. USE OF COMPUTERS IN FIELD EXPERIMENTS

Automatic data processing through computers is increasingly important in aspects of our day-to-day living. Agricultural scientists have made use of computers for a long time, particularly since the mid 1950s for statistical analyses of relatively large data sets. During the late 1960s and the 1970s statistical package programmes were produced which are so simple to use that most data sets, other than those which have been very small, are now best analysed on the computer. The availability of these package programmes has meant that not only are experiments analysed more quickly and with less likelihood of error, but also that more sophisticated analyses are possible. The latter would not have been considered previously because of the work involved in the calculation.

When designing experiments, the experimenter is no longer daunted by the complexity of the analysis; consequently, increasing use is being made of sophisticated experimental designs and analysis.

During the 1980s increasing use will probably be made of electronic data recording devices; the impact of these is already being felt. In plant breeding, for example, where plots yields were previously recorded into field books by hand, they are now recorded automatically on magnetic tape which can be fed into the computer for analysis. In the future most data will probably be recorded electronically. While this may be viewed negatively (as the cause of redundancies), it can be viewed positively as making the work programmes more efficient. Everyone should be concerned with upgrading the efficiency and output of their work and research programmes and computers and electronic data recording equipment offer one means by which this can be achieved.

In plant breeding, computers have an important role to play in the bookkeeping tasks – producing plans, labels, field books, and general record keeping and updating. Extensive use of this aspect of computers is also being made by the variety testing programme, fleece testing service, and dairy herd recording scheme. For relatively small agricultural experiments the use of computers for this purpose has had relatively little impact, but as computers become more available this will no doubt change. Besides reducing errors in transcribing information and the speeds with which these clerical tasks can be performed, the computer provides more information to technical officers and research workers on the nature of treatments in an experiment. For example, where previously a sample may simply have been labelled with a plot number, it can now be labelled with a computer produced label with details of the treatment, plot, variety, crop experiment number, and research officer involved.

In using computers, technicians need to be aware of some of the pitfalls and restrictions involved. Firstly, if data is ultimately to be recorded on to magnetic tape or cards then it needs to be clearly set out and recorded consistently. If information is recorded into field books then there is no reason why this information need be transcribed before keypunching (typing data on to punch cards or magnetic tape so that it can be read by a computer). The field book or a photocopy of the field book should suffice. If a technician is recording weights to the nearest tenth of a gram then it is important that it be done consistently, e.g. 3.2, 2.6, 4.0, but not as 3.15, 2.6, 4.0. While your research officer may

16.1
understand what you mean, a keypunch operator is not expected to. If computers are being used to produce plans there may be restrictions on the field layout which you will have to tolerate. People not used to computers may find some frustrations in not being able to do things exactly as they did before, but usually it is better to adapt rather than opt out. If the frustration is serious and important enough it may be worth the research officer's (or technician's) while to discuss the matter with a biometrician or the author of the computer program to see if program changes or options can be considered.

It should be remembered that computers are only a tool for bookkeeping and data analysis and not a substitute for good agricultural experimentation. If we feed bad data into the computer our answers will not be any better for having used a computer. A computer will never produce a better wheat variety by itself, although it might provide assistance along the way. Ultimately, good experimentation depends more on the creativity, care, and effort that technicians and research officers put into their work, rather than the fact that they are using micro-electronic circuitry.
17. WORK SAFETY

A. DEPARTMENT OF AGRICULTURE WORK SAFETY POLICY

B. SAFETY WITH MACHINERY

1. General precautions
2. Cultivating implements
3. Mowers
4. Balers
5. Forage harvesters
6. Headers and harvesters
7. Elevators and grain augers
8. Hammer mills
9. Circular saws
10. Chain saws

C. SAFETY WITH AGRICULTURAL CHEMICALS

1. Storage
2. Mixing of concentrates
3. Application
4. Toxicity
5. Containers
6. Equipment design and method of application
7. Respiratory protection
8. Undesirable residues in food
9. Suspected poisoning
17. WORK SAFETY

A. DEPARTMENT OF AGRICULTURE SAFETY POLICY

The Director of Agriculture has stated the following as the Department's Safety Policy:

- The Department of Agriculture affirms the prime importance of the safety and health of its employees.
- The Department will ensure that every effort is made to avoid, remove and remedy causes of industrial accidents.
- Leadership errors or oversights must be avoided to prevent staff being placed in danger.
- Senior officers will provide effective leadership and example, but it is the responsibility of all staff to plan work activities in a manner that minimises the risk of accident.
- Every accident will be listed and investigated. Accidents involving injury or loss of time will be the subject of a report.
- Suggestions for improvements in safety are encouraged from all staff.
- Safety is not the sole responsibility of any one person. It is the responsibility of all concerned in the Department's operations at all times.

It must be realised that accident prevention depends very heavily on the attitude of employees, the people using machinery, vehicles and equipment. However, a great responsibility also rests on the shoulders of group and section leaders, who must always ensure that safety is a prime consideration in task allocation, in training and in supervision.

When an accident does occur, or when one is averted by chance, all concerned must immediately consider the circumstances and ensure that further activity avoids those actions or conditions contributing to the accident or the risk of accident.

Booklets dealing with accident prevention, with the responsibilities of supervisors and workers, and outlining methods of accident prevention are distributed throughout the Department. You are strongly urged to read these carefully, and often, and adopt the recommendations made. As a technician attaining promotion, you become increasingly responsible for leadership and supervision. In the area of safety, you are expected to:

- Recognise unsafe actions predisposing to accident and injury
- Detect hazards likely to cause accidents
- Assist in accident investigations
- Train new employees in safety procedures
B. SAFETY WITH MACHINERY

1. General precautions
   - Read and act on makers' operating instructions.
   - Keep all shields and safety guards in place.
   - Do not attempt to lubricate or adjust moving machinery.
   - If guards have been removed for any reason make sure they are replaced before the machine is started.
   - Make sure the controls of machines and the machines themselves are in good working order. Check for broken, missing or damaged parts that may affect the performance of the machine.
   - Hydraulic equipment should not be left in the raised position. If it is necessary to work under or around raised equipment, always provide a substantial support for the load in case of hydraulic failure.
   - Do not stand on the drawbar of a moving implement.
   - Never allow children to ride on a tractor or implement and do not carry passengers unless special provision has been made for them.
   - When coupling an implement to a tractor, keep hands and feet clear of places where movement of the tractor or drawbar could crush them.
   - Do not try to clear a blockage on running machinery.
   - Be sure all power-drive guards are in place when a power implement is attached to the tractor.
   - Make sure that operators are trained properly. Do not allow anyone to use a machine unless you are sure they are capable of handling it safely.
   - Be especially cautious when working long hours. Your reactions slow down as you become tired.
   - If the implement you are towing is operated by a trip rope, always tie the rope to the tractor, and never to your body. Make sure the rope is tied in such a position that it will not cause you to trip when alighting from the tractor.
   - It is not advisable to use makeshift hitches so that extra implements can be towed. If two or more implements are to be towed by a tractor, make sure linkage points are properly designed.
2. **Cultivating implements**

- Most types of tillage implements have few moving parts, but offer no protection if someone falls on or in front of them. Make sure no-one rides on towed implements unless these are designed for the purpose.
- When they are not in use, leave harrows with the tynes down.
- Do not put your hands in the seed box when fertilising or seeding is in progress. They may get trapped.

3. **Mowers and implements with cutter bars**

- Never get off the tractor while the mower blade is moving.
- Do not raise the cutter bar of the mower by means of the cutter bar fingers, and do not carry out adjustment while the cutter bar is in a vertical position.
- If the cutter bar of a mower becomes clogged, either reverse the tractor or clear the clogging with a fork or other implement, not with your hands.
- Keep a guard on spare reciprocating-mower knives.
- Check rotary mowers or slashers frequently to see that the blades are firmly fixed to their shaft.
- Children and animals should not be allowed in paddocks during mowing.

4. **Balers**

- Never clear blockages or make adjustments while the baler is running.
- When checking the area around the shearing knives, see that no-one is near the fly-wheel. If the fly-wheel is moved, a finger or hand can be easily cut off.

5. **Forage harvesters**

- Make a frequent check that the flails or hammers are securely attached to their shafts.
- Keep away from the mouth of the machine and don't stand behind the machine when it is operating.

6. **Headers and harvesters**

- Many machines of these types are manufactured with exposed driving belts and pulleys, which can inflict serious injury on contact. Simple metal guards can be made and fitted easily.
Check that everyone is clear of the machine before moving backward or forward with a header or tractor.

Keep children away from the machine when it is operating, particularly when it is turning or emptying.

Make sure brakes are locked on before getting off the machine.

Use a stick or fork to clear cutter bars or choked fingers.

Protect your eyes from dust and chaff - wear close-fitting safety goggles.

7. Elevators and grain augers

The speed of gears, chains and rotating shafts on elevators and augers is considerably less than on other machines, but accidents can still happen. Make sure that guards are fitted over moving parts.

Do not hoist your elevator or auger higher than recommended by the manufacturer.

Injuries to hands and fingers are likely to occur where the auger enters the tube - make sure this area is shielded by a mesh guard all the time the auger is in use.

Do not block up the wheels or axle to get greater discharge height, as this could cause the elevator to overturn.

Make sure that high equipment, such as elevators and augers, is kept well clear of overhead power lines.

Do not use the elevator as a ladder or scaffold.

Keep elevators lowered when not in use. Most elevators have a device for stopping the hoisting crank if you lose control when raising or lowering the elevator. Make sure this device is in good order - a spinning crank handle can cause a serious injury.

8. Hammer mills

Make sure the belts on the hammer mill are suitably guarded.

Fit a protecting grille over the mouth of the machine to prevent hands being put in too far.

Stand slightly to one side of the machine while feeding in material, as small stones are likely to fly out.

Make frequent checks to see that the hammer retaining shaft and locking pins are properly secured.

Do not remove covers when the machine is running.
9. Circular saws

- Instruct new workers in the operation of the saw before allowing them to use it.
- Do not use a saw blade that is cracked, warped or has teeth missing.
- The blade of a circular saw should be guarded above as well as below the table.
- Do not repair a cracked saw blade by welding or brazing.
- If the saw is belt-driven, the belt should be guarded to prevent contact with it.
- Make sure the saw bench has a properly fitted riving knife if the saw is used for ripping long lengths of timber.

10. Chain saws

- Do not carry a saw with the motor running.
- When using a chain-saw, wear close-fitting clothing, make sure you have a firm footing and always stand where you will be safe from unexpected shifting of the log or branches.
- Plan each cut before starting the saw - do not start until there is a clear place to work and a safe exit path.
- During operations keep bystanders clear.
- Before starting to cut, examine the lean of the tree, and look for loose limbs or intertwined branches.
- Where possible, place the pivot grip against the tree or log before commencing operations.
- Before starting up, make sure the chain is not touching anything.
- The cutting chain should be correctly tensioned and kept sharp.

C. SAFETY WITH AGRICULTURAL CHEMICALS

PESTICIDES ARE POISONOUS - SOME EXTREMELY SO

This fact should never be forgotten. However, commonsense and a knowledge of the product offer the best guarantee against unsuccessful or dangerous use. Most problems arise through carelessness, from accident or misuse.
1. Storage

Pesticides should be stored in a well-aired shed or room that can be securely locked. Transfer the contents of leaking containers to sound ones and label the containers carefully. Spilled chemical should be mopped up with soil plus lime or soda (whichever is available), and the material buried. The area should finally be cleaned with washing soda solution.

Transferring chemicals from original to other containers should be discouraged (except when the original container is damaged).

2. Mixing of concentrates

Concentrates present the greatest danger to operators. Before mixing read the label and follow the instructions carefully. As many concentrates contain highly flammable solvents the use of a naked flame to inspect the contents of containers (and of course smoking) must be avoided. When the drum has been opened allow aeration for a few minutes before taking chemical out. Wettable powders should be mixed by adding the powders gently to the water and then allowing them to settle before stirring them in.

Empty containers of concentrate should be rinsed twice or more with a little extra water and this added to the spray mix.

It is important that protective clothing, particularly impervious gloves, and a respirator be worn when handling concentrates.

3. Application of chemicals

Spraying or dusting should only be carried out in low wind conditions to avoid chemical drifting to neighbouring premises. Plan the work so that a minimum of spray will drift onto the operator's body.

Check equipment to ensure there are no leaks and that it is in good working order.

The degree of personal protection varies with the agricultural chemical used and the type of operation. Spraying in the cool of the morning is usually to be preferred when air movement is likely to be less troublesome, and conditions are more comfortable for wearing protective clothing. In very hot conditions the wearing of full protective clothing is difficult because of heat stress, and every effort should be made to have pesticides applied during the cooler periods of the day; alternatively, periods of exposure should be brief and repeated as frequently as necessary.

4. Toxicity

The toxicity of a pesticide is usually quoted as the acute oral toxicity (by mouth) or acute dermal toxicity (via the skin) in milligrams of active ingredient to each kilogram of body weight. Certain pesticides, which are extremely hazardous as far as acute oral toxicity is concerned may yet be safe to apply if they have a low dermal toxicity, indicating that they are not readily absorbed through the skin, or if they are absorbed they are rapidly excreted or neutralised by the body.
In general, the more toxic chemicals are safer to use in the form of pellets or granules providing there is no breakdown to dust. Dust particles that are very fine are readily inhaled and for this reason can be very dangerous. Larger particles of spray tend to settle out quickly by gravity while fine mists may remain suspended for long periods and are potentially more dangerous for the operator, especially if located downwind.

Although pesticide is more completely and more rapidly absorbed into the body by both oral route and the respiratory tract, except in the case of fumigants, skin absorption is considered the most probable means of poisoning from occupational exposure.

For normal spraying operations combination cotton overalls should be worn; and washed regularly, preferably at the end of each day's work. For heavy exposure it may be necessary to wear impervious clothing. Long trousers must always be preferred to shorts and long-sleeved shirts to those with short sleeves. A washable hat to protect the head and some of the face is important.

For certain overhead spraying the use of impervious head wear may be necessary. Hard hats which allow circulation under the hat should not be used when exposure is to toxic dusts. The brims of such hats are usually too small to give adequate protection. Impervious gloves should be worn when handling pesticide concentrates or when spraying toxic material. Gloves with tears in them or even pin holes are dangerous. Care should be taken to prevent seepage of spray down inside the gloves. To help prevent this the cuffs of overalls should cover the tops of the gloves. Waterproof shoes or boots are necessary for large scale spraying. Footwear becomes contaminated, not only from falling spray droplets but also from contact with contaminated grass and plants. Canvas and leather footwear absorb pesticide and may keep the chemical in contact with the skin to be gradually absorbed into the body.

Protection of the respiratory tract is especially important when fumigants, fine dusts or fine spray particles are present. It is also necessary when opening drums of concentrate. Suitable protection can be provided by the use of a twin cartridge, half-face-piece respirator using agriculture type cartridges. These cartridges, which are usually yellow in colour, protect against dusts and chemical vapours.

For protection against heavy applications during overhead spraying a plastic hood with inbuilt filter cartridges may be warranted or, alternatively, a full face respirator fitted with an appropriate canister may be used.

It is important that when handling fumigants, which are all true gases, nothing less than a full face respirator be used. The canister should be checked to see that it is the correct type to protect against the particular fumigant and that its shelf life has not expired. A canister that has been used on a previous occasion must be suspected. Irrespective of the type of respiratory equipment fitted, if the pesticide can be smelt by the wearer he should move out of the contaminated area and check for defects. These will usually be either wrong or old filters or a poor face fit. A bearded face sometimes makes it difficult to obtain an efficient face fit.
5. **Containers**

No spraying should be considered as complete until the empty concentrate container has been disposed of in a safe manner. It is preferable to rinse empty containers and add the rinsings to the spray. Metal containers should be punctured and arrangements made for them to be put into a Local Authority tip or privately buried. Care should be taken to avoid contamination of any water supplies. Chemicals for ULV treatments should be rinsed in kerosene before disposal. Aerosol containers should not be punctured or burnt. Multiwalled paper bgs may be burnt except those used as herbicide containers.

6. **Equipment/design and method of application**

Much can be done to reduce risks of contamination if the operator organises his spraying by moving upwind and directing the nozzle behind him instead of in front. The design and maintenance of taps, tank lids, valves, etc., should be such as to reduce leaks and thus avoid spillage. The hands should never be used for mixing, a stick is better and safer.

When ultra low volume (ULV) sprays are used, proper selection of particle size will help reduce drift and minimise inhalation of particles. Fine particles are easily inhaled and tend to drift a considerable distance.

Mixing of chemicals should be avoided unless a combination of pesticides is recommended by an appropriate authority. Mixing may increase the toxicity to man and other animals, and the chemicals themselves may be incompatible.

The labels should be read and the instructions and precautions adhered to.

Avoid eating and smoking when working with chemicals. Have a shower after spraying and launder clothing as soon as possible. Spray equipment should also be cleaned as soon as possible after spraying, as the longer it is left the more difficult it will be to remove because of solid chemical settling out.

7. **Respiratory protection**

Where toxic dusts, gases or small spray droplets are prevalent or where application is in confined spaces respiratory protection is important.

Do not wear a respirator hanging around the neck during spraying or leave it exposed where it may become contaminated on the inside.

A twin cartridge respirator equipped with agricultural type cartridges is appropriate for most situations. However, if fumigants such as methyl bromide are used or if work is for a prolonged period in enclosed areas with mists or fogs a full face respirator is required. Respirators should fit firmly to the face. If chemical can be detected by smell while wearing a respirator either the face fit is not efficient or the filtering cartridges can no longer absorb the chemical and should be replaced.
Spillage of concentrate pesticide on the skin or clothing warrants immediate action. The skin should be washed thoroughly with soap or detergent and water. Clothing should be removed and laundered before re-use. Men engaged in spraying away from facilities should carry water, soap and a towel for emergency use. Contamination of eyes should be treated by flushing with tap water for at least five minutes. When poisoning is by mouth, attempts should be made to induce vomiting and obtain medical help. The pesticide label should be kept and passed on to the doctor providing treatment.

After using a respirator, the cartridges should be removed, the face piece washed, dried and stored in a plastic bag away from exposure to heat and sunlight. Spare cartridges should be on hand and the old ones replaced when necessary. It is difficult to give a specific period of time that cartridges may be used as this depends on the chemicals used and the concentration as well as other factors.

However, it is doubtful if they would be effective for more than one day's spraying.

8. Undesirable residues in food

Some residues are relatively toxic and care should be taken to ensure that withholding times recommended on the labels be complied with.

Do not use the persistent chemicals dieldrin, aldrin, endrin, heptachlor or chlordane for the treatment of any pests on vegetables. These chemicals must be avoided where possible because of their persistence in the environment. Avoid spraying poultry pens for flea or fly control with any of the above persistent chemicals - the chemicals are not only toxic to poultry but may be passed into the eggs.

9. Suspected poisoning

Should you suspect a poisoning from pesticide exposure, report the matter to the Occupational Health Division of the Public Health Department so that follow-up tests may be carried out and advice given.

For emergencies relating to accidental skin contamination with concentrated pesticide or accidental swallowing refer to the Public Health Department emergency chart or if this is not available ring the Poisons Centre (381 0222).
PESTICIDES

EMERGENCY ACTION

When a Chemical May Cause Harm

<table>
<thead>
<tr>
<th>IF SWALLOWED</th>
<th>IF INHALED</th>
<th>IF IN EYES</th>
<th>IF ON SKIN OR CLOTHING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rinse mouth with plenty of water.</td>
<td>Remove person to fresh air.</td>
<td>As quickly as possible wash eyes thoroughly for 15 minutes with clean water.</td>
<td>Remove contaminated clothing or shoes immediately.</td>
</tr>
<tr>
<td>Apply first-aid as stated on the label of the chemical container.</td>
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<td>Use a gently running tap or hose.</td>
<td>Wash contaminated skin with plenty of cool water. If the chemical is difficult to remove use detergent or soap with the water.</td>
</tr>
<tr>
<td>If the label recommends vomiting the person, this can be done by:</td>
<td>Call a doctor or take the person to him. Take the label from the chemical container, (or the sealed container itself) to the doctor. Having the label will hasten treatment.</td>
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</tr>
<tr>
<td>1. Administering syrup of Ipecacuanha.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2. Giving salt and water.</td>
<td></td>
<td></td>
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<tr>
<td>3. Poking a finger down the person's throat.</td>
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<td></td>
<td></td>
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