CHAPTER 1 SCOPE AND NATURE OF THE FARM INDUSTRY

Australia, and many other countries, have traditionally been very dependent on their primary industries. Increased technological and infrastructural changes are challenging the ability of the Australian farmer to compete both in Australia and against overseas competition.

There still remains a place in Australian society for the farmer, but a willingness is required to embrace change and face new challenges the likes of which would never have been anticipated by farmers a generation ago. Many farmers are finding that they must become more knowledgeable in areas which they would not have paid much attention to in the past. The farmer of the 21st century must be technologically astute; shrewd in business, yet still cart hay in season; be able to recognise a sick or distressed animal; and know what course of action to follow to rectify the problem.

Types of Farms

Farms can be of many types, they might be a fat lamb and wool producing farm, a dairy farm producing milk, or a cropping venture producing vegetables or grain. Most farms, while generally specialising perhaps in one or two areas, are often capable of producing a variety of products without too much changeover. This is a handy position to be in, especially considering the sometimes volatile nature of such factors as the weather and markets.

What is produced may not necessarily be for sale, but used to reduce costs that would otherwise have to be outlayed, such as hay or fodder crops grown by a dairy farmer to feed his herd in times of poor pasture. Alternatively, having a milking house cow, or running a few head of beef for meat are simple, but effective ways of reducing your expenditure.

What to Produce

It is tempting to choose to grow particular livestock or crops because it 'seems' like a great idea; without fully considering (and comparing) all other options. Farmers may choose to grow wine grapes because they like drinking wine. They may decide on farming Emu's because they have read enthusiastic articles about these animals. Some farmers choose to plant a particular crop, because they know someone else who just had a good year with it.

These reasons alone are not enough! You need more if you are planning to invest a lot of time, money and effort into some particular farm enterprise.

Follow a logical and complete process, when selecting what to produce. Preferably, work it out on paper, perhaps like this:

1. List all of the possible things which can be grown/produced in your locality. Be sure to consider factors such as soil types and conditions, water supplies, climatic conditions, etc. (see Chapter 2 for further site considerations).
2. Consider what facilities/abilities you have (ie. land, manpower, expertise, money, etc). Remove anything from your list of potential products that would require facilities that would be expensive or difficult to provide.
3. Consider how long it might take before each potential product would be ready to market. How long would it be before you get a return on your investment? Can you cope financially until then? Consider what demand there might be for each of these things at that point in time. Reduce the list of potential products further.
4. Consider the level of risk involved with each of the remaining products. Think about what might go wrong with each (eg. flood, drought, pest plague, over supply on the market, etc). Now produce a new list arranging your options in order according to risk - the least risky at the top, the most risky at the bottom.
5. Now choose what you want to produce. You may decide to produce more than one type of produce - hence reducing the likelihood of serious failure (ie. if one fails, another may turn a profit).

Chicken Coup

Standards & Efficiencies

The use of Australian standards in farming is a relatively new concept in Australian farming. In the past the produce of farms may have been tested for impurities or chemical traces but actual farm practise standards were left to the farmer and still largely are. However, more buyers of produce are requiring certain standards in the ways produce is prepared for market. This, they feel ensures the quality of the goods, whether they be eggs, milk, meat or cabbage. Standards might detail the type of housing that animals are kept in, the food they are given, the levels of chemicals they will be subjected to. They will also force farmers to look at their own methods of farming and this will hopefully encourage better farm practises all round.

What is Management

Management involves making decisions, and then following through to implement those decisions. This generally requires long term planning. Planning should be routinely reviewed and modified to fit changing situations.

Making good management decisions requires two things:

1. Full knowledge of the possible options (ie. What are all of the choices). Lateral thinking helps greatly in being able to devise different and innovative options. Successful farmers are often good lateral thinkers.

2. The ability to forsee all of the important implications arising from following each alternative choice (both short & long term implications). Part of this process involves determining and considering the likely problems associated with each option (ie. this is called Risk Analysis).

Starting Out

Due to a number of key factors, such as cost and suitable knowledge, the people who are most likely to become farmers are those people who have been raised or lived on a farm. This is not always the case and recently there have been increasing numbers of people who are leaving urban lifestyles for a farming life. Hobby farmers often start with a small allotment, while maintaining their mainstream work or income until they are comfortable about making a living from their 'hobby'. Some progress to larger properties once they have hopefully established the skills, knowledge, and financial backing to enable them to farm profitably on a larger scale.

Improving an Established Farm

Farming is a dynamic business, don't let the old cliche of the slow talking man on the land fool you. Those farmers who don't keep their finger on the economic pulse soon go out of business. In Australia, many soldier settlement farms were established after the world wars. Many soldier settlers have gone on to create viable business enterprises for themselves and their offspring but the majority struggled and eventually opted for a less harsh lifestyle.

Improving an existing farm requires assessing the positive and negative aspects of what exists on the property, and weighing up your options for improvement. Are the pastures weary? Do the fences need attention? What about the stock, for example, are these cows second rate milkers because no breeding program has been in place. Obviously the list of questions goes on and on and should continue even when you feel that you have rectified many of the existing problems.

Share Farming

There are many forms of share farming arrangements available and they tend to be individually tailored to the situation. Often they will involve a percentage of the profit in lieu of wages for a farm worker, but may also include other factors such as rental or lodgings, or partial wage plus a smaller percentage of profits, etc. The share farmer may have total managerial control of the property albeit with some budgetary considerations in place. If you are a potential share farmer be sure to thoroughly investigate any proposed arrangements you may be contemplating before you sign any binding agreements, in particular ensure that any estimates of future profits are realistic. In addition be sure to put down in the agreement all responsibilities of both parties, including who is responsible for which costs (e.g. rates, services, insurances, cost of materials).

Leasing

Leasing or renting is generally considered a more flexible way of farming than share farming. Farmers can expand or reduce the amount of leased land to match market forces (subject to the availability of land for leasing). It does however have the problem of "insecurity of tenure". Leasing can allow a farmer with limited capital to start a new enterprise. A major problem with leasing land, particularly for short term periods, is that most farmers will be unwilling to spend much time and effort on maintaining or improving the leased property, unless they absolutely have to (e.g. replace fences that are falling down). This can result in a decrease in the productivity of the leased land, often in a very short time. Some lease agreements stipulate certain activities that must be carried out on the part of the leasee (person who is leasing the property), such as maintaining fences, controlling weeds, and maintaining pasture quality.

CHAPTER 2 THE FARM SITE

The location, size and internal characteristics of a farm must be appropriate for the type of farm you are operating.

The amount of land required for a successful farm operation depends upon the type of farming to be undertaken and the required size of the enterprise. Farm size can range from a few hectares in the case of intensive fresh herb production, to ten or more hectares for a poultry farm or vineyard, to hundreds, even thousands of hectares for grazing properties.

The size of land required can depend on the following:

- Cost of land: a compromise may be necessary due to what can be afforded. A property that is further away from services, markets and cities can be obtained at cheaper prices.
- What is available: restricted by what is available on the market (i.e. if you need 150 hectares; land might only be selling in 100 hectare or 500 hectare lots in your preferred locality).
- Amount of land required to produce a reasonable living: this could depend upon whether the farm will be the sole income of the family, or whether you will have off-farm income (e.g. investments, other employment).

Farmland

FARM SITE CHARACTERISTICS

If you are contemplating purchasing a property for use as a farm, or evaluating an existing one, consider the following:

1. SITE CHARACTERISTICS

Slope

Sloping sites can be very difficult for stock to traverse, or for you to cultivate. They may require expensive earth works to prepare suitable sites for buildings, and terracing for areas to work on. Sloped sites will generally have good drainage, although steeper slopes that are subjected to heavy rainfall, may result in high surface runoff and erosion. Slopes on unstable soil are also more likely to fail (landslips).

Aspect

For crop production choose sites with maximum sunlight hours and with protection from prevailing winds; for example, in the Southern Hemisphere, North to North - East facing slopes are generally preferred – in the Northern Hemisphere choose a South facing site.

Soil

Soil characteristics play a major part in the success of both pasture and crop production. Contact the local Department of Agriculture, Land Management or similar body to discuss any potential problems (e.g. salinity, erosion) of targeted properties.

Factors to consider include:

- Nutrient levels - soils that have been used previously for agricultural purposes may be deficient in some nutrient elements. This can often be rectified by fertiliser applications. It can be quite expensive however to do so when large scale production is planned. Soils that have a high initial fertility will save time and money. In rare cases soils may even have toxic levels of some nutrients that can damage or even kill your plants. Tests should be carried out to determine nutrient levels prior to land purchase to see if they are suitable.
- Soil structure - well-structured soil will have a crumbly friable structure that is easily cultivated. Well-structured soils have good aeration and good drainage so that plant roots can readily penetrate the soil. Soil structure can be improved by the addition of materials such as lime, gypsum and organic matter - depending on the soil chemical composition. Soils that have good structure to begin with will enable you to commence production earlier and be easier to maintain in good condition.
- pH - the degree of acidity or alkalinity of a soil is critical to maintaining the health of pasture and other crop plants, and in turn maximising production. Each type of plant has a preferred pH range. Most will grow quite successfully in the pH range 5.5 to 7.0. Some may prefer slightly more alkaline conditions (above pH 7). When soil pH is not far out of the preferred range, it can be modified fairly easily using acidifying materials such as super phosphate or ammonium sulphate fertilisers to lower pH, or alkalising materials such as lime to raise pH. Soils that have very low or high pH conditions should be avoided. These are often very hard to modify or maintain to a suitable pH range. Soil pH can be easily and quickly measured using a simple test kit or pH meter. Laboratory testing is recommended though for larger sites.
- Salinity - increasing salinity of both land and water is a problem in many countries. Soils for crop production should have low salinity levels alternatively crops that are tolerant of saline conditions may be necessary. However not many crops are tolerant of very high salinity; these sites are best avoided.
- Drainage - this includes both infiltration into the soil, and surface runoff (i.e. how much surface runoff occurs and where does it run to?). Speak with neighbours! Consider all parts of the property. Are any areas prone to flooding?

The presence of moisture loving plants, such as rushes found in an open paddock, will give an indication of areas that tend to remain moist or those that are prone to flooding. If possible try and visit any properties you are considering purchasing, during, or as soon as possible after, a heavy downpour to help determine any drainage problems.

2. CLIMATE

All plants and animals are adapted to particular climatic conditions. To get the best out of them in terms of both quantity and quality, you need to choose a site that provides conditions best suited to the particular plants and/or animals you are growing. If you already have a site, select plants and/ or animals that suit that site. Modification of the site to alter conditions may make it more suitable for the plants and/or animals you wish to grow (i.e. build dams to provide additional water for irrigation, or grow windbreaks for shelter). However these can be expensive.

Climatic data for an area is often available from the Bureau/ Department of Meteorology in your region. They provide climatic data in a variety of forms for the entire country and this data can be easily used to determine growing conditions in most areas.

Temperature

All plants have a temperature range in which they will grow. Within this range is an optimum range, where the plants will give their best results. For example a particular plant may grow within the range 4 - 35 degrees Celsius with an optimum range of 15 - 25 degrees Celsius.

Maximum temperatures at a potential site are generally not as critical as minimum temperatures. At high temperatures plants may slow their growth to reduce water loss, whereas at low temperatures the plants may cease growth or even die. As temperatures can vary quite significantly, not only from season to season - but also from day to night, it is important to consider the annual temperature cycle for each potential farm site. Tables or maps (again they should be readily available from the Dept./Bureau of Meteorology but also from the body dealing with primary production in your area (e.g. Dept. of Primary Industries) that indicate the average maximum and minimum temperatures for each month, can be used to determine the potential growing season for different plants at that site.

As with plants, animals also are adapted to certain climatic conditions. For example there are cattle breeds that are better suited to warm climates, such as the Brahman and its crosses, and ones that are better suited to cooler areas (e.g. Angus). It is far easier to select animals that are suited to your local climatic conditions than to try and modify your property to suit the particular animals you wish to grow. Simply driving around the area and seeing which crops and animals are growing well, or talking to local farmers, can give you a good indication of what to grow yourself.

Frosts

Frosts can cause major damage to plants. Plants recently removed from protected conditions (such as in a green-house or shade-house), and have not had enough time to "harden up", are prone to frost damage. Many fruit crops are also susceptible to frost damage. Frost frequency depends on location and on local topography. Frost conditions are most likely to occur on clear cold nights, with little or no wind, at inland sites or at higher altitudes. It is least likely to occur in slightly elevated coastal areas, particularly where it is windy. The likelihood of frost occurrence can be established from climatic records, and from talking to locals.

Rainfall

A major limiting factor which will determine what can be grown (plant or animal) on a particular site is the rainfall the site receives. Low rainfall can be offset by irrigation from alternative sources of water. If these sources are not available, the quality is poor, or if the cost to supply the irrigation water is prohibitive - then you need to choose a site that provides sufficient natural rainfall.

There are four major points to consider regarding rainfall these are:

1. Distribution - this refers to when the rain falls. 25 mm (1inch) of rainfall in a normally moist site during winter conditions, will not have the same significance as the same amount falling in a normally drier site, or in summer.

2. Variability - some areas have a very consistent rainfall, others do not. Two sites may have the same average annual rainfall, but there may be quite different variation around that average at each site. For example, each site may have an average annual rainfall of 1000 mm (40 inch) but one may vary between 250 and 2000 mm from year to year, while the other may only vary between 750 and 1300 mm from year to year. This has important consequences in determining what crops/animals to grow, and the extent of water storages (e.g. dams), and alternative water sources required (e.g. bores).

3. Frequency - this is a measure of how often it rains, and can be important in determining the size of water storages. For example where there is a large interval between periods of rain, then water storages (e.g. farm tanks) will have to be larger than for sites where rain falls frequently. As an example Sydney (Australia) has a higher average annual rainfall than Melbourne (Australia), but it rains more often on average in Melbourne (a lower intensity) than in Sydney.

4. Intensity - this is the total rainfall annual divided by the number of wet days (days exceeding 0.2mm of rain). This is very important in terms of runoff. In areas of high intensity rainfall, runoff is generally high, and consequently the % of water infiltrating into the soil is low in comparison to areas with low intensity rainfall. Erosion can be a major problem in high intensity rainfall areas, while getting sufficient runoff to boost water storages can be a problem in low intensity areas. Areas in cooler climates tend to have lower intensity rainfall than areas in sub-tropical or tropical climates.

Evaporation

Evaporation is the loss of water as water vapour. It increases as temperatures increase, humidity drops and winds increase. It can be measured by determining the amount of water evaporated from a free water surface exposed in a pan. In countries where surface water storage is extremely important for agricultural purposes (e.g. Australia, Israel, South Africa etc.), evaporation is very significant. As with other climatic data, maps or tables of evaporation data are generally readily available.

Effective Rainfall

Perhaps the most important climatic parameter that determines the growing season (for crops and pasture) at a particular site is 'Effective Rainfall'. This can be defined as the rainfall over a certain period (e.g. month) minus the soil evaporation (equivalent to approximately one third of pan evaporation figures) during the same period. Positive figures indicate that soil moisture is increasing, or in other words the amount of rainfall received in that period exceeded the amount of water lost by evaporation. Negative figures indicate that evaporation has exceeded rainfall and that the soil is drying up. The number of months in succession in which rainfall exceeds evaporation (as long as temperature isn't a limiting factor) determines the growing season of a particular site.

To demonstrate:

During rainfall water lands on the soil surface, some rain water will infiltrate the soil, some will stagnate on the surface and some will run-off the surface.

After rain ceases some of the stagnant water on the surface will evaporate into the atmosphere, the balance will slowly infiltrate the soil.

Some of the water that infiltrates the soil will percolate below the root zone. The rest is stored at the root zone; this root zone stored rainfall is termed 'Effective Rainfall' because it is readily available for uptake by plants.

- To calculate 'Effective Rainfall' therefore you must firstly know how much rain fell.
- From this you subtract the run-off.
- From the run-off you subtract the evaporated water.
- From this you subtract the deep percolation water.
- Effective rainfall then is the water that is retained in the root-zone.

There are several formulae available for calculating Effective Rainfall; here is an example:

MONTH	Dec.	Jan.	Feb.
Evaporation (E) in mm	187	204	179
Soil Evaporation = 1/3 (E)	62	68	60
Rainfall (R) in mm	58	47	48
Effective Rainfall = R - 1/3E	(-4)	(-21)	(-12)

This indicates that there is no effective rainfall for the summer months in this locality. For plants to successfully grow during these months there would have to be sufficient soil moisture storage left from previous months or an irrigation system in place.

When the entire year is considered it can be seen that the natural growing season for this area would extend from March through to November.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
-21	-12	+8	+28	+39	+37	+34	+31	+31	+27	+9	-4

Wind

Wind is important in a number of ways: the stronger the wind the greater the amount of evaporation; vegetation and soils will dry out more quickly; water storages will be reduced. Strong winds can physically damage plants and facilities (e.g. polyhouses, packing sheds, stables). Animal stock can be injured by falling branches or wind-blown debris. Cool winds can result in reduced production as animals burn up energy to keep warm, instead of utilising it for growth. Slight winds on cold clear nights help prevent frosts occurring. Sites subject to regular strong or gusty winds, hot dry winds, or very cold winds should be avoided unless the site can be readily modified, for example by wind breaks, or protective structures such as greenhouses.

Extreme hazards

Some areas will be subject to hazards such as hail, snowfalls, thunderstorms, lightning, or bushfires. These may be infrequent, but they can do a lot of damage to stock, equipment and facilities. Both climatic records and historical records (e.g. newspapers) can be useful in determining the likelihood of such events occurring.

Microclimates

These occur when local conditions modify the climate in some way from the general overall climatic conditions of the area. For example trees provide shade and maybe frost or sun protection, but can restrict light and reduce growth rates of plants (an advantage with some and disadvantage with other plants). Careful inspection of the farm site will help in identifying where such conditions occur.

3. BIOLOGICAL

Pest and Diseases

Some sites, particularly those that have been used previously for agriculture, may have populations present of particular pests and diseases that could be damaging to plants and animals. Control of these can often be very costly and time consuming. Inspection of existing vegetation on-site or of crops on adjacent properties, should give some indication of what types of pest and diseases are around. Talking to neighbours will also give you an idea of what pests and diseases are problems in the area.

Existing Vegetation

Existing vegetation can be both an advantage and disadvantage. Clearing large areas of vegetation so you can establish a farm can be quite expensive. Large areas of vegetation can pose a fire risk, or they may provide shelter for pests and diseases. Tall trees may create shaded areas.

Weed infestations may be widespread. Existing vegetation may be utilised as a windbreak, for erosion control, as a buffer strip alongside streams or other water bodies, providing privacy, providing valuable timber or firewood, or be important for wildlife conservation. One method of clearing thick undergrowth is to introduce goats onto the affected land.

4. WATER

Virtually all farms (especially those in drier areas) will require an additional source of water to supplement natural rainfall. The amount of water required will depend on the amount, reliability, frequency and distribution of rainfall, coupled with how many and what type of plants and/or animals you are growing. Additional water for irrigation is generally obtained from the following sources:

- On-site storage such as dams or tanks where runoff is collected and stored for later use.
- Bore water (degree of use will be depend on flow rates and quality).
- Irrigation channels where water is distributed from storages often large distances away.
- From lakes, streams or rivers.
- From mains or town water systems (usually carried by pipes and/or aqueducts or channels).

The chosen site will need to have access to one or more of these water sources. A license to draw suitable amounts of water from them may also be necessary and should be checked out.

The quality of the water is very important. Chemicals in the water may result in toxic symptoms or slow death of plants and animals. Salinity levels should be low, otherwise plants could be damaged, or the structure of soils affected. Sediment levels should also be low or blockages of pipes or sprinklers could occur and leaf surfaces on plants may become coated with deposited sediment, affecting both the plants ability to photosynthesise, and its palatability to stock.

5. OTHER FACTORS

Closeness to Markets

Marketing costs are cheaper if customers or transportation to customers is close.

Cost of Land

In some cases it is cheaper to move further away from your market to enable you to by suitable land at a far cheaper price than you can obtain closer to your market.

Access

Good, all weather access to, onto and around the site is very important if you want to have a safe, efficient farm.

Existing Facilities

Does the site have existing facilities such as buildings, watering systems, power, phone, dams, roadways, windmills or bores? The presence of these could save not only the money required to build them, but also the time saved could enable you to start production earlier.

Services

If you have to pay for water, power, phone, etc. to be brought some distance to your property, this can be very expensive. In many cases the land may seem a real bargain until you take into consideration the cost of supplying these necessary services.

Air Quality

Some consideration should be given to nearby industrial businesses. Pollutants can contaminate the air and deposit residue on plant stock. If there is a pungent smell in the air, prospective customers may be deterred from visiting your farm.

Labour Supply

Farms that are situated far from populated districts may have difficulty in obtaining staff during busy periods. This is a common place occurrence with fruit growers, where pickers can often be in short supply, even in times of high unemployment.

Security/ Biosecurity

Security is important to help avoid damage from both animals and humans. Native and domestic animals can all effect crop production by eating plants, causing damage to irrigation systems, killing stock, or knocking over and breaking plants. Humans may cause damage through vandalism or theft. Security can sometimes be essential. Alternatively, a house on the property provides continuous security if someone is living at the site.

Today farmers must also be aware of biosecurity (biological security) and adopt measures that limit biosecurity problems. In limited terms the aim of biosecurity procedures is to protect our natural resources from biological threats or invasions. Biosecurity can be breached through the inadvertent introduction of pests, diseases, weeds, harmful biological agents and modified biological organisms, through the movement of plants, animals, machinery and people, and through feed and water. Biosecurity in the broader sense also includes economic issues and terrorist threats.

Governmental Regulations

Certain farm operations can only be established in a suitable land planning zone. Local government planning schemes should be carefully checked, and necessary planning permits obtained. All state and federal government regulations, compliances and statutory requirements must be met. In most countries each state/ has regulations covering the transportation and storage of dangerous or hazardous substances (including pesticides), quarantine for a range of plants and animals, and the movement of plants or animals into and within the area (biosecurity), workplace health and safety, and tractor operations.

Quarantine

SOIL MANAGEMENT

Soil has three main aspects:

1. The physical structure of the soil.
2. The chemical characteristics of the soil.
3. The biological factors in the soil.

Soil management is extremely complex; when we ‘manage’ soil we should consider all things which might bring about changes in the soil, and try to foresee all of the implications of any change which does happen. Put simply, the thin layer of soil at the earth’s surface is essential for maintaining life. If soil is lost or degraded, then the potential of an area to support life, both plant and animal is greatly reduced. In sustainable terms, maintaining, or even hopefully improving the soils you farm is vital.

It may take many thousands of years for a soil to form, but only a few years for it to be degraded or lost due to poor management practices. For this reason it is critical that the techniques we use to manage our soils will maintain them in a manner that ensures that they are at least as productive for future generations as they are now, and hopefully are even improved.

Factors which can have an influence include: the climate (including microclimates), fertilizing, topography, water and water quality, cultivation, the species of plants grown in the soil, microorganisms, mulches, insects and other living things in the soil, compaction caused by machines and animals, soil additives (e.g. lime, compost, gypsum) and a well-designed crop rotation system or . All these factors interact with each other and should be managed accordingly.

For a farm to be productive it must have good soils, and it is up to the farmer to understand the nature and condition of the soil on the farm and improve or maintain it, as required. As discussed previously there are various factors that need to be considered and tests that will need to be performed in order to determine soil condition and health. Factors that need consideration are discussed within this chapter in greater detail, but include:

- Structure and texture and the possibility of structural decline.
- Drainage capabilities and areas of compaction.
- pH status (the acidity or alkalinity of the soil (tests will need to be done in many locations on the farm, as pH can vary considerably within even small areas). pH is explained later in this chapter.
- Nutrient status (again various samples will need to be collected for analysis, to cover the entire farming or cropping areas).
- Erosion or erosion potential, through wind and rain.
- Salinity or possible salinity.

All of these factors can be ascertained through a series of tests – usually these would be outsourced to a specialised laboratory, but small initial tests can be conducted by the farmer, to determine if further professional testing will be required.

Simple Drainage Test

Drainage can be tested by observing the way in which water moves through soil which is placed in a pot and watered. However, when soil is disturbed by digging, its characteristics may change. To get a more reliable result, use an empty tin can. With both the top and bottom removed it forms a parallel sided tube which can be pushed into the soil to remove a relatively undisturbed sample. Leave a little room at the top to hold water, add some to see how it drains and then saturate the soil and add some more water to the top. You will often note slower drainage on saturated soil.

HOW SOIL CHARACTERISTICS RELATE TO PLANT GROWTH

Texture and its Effect on Plant Growth

Texture is the overall description of the particle size divided basically into sand, silt and clay, in which the particle size decreases respectively. Soil particles are packed in specific ways, leaving pore spaces between the particles. For sandy soils, the pores are quite large but the total volume is much less when compared to clays that have smaller pores but a greater quantity within a specified area. In these pore spaces, water and air are held for plant use by root uptake. The size of the pore determines the suction force plants have to apply to take up H2O.

In sandy soils, because of their larger pore spaces, water and minerals drain through faster than in clay soils. The disadvantages of sandy soils in relation to plant growth are that it requires more water to prevent the plants from wilting or exceeding the wilting point, leaches easily, and often special slow-release fertilisers are used. The advantages of these soils are that they drain quickly and can leach away dangerous or high levels of salts. Sandy soils can be improved by adding clay, organic matter, and wetting agents.

Clay soil disadvantages are root penetration impediments, poor root growth, poor water penetration and drainage, water logging, surface crust and clod formation, and the holding of high levels of salts. Advantages of clay soils in relation to plant growth are high water holding capacity and therefore lower amounts of irrigated water, and sometimes fertilisers, are required. Clay soils can be improved by adding organic matter, or sand to a lesser degree, gypsum, products such as clay breakers.

The ideal texture is one that has sand, clay and silt in approximately equal proportions e.g. clay loam, and which also has some organic matter content.

Structure and its Effect on Plant Growth

Structure is the form or shape of aggregations of the sand, silt and clay particles, into natural peds. It is described according to grade, size and shape.

Between peds there are often numerous spaces or pores through which water can percolate, plant roots grow, and air can circulate. A well-developed structure therefore aids the growth of plants. In contrast, a poorly structured soil may break into clods through which water and air circulate only slowly and roots have difficulty growing. An example is where a soil is compacted causing a reduction in void volume which changes orientation and accommodation of peds, subsequently reducing air and water supply. As well, preferred paths for root growth are more tortuous and are less favourable for plant growth.

Platy shape structures are more likely to inhibit root, water, nutrient and air penetration when compared to angular blocky, sub angular blocky, prismatic and/or columnar. 'Tilth' (not used in the writing of soil descriptions) is a word used to describe the suitability of a soil for plant growth and cultivation. A good tilth soil is composed of small crumbs which allow easy access of water, air and plant roots. Good tilth is generally a consequence of a soil initially having a well-developed structure. Structure and good tilth may be improved with heavy applications of organic matter, and for clay soils with high sodium content by the addition of gypsum (calcium sulphate).

Soil structure changes from the surface of the soil as you move deeper down into the earth. One reason for this is that surface soil contains more organic matter than deeper soil. Surface layers frequently drain better - drainage rate decreases as you get deeper. Bad cultivation procedures in soil can damage this characteristic of a gradation in soil structure through the soil profile by destroying the structure at the surface. Such a situation can be very bad!!

Consistence and its Effect on Plant Growth

Consistence refers to the strength of cohesion and adhesion in the soil. Strength will vary according to soil water status. Consistence is therefore recorded with a soil status of dry, moist or wet. By comparing the strength of the soil fragments in these three soil water statuses, a relationship to plant growth can be formed. If a soil has a moist consistence of extremely firm and a dry consistence of very hard, roots would find great difficulty in penetrating deep into the soil, compared with a soil which has a moist consistence of friable and a dry consistence of slightly hard.

Consistence is estimated according to moisture status - dry, moist, wet.

It is defined as the strength of cohesion and adhesion in soil.

Measure consistency as force in terms of:

0	Loose - no force required - separate particles such as sand
1	Very weak - very small force, almost nil
2	Moderately weak – a small but significant force
3	Moderately firm - moderate to firm force
4	Very firm - strong force but within power of thumb and forefinger
5	Moderately strong - beyond the power of thumb and forefinger – it crushes underfoot on hard flat surfaces with small force
6	Very strong - crushes underfoot on hard flat surface with full body weight of an average man (80kg) applied slowly
7	Rigid - cannot be crushed underfoot by weight of average man applied slowly.

When soil is wet, soil tester needs to consider stickiness and plasticity:

a) Stickiness	
0	Non-sticky - does not adhere to fingers (e.g. sand)
1	Slightly sticky - adheres to thumb and forefinger moderately
2	Sticky - adheres and tends to stretch
3	Very sticky – it adheres strongly to the thumb and forefinger, and stretches notably.
b) Plasticity	
0	Non-plastic - no roll
1	Slightly plastic - forms a roll and supports its own weight (usually 6mm diameter particles)
2	Moderately plastic - forms roll and supports own weight (4mm)
3	Very plastic - will form roll and supports own weight (2mm).

Depth of Profile and how it relates to Plant Growth

Soil depth is important for plant growth. The depth reflects the volume of soil available for plant root extension and development before reaching the sub-soil and parent rock. Thin top soiled profile bodies can only furnish plants with surface dwelling roots i.e. tap-rooted trees and large shrubs are less likely to survive. Deep soil profiles can grow tap-rooted and deep-rooted plants more successfully. These soils usually have larger trees as the larger volume of soil allows roots to establish and support the trees.

Porosity and how it relates to Plant Growth

Porosity refers to the pore space in soils not occupied by solid matter. If more pores are present in a profile then the ability of roots, water and air to penetrate the soil is made easier. Compacted soils have few pores and therefore water absorption and air content are much lower. Tree roots will struggle to move freely through the soil, and fewer nutrients are available to plants thereby creating a less unsuitable environment for plant growth.

pH and its Effect on Plant Growth

The particular pH of a profile indicates the type of plants capable of growing in that soil. Certain plants can only survive in a limited pH range.

If pH is 0-6 only acid loving plants can survive e.g. Camellias, Clethra, and Magnolia

If pH is 8-14 only alkaline loving plants can survive e.g. Buddleia davidii, Lavendula, Malus spp.

It is important to note that many plants grow over a wide range of pH factors. All plants have a preferred range. It is within this preferred range that maximum growth and flowering can be achieved. If the plant is grown outside the preferred range it may still grow, but it will be slow, sickly and may never flower.

WHAT IS pH?

pH is a measurement of the hydrogen ion concentration in a particular medium, such as soil. More simply it refers to the acidity or alkalinity of that medium.

The pH is measured on a logarithmic scale ranging from 0 to 14 with 7 being considered neutral, above 7 being considered alkaline and below 7 as acid.

The pH of a media or a soil is important to plant growth. Each particular plant has a preferred pH range in which it grows. If a plant is subject to a pH outside of its preferred range its growth will at the least be retarded, or it may even die. Very low pH (less than pH = 4.5) and very high pH conditions (above pH = 9) can directly damage plant roots.

Very high and low pH values can also affect plants as follows:

As the pH of a media changes so does the availability of nutrients. The majority of nutrients are most available at a pH range of 6 to 7.5. Somewhere in this range is generally considered to be the ideal for growing the majority of plants, although there are plants that prefer higher or lower pH conditions. In some circumstances, particularly at very low or high pH conditions some nutrients may become 'locked' in the media thereby becoming unavailable for plant growth. The nutrients may be there in the media but the plant cannot use them. At very low pH conditions toxic levels of some nutrients such as manganese and aluminium may be released.

As the pH of some media is raised more negative charges are produced on some colloid (particle) surfaces, making them capable of holding more cations. This allows some media to hold larger quantities of nutrients.

Soils and growing media that contain clays, and some of those derived from volcanic materials, are most affected.

Like plants, microorganisms have a preferred pH range in which they thrive. Altering the pH may severely affect the populations of both beneficial and detrimental microorganisms. For example the bacteria that convert Ammonium to nitrogen prefer a pH above 6.

Most mycorrhizal fungi prefer a pH range of 4 to 8.

Adjusting the pH

The improvement of soil structure may use two approaches. First, where the soil has not been badly leached, the addition of organic material, use of crop rotations (with legume cover crops to fix Nitrogen) and proper (not excessive) cultivation, will normally give the best long term results. However, where soils have been leached and have become very acid, or very alkaline, the use of soil ameliorants such as lime and gypsum may be required. These act not only to adjust soil pH, but replace sodium ions in the soil with others (principally Calcium and Magnesium). These help flocculate clay particles and so produce some initial structure which will allow the soil to be worked as above.

Before using a soil you should always test the solution pH. Ready to use soil should normally have a pH between 6 and 6.5 (though for some types of plants, the ideal pH is higher or lower than this). If necessary, the pH can be changed as follows:

- Add lime (or some other calcareous component) to raise pH.
- Add diluted sulphuric or nitric acid to lower pH.
- Ammonium salts will acidify (e.g. ammonium sulphate).
- As some nutrients are absorbed and others are left in the root environment the pH will change.
- Careful addition of caustic soda will increase pH.

Some additives affect pH, for example peat is acidic and freshly mined scoria is alkaline.

Use of Liming Materials to raise pH

There are a number of different liming materials which can be used to raise soil pH levels. Liming materials contain calcium and/or magnesium. It should be noted that not all materials containing calcium are effective e.g. gypsum. Although calcium is present in gypsum, when it hydrolises (dissolves) in the soil solution it forms a strong base and a strong acid which neutralise one another. Also, lime is taken up more readily when it is in a finely ground form. Better sources are hydrolitic and calcitic limestone which only hydrolise to form weak acids but strong bases which attach to soil colloids and reduce acidity.

Dolomitic Limestone

This is a ground limestone which is a mixture of calcium carbonate and magnesium carbonate. It has a neutralising range of 95-108 compared to pure calcium carbonate.

Calcitic Limestone

This is ground limestone which contains predominantly calcium carbonate and around 1-6% magnesium. Its neutralising value depends on its purity and fineness of grinding.

Hydrated Lime

Also known as slaked lime or builder's lime, hydrated Lime (Ca OH2) is calcium hydroxide and is a fast acting powdered form of lime. It has a neutralising range of 120 and 135 compared to pure calcium carbonate.

Marls

These are naturally occurring calcium carbonate deposits with low magnesium content found in a mixture of clay and sand. They have a neutralising range of 50-90. The value is reduced by the amount of impurities present, mostly in the form of clay. Their effectiveness as a liming material is reliant upon their neutralising value and the cost of processing the material which involves drying and grinding before use. They have a somewhat similar effect to calcitic lime.

Slag

Slag is produced during the steel making process and contains calcium silicate. It also contains 2-6% phosphorous, magnesium, and micronutrients. Slag has a similar effect on soil acidity to ground limestone. It has a neutralising range of 60-70% but because the particles are smaller than agricultural lime it reduces soil pH more quickly.

Ground Shells

Sea shells are made out of mostly calcium carbonate with little magnesium and can be used as a liming material if ground down to powder form. They have a neutralising value of 90 to 110.

Table: Comparison of Liming Materials

Liming Material	Chemical Composition	Calcium Carbonate Equivalent
Dolomitic Limestone	$CaCO^3$ & Mg CO^3	95-108
Calcitic Limestone	$CaCO^3$	85-100
Hydrated Lime	$Ca(OH)^2$	120-135
Marls	$CaCO^3$	50-90
Slag	$CaSiO^3$	50-70
Shells	$CaCO^3$	90-110

Soil Humus

Soil humus is the result of organic matter decomposition and microbial synthesis. It has a high Cation Exchange Capacity (CEC) and moisture holding capacity. Some 95 - 98 % of total nitrogen is held in the humus complex, as is a large amount of phosphorus and potassium.

Salinity Build Up

When a plant uses a nutrient from a chemical 'salt' molecule supplied in a nutrient solution, it is in fact only using one part of that molecule. The remaining part of the molecule generally stays in the soil or nutrient solution (in the case of hydroponics). Some may be used by the plant, but more commonly it builds up and can reach a level where it causes damage to the plant. This is referred to as 'salt build-up' or a 'salinity' problem.

Salinity problems are most common in soils, or other media, which have a high cation exchange capacity or when using a closed hydroponic system with the same nutrient solution for an extended period.

Salinity problems will sometimes be visible. If you see a white caking around the edges of drainage outlets, or on the surface of media, this indicates the problem is reaching a danger level. Salinity can be sometimes cured or prevented by simply leaching the salt out of the root growing area, by washing it out with clean water. This water, of course, must be drained out of that area. In many soils, then, improved drainage will be more effective than increased irrigation.

Buffering Capacity

The soils ability to withstand rapid pH fluctuations is known as 'Buffering Capacity'.

The greater ability a soil has to withstand fluctuations the greater the amount of acid which must be incorporated with a material to alter the pH.

- Sandy soils that have little clay or organic matter have low buffering capacity
- Soils that have lots of mineral clay and organic matter have a high buffering capacity
- Soils with low buffering capacity need less lime to raise the pH then soils with a high buffering capacity.

Cation Exchange Capacity and Soil Nutrient Status

Cations are atoms which have lost electrons. As such, they are particles which have a positive charge.

Many important plant nutrients occur in a soil or nutrient solution as cations (i.e. potassium, calcium and magnesium).

These particles will be attracted to particles which have a negative charge, hence staying in the soil, or other medium, and being available to the plant roots for a longer period of time.

Organic matter such as peat moss, and fine particles such as clay, have a lot more negative charges on their surface, hence a greater ability to hold cations (higher cation exchange capacity) than larger sand or gravel particles.

Soil or media with a very low cation exchange capacity will require more frequent application of nutrients than ones with a higher cation exchange capacity.

When a nutrient is applied to a soil (or growing medium) with a low cation exchange capacity, but high water holding capacity, the medium might remain moist, but many nutrients will be lost with drainage of excess irrigation water so becoming leached more rapidly. A higher cation exchange capacity will reduce this tendency.

OTHER METHODS TO IMPROVE SOILS

1. ADDING ORGANIC MATTER

Organic matter can be added to improve nearly any soil, except those rare ones that are naturally high in organic matter, such as peats.

Organic matter:

- Adds valuable nutrients to the soil.
- Acts as a buffer against sudden chemical or temperature changes which can damage plant roots or adversely affect soil microorganisms.
- Helps improve the structure of soil.

Soils with good organic matter content are generally easily worked (said to have a good tilth). Squeeze a handful of soil into a ball in your hand, if it remains in hard lump, then it has a poor tilth; hard clods will result when it is ploughed. If it crumbles, then it is well granulated...organic matter promotes granulation. Cultivated soil with good tilth is less subject to wind and water erosion.

It is difficult to increase the % of organic matter in a soil, but it is important to try to maintain that %. The average mineral soil in Australia contains around 2 to 5% organic matter. Organic content will drop if you remove plant material which grows in a soil and don't return organic material to the soil.

This can be done the following ways:

- Compost can be added regularly.
- Shredding pruning material and use as mulch.
- The unharvested parts of plants grown, once finished, should be cultivated back into soil, or used as mulch.
- Use of organic mulches on the soil.
- Feeding plants with manures (well-decomposed).
- Growing green manure crops; cultivate back into the soil once matured but before flowering.

2. USING OTHER SOIL AMELIORANTS, IMPROVEMENTS AND CHANGES

- Sulphates (sulphur containing salts)/Sulphur powder - used to help lower soil pH.
- Wetting agents - used to improve the wettability of soil (e.g. water penetration), particularly of non-wetting sands.
- Crop rotations
- Cultivation to physically break up the soil (e.g. surface crusts).
- Deep ripping to break up hard pan or impermeable layers.

3. APPLYING FERTILISER

Plants need the right types of nutrients and in the right amounts to thrive. About 16 nutrients are needed by all plants, with three of these, carbon O, hydrogen (H) and oxygen (O) being obtained by the plant from air, water and oxygen. The rest of these nutrients are naturally obtained from the soil and these are sometimes called the mineral nutrients. Some plants also require various other nutrients to thrive.

Plant nutrients are divided into two groups, the major (or macro nutrients) and trace (or micro nutrients) elements. The major elements are carbon (C) hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) magnesium (Mg), and sulphur (S).

The mineral nutrients used in the largest amounts are nitrogen, phosphorus and potassium (N.P.K.). These are the most frequently applied as fertilisers, either from organic or inorganic sources, to encourage plant growth.

Every nutrient has its purpose and a deficiency, or oversupply, of even a minor nutrient can have a major effect on the plant. Deficiencies can be difficult to detect, but as time passes symptoms will appear. Signs are stunted growth, unhealthy leaves that may be mottled, stunted and dying off, distorted stems and undeveloped root systems. If a nutrient is easily dissolved, the older leaves will be affected first, otherwise the growing tips, i.e. the new leaves will be affected.

Every plant has different nutritional requirements. An awareness of whether a plant is a 'heavy feeder' or a 'light feeder' will help in deciding on the uses of that plant in a farm or garden. Most fertilizer applications on farms consist of various ratios of the elements Nitrogen (N), Phosphorus (P) and Potassium (K) (known as N:P:K).

An over-supply of nutrients may initially cause extra growth, but (may) then become toxic and plant growth will be reduced. Deficiencies are not always a result of the nutrient not being present, it may be the nutrient is being held in some form which prevents the plant taking it up, for example it could be attached to an insoluble material (known as immobilisation or being "locked up"), or be affected by pH. In simple terms, in order to ensure health plant growth - do not let plants suffer from nutrient deficiency or toxicity.

Nutrients can also be readily lost from the soil through erosion, through leaching (the loss of soluble nutrients down through the soil profile in soil water), through conversion of nutrients to gaseous forms (e.g. ammonia gas) - which escapes to the atmosphere, and through the removal of plant material (e.g. crops). To maintain or improve the nutrient status of soils, at least as many nutrients that are taken from the soil will need to replaced. More nutrients are supplied to the soil than crops require as some nutrients will lost through leaching (e.g. nitrogen, potassium), and some will become "fixed" or unavailable for plant growth in the soil (e.g. phosphorus). Although chemical fertilisers will compensate for nutrient losses in the short term, to be sustainable a farmer should also be looking towards cover crops, mineral powders and composts which release nutrients slowly (more on this later). This requires careful planning as benefits will only accumulate gradually.

4. USING TRACE ELEMENTS

Very poor soils, soils with high pH, and sites where farming has been intensive, may be deficient in some of the trace elements such as boron, molybdenum, copper, and cobalt. The addition of small amounts of such elements can have spectacular results in terms of increased production. Oversupply however, may damage or even kill your crops.

For the organic farmer, supply of minor trace elements to suffering plants may seem a bit daunting. Provided you use a wide range of organic fertilisers as sources of organic matter, it is unlikely that plants will suffer from any deficiencies. In fact, soils high in organic matter hold more nutrients than inorganic soils.

SOME COMMONLY USED FERTILIZERS

The following are used to supply only one of the major plant foods. Combinations of these various fertilizers can be used to provide a balanced mixture of the required nutrients.

Nitrogen Fertilizers

Ammonium nitrate (33.5 - 34.5% N)
Ammonium nitrate lime (21 - 26% N)

Urea (46% N)
Sulphate of Ammonia
Calcium nitrate (15.5% N)
Anhydrous ammonia (82% N)

Heavy dressings can lead to soil acidification. Does not cause soil acidity. A mixture of lime and Ammonium nitrate. May temporarily cause high pH levels in soil. Has a strong acidifying effect on soil. Generally expensive and so not widely used. Mainly used in Europe. Liquified ammonia under high pressure that is injected into the soil.

Phosphorus Fertilizers

Generally the quality of phosphorus fertilizers is expressed as a % of phosphorus pentoxide (P^2O^5) equivalent.

Ground rock phosphorus (up to 29% P^2O^5)
Superphosphate (18 - 21% P^2O^5)
Triple Superphosphate (47% P^2O^5)

Best used on acid soils in high rainfall areas. Also contains gypsum. Widely used for most crops and soil conditions. Similar uses to superphosphate - 1 bag

Potassium Fertilizers

Expressed as a % of Potassium oxide (K^2O)
Muriate of Potash (60% K^2O)
Potassium sulphate (48-50% K^2O)

Most common source of potash for farms. More expensive than muriate of potash, but widely used for market garden crops.

Organic Fertilizers

These generally contain a combination of elements. The cost can vary considerably depending on availability. Common organic fertilisers include:

- Animal manures
- Seaweed (liquid and solid forms)
- Blood and Bone
- Bone Meal
- Fish Meal
- Cereal Straws
- Cotton or wool wastes.

METHODS OF APLYING FERTILIZERS

Fertilizers are sold in powder, granulated or liquid form, with powder or granulated forms being more common, particularly for use on larger properties.

Fertilizers can be purchased loose by the truckload or by the bag. The 50kg bag being the most commonly bought. These are supplied on pallets (e.g. 30 bags per pallet) which can be easily handled using a forklift, or forklift attachment on a tractor.

On broad acre farms fertilizers are usually spread with mechanised spreaders, generally towed behind a tractor. Larger properties use purpose built fertilizer spreaders. On a small property, fertilizers are often spread by hand.

TYPES OF SOLID FERTILIZER SPREADERS

Broadcasters:

Pneumatic - where the fertilizer is spread by blowing it through different types of tubing.

Others utilising brushers, chains or rollers:

- Spinning discs - usually mounted on the three point linkage of the tractor or drawn on a trailer. The fertilizer is spun out by the rotating discs.
- Combine drills where seed and fertilizer are spread at the same from separate hoppers into the same drill (spout) or adjacent drills.
- Fertilizer drills - these place the fertilizer in the soil to the side and below the crop seed
- Aerial broadcasting - used for larger crops such as cereals, when soil conditions are wet making ground access unsuitable, and for hilly areas.

Spreading Liquid Fertilizers

Common methods include:

- Liquid injectors - liquid fertilizers such as Anhydrous ammonia are injected under pressure through spouts directly into the soil.
- Foliar spraying - low concentration fertilizers can be directly applied to foliage via a sprayer or an irrigation system (e.g. overhead sprinklers).
- Fertigation - liquid fertilizers can be spread through irrigation systems (known as fertigation).

Determining how much Fertiliser is required

How much fertilizer to apply to a crop (or pasture) depends:

- On the requirements of the particular crops.
- On the availability of nutrients from the soil in which they are growing.

Plant Requirements

Determining how much of each nutrient a crop requires, can be obtained from Departments of Agriculture or Primary Industry bodies. For new varieties or poorly researched crops, it may be a case of experimentation initially to determine nutrient requirements. Plant nutrient requirements are generally expressed in terms of kilograms per hectare (kg/ha).

Nutrient Availability

The levels of nutrients in your soil can be established by soil testing. Soil testing is sometimes carried out by relevant government agencies (e.g. Agriculture), or by commercial soil testing companies. These can be found in trade magazines, or listed in the phone directory (e.g. yellow pages). Experience gained from growing particular crops as well as talking with agricultural advisers, fertilizer companies and other local farmers will likely cause you to modify your fertilizer applications to best suit local growing conditions.

Repeated soil testing every few seasons will further aid decisions on application rates to reach a level where you are supplying sufficient, but not too much, of each nutrient. Excess application of nutrients is just wasted money, and can in some cases create toxicity problems.

How Much Fertilizer DO I Need?

Each fertilizer will have an analysis of its nutrient content expressed as a %. For bagged fertilizers this ratio should be clearly stated on each bag. This is known as the NPK ratio. For example a fertilizer with a stated NPK ratio of 15:12:10 will contain 15% nitrogen, 12% phosphorus & 10% potassium. 100kg of 15:12:9; fertilizer will therefore contain 15 kg of nitrogen, 12kg of P2O5 & 9kg of K2O, while a 50kg bag will have half of those amounts for each of the three nutrients. The ratio of nutrients in the fertilizer may suit your crop requirements, but if it does not then a fertilizer combination might be required.

Using wheat as an example the recommended nutrient application in kg/ha for a particular crop is:

	N	P	K
Recommended rate	130	60	42
Five bags of the 15:12:9			
fertilizer will supply	75	60	45
Additional amounts of nutrients required to meet plant requirements	55	-	-

In this case an additional 55kg/ha of nitrogen would be required. This could be obtained using one of the 'straight' nitrogen fertilizers, such as urea, ammonium nitrate or sulphate of ammonia. If, for example, we selected urea which contains 46%N we would have 23kg of nitrogen per 50kg bag. To make up the shortfall of 55kg/ha of nitrogen we would need to apply just over 2 bags of urea per hectare, in addition to the five bags of combined NPK fertilizer.

5. CULTIVATION AND COVER CROPS

The farm floor is a living biological ecosystem that must be managed to the benefit of the crop and to the broader ecosystem of the region. Many traditional systems were a multiple cropping system, even today on some modern commercial farms and market gardens these polycultures are still done this way. In the USA (especially in young fruit orchards) you can still occasionally see hay or wheat crops grown between the trees. Similarly, in some vineyards in the 'Granite Belt' of southern Queensland (Australia), intercropping grape vines with vetch, clover, capsicums and tomatoes is now practised.

Throughout the world many modern farms are clean cultivated. This means that no permanent clovers, grasses or other plants are allowed to grow. The farm is regularly cultivated, creating bare soil beneath the crop plants and between the rows. Often chemical herbicides are used to maintain the 'clean' cropping area.

The supposed advantages include:

- Lower humidity occurs over bare ground helps discourage fungal disease.
- Less competition for soil water and nutrients.
- More heat is absorbed during the day and released at night, thus reducing the danger of frost.
- More rapid air drainage over bare soil may also help to reduce frost on sloping ground.

However, there are major disadvantages with this sort of approach, including:

- Increased exposure to water erosion, particularly on sloping ground.
- Increased exposure to weed infestation.
- Soil compaction from machinery usage.
- Soil compaction worsened by lack of plant roots 'tilling' soil.
- Reduced soil aeration and porosity.

In addition the following benefits of retaining cover crops are lost:

- Improved water penetration on flat surfaces during heavy rain.
- More water absorbed, less immediate run-off.
- More water retained through mulching effect.
- Soil and ambient temperature changes moderated or reduced.
- Better conditions for soil micro- and macro-organisms.
- More food and habitat for insects, spiders, etc.
- More food and habitat for small animals (e.g. lizards, frogs, mammals) and birds.
- Economic harvest potential of cover crop plants.
- Plant growth improved through easier root penetration.
- Competing cover crops may use up surplus nutrients and water in overfertile or wet soils.
- Working conditions are more pleasant in an area covered plants.
- Organic matter status (humus) of the soil is greatly improved.
- Improved nutrient status of the soil over medium- to long-term.

Limited cultivation is acceptable to prepare areas for planting or initial control of weeds. Excessive cultivation or continuous movement of tractors only destroys and compacts the soil structure.

Cultivation Techniques

Cultivation involves ripping, digging, scratching or mixing the soil.

This may be done for any of a range of reasons, including:

- To mix in compost, fertiliser or a cover crop.
- To kill weeds.
- To break an impermeable layer on the surface to allow water or nutrients to penetrate.
- To improve drainage.
- To allow for better plant root penetration.
- To break up an impermeable sub-surface layer.

Cultivation can however also cause problems. Over cultivation or regular turning can damage soil structure. Each time soil is cultivated it damages some of the small aggregates, allowing the organic matter which binds these aggregates to be consumed by micro-organisms. Cultivation is one of the main culprits in causing erosion, and soil structure decline. It can also change drainage patterns of the soil and can cause the fertile top layer to be diminished by mixing it up with lower soil layers.

Minimal cultivation is normally preferred in sustainable agriculture, but cultivation is a necessary part of any farming operation.

Some ways to minimise damage include:

- Tilling only where necessary, for example, leaving strips of land unturned staggered with tilled soil.
- Tilling only when necessary.
- Not tilling when soil is overly wet. A simple test is to take a handful of soil and squeeze it in your hand. Moisture levels should be no more than you would get with if you had squeezed a sponge dry.

It is preferable to use discs or ploughs rather than rotary hoes or tillers which mix the soil more.

Conservation Tillage

This aims to reduce tillage operations or cultivations to only one or two passes per crop. It has been made possible by the use of herbicides to kill crop residues or pasture prior to planting, and the development of direct drilling seeding machinery capable of seeding through stubble. For some farmers the extensive use of these herbicides does not fit in with their view of what sustainable farming should be, however for many farmers the disadvantages of using such herbicides, are more than offset by the benefits of maintaining or improving soil characteristics, in particular structure. Conservation tillage has been shown to give sustained, improved yields when compared with cultivated paddocks. There are also considerable benefits in reduced labour costs, less wear and tear on equipment, and decreased fuel costs, as a result of the reduced number of passes required.

Stubble retention (from the previous crop) is a major component of conservation tillage. The stubble provides a protective layer on the soil, reducing evaporation losses, and reducing the impact of rain drops.

This prevents the formation of surface crusts, and improves aeration and water infiltration (entry of water into the soil) There is also a reduction in diseases of legume crops that are spread by raindrop splash. Soil micro-organisms have also been shown to increase in numbers, further helping to improve soil structure and fertility.

The biggest barrier to the use of conservation tilling has been the cost of buying or modifying tillage and seeding machinery. Conventional seeding machinery has had difficulty coping with the retained stubble. As this method of cultivation has increased in popularity, there has been extensive development of new machinery that can cope with such demands. The gains, however, are seen to more than outweigh the cost outlays and this method of farming is sure to increase.

(Reference: There's No Money in Dust: A Guide for Farmers Modifying Their Seeders for Conservation Tillage by Nicholas Bate. Published by Farm Advance – Bendigo Victoria, AUSTRALIA 3550).

Green Manures and Cover Crops

Green manures are crops that are grown specifically to mow or cultivate back into the soil, to improve the structure, the organic matter content, and the fertility of the soil. Green manure crops usually include legumes and crops that provide bulky organic matter. Many genera and species of beans, peas and other legumes are used, along with a wide variety of grasses and broadleaf plants.

Legumes should be mown down or cultivated into the soil when the plants begin to flower. It is also important to know that organic matter 'volatilises', or releases, nitrogen and other nutrients into the atmosphere as it dries out. This is one reason why organic growers frequently cultivate green manures into the soil, in preference to simply mowing them down. Leaving mown green manures on the soil surface can prevent erosion.

Although a cover crop is most commonly ploughed in, but can also be cut and left lying on the soil. The latter method is very slow, but can be effective. In theory a cover crop should increase organic content and fertility of the soil, but research has shown that this is not always the case.

The real contribution of a cover crop is affected by:

- The amount of growth achieved.
- The plant varieties grown (e.g. legumes add more nitrogen to the soil than they take out during growth).
- Whether any part of the cover crop is harvested and removed from the paddock (perhaps as hay).
- Whether there is a strong leaching effect (e.g. in sandy soils or on steep slopes).
- Temperature and moisture conditions (excessive heat and moisture can result in rapid decay of organic material and in fact little if any increase in soil organic content. Excessive dryness can result in very little decomposition).
- Carbon to nitrogen ratios of residues. (Residues with high ratios such as 100:1 are slow to decompose, but those with lower ratios may be much better.)
- Soil life (the presence of certain micro- organisms, worms, etc. can have a significant bearing upon decomposition, release of nutrients, and even mixing of residues into the soil mass).

Cover crops are used for varying combinations of the following reasons:

- To improve soil fertility, soil structure or tilth.
- Control erosion.
- Reduce the need for fertiliser and other soil amendments.
- To increase nitrogen levels (i.e. legumes as a green manure).
- Improve nutrient availability.
- Minimise leaching.
- Weed, pest or disease control.
- Preparing land for production of other crops (e.g. vegetables or grain).
- As a livestock feed supplement.

Green manure/cover crops help the soil by improving fertility, increasing organic matter, holding more water, and suppressing weeds.

Sow a green manure crop in fallow beds in autumn or winter and dig in before they reach maturity (before flowering) in spring or just leave on top of the soil as mulch.

Soil bacteria have a symbiotic relationship with legumes. The bacteria (Rhizobium) infect the root system of legumes and change atmospheric nitrogen into a form that is usable by plants. This nitrogen is contained in root nodules produced by the Rhizobium. When the plant is dug in or allowed to decompose on top of the ground the available nitrogen will feed the following crop.

In some circumstances, legume seed is 'inoculated' with Rhizobium spores to ensure good nodulation.

What to grow to improve soil fertility:

- Legumes (tic peas, field peas, broad beans, lupins, vetch, alfalfa) add nitrogen and organic matter. Lupins and alfalfa are deep rooted and also help to break up heavy soils allowing deep rooted crops such as tomatoes and corn (maize), to penetrate to lower levels for water and nutrients.
- Clover adds nitrogen and also acts as a weed suppressant when grown as a living mulch under other crops.
- Barley increases phosphorous uptake of following crop (excellent crop to precede tomatoes) and also provides excellent mulch.

Inoculation of Legumes

You can use pre-inoculated or pelleted seed, or you can inoculate seed yourself.

Inoculating Seed

Add the inoculant to another medium (e.g. peat mixed with water and gum arabic). Use 1 part sticking substance (e.g. gum arabic) to 10 parts water. Other sticking materials that can be used include corn syrup, sugar, powdered milk or various commercial stickers.

It is critical to use only fresh inoculant in the appropriate concentration.

Use the appropriate rhizobium sp. for the legume being grown. Keep in mind that rhizobia perform better on some legumes, (e.g. alfalfa) when seed is coated with Calcium Carbonate, while others perform better when left uncoated (e.g. red clover).

- Check expiry date. Commercially produced, pelleted seed should be sown as soon as possible, at least within 4 weeks of production as it does not store well.
- Always store inoculants in cool, dark place.
- In dry conditions, inoculants rate may need to be doubled.

- If legumes exhibit yellowing of foliage, this may indicate nitrogen deficiency resulting from failure of the inoculant.
- Applying some nitrogenous fertiliser when planting a cover crop may actually enhance the nitrogen fixation of the legumes (e.g. around 30 kg per hectare of starter nitrogen)
- Generally soil pH needs to be over 5.5 for rhizobium to survive.

Guidelines/principles

The cover crops used must be matched with the desired outcome. The following tips will help in determining selection of a cover crop:

Type of Crop

Perennial crops are generally preferred over annuals. With annuals, large populations of nematodes often move into the soil after maturing, causing problems for the root system of any subsequent plantings.

Effect on Soil pH

Alkaline tolerant plants such as sorghum and barley can be grown to reclaim alkaline (lime) soils. Growing a single crop of these plants may cause sufficient soil acidification to allow less lime tolerant legumes to be grown, further acidifying the soil and allowing it to be used for livestock or a cash crop.

Timing

The crop should be incorporated (tilled) before maturity (i.e. before flowers and seed forms)

Water Use

While cover crops, like any other crops, do use water, their root growth can lead to better penetration of water into the soil. Additionally, residual organic material left by the plants will lead to increased water conservation.

Shade Tolerant Cover Crops

These include Cowpea (*Vigna unguiculata*), Burr medic (*Medicago polymorpha*), Hyacinth Bean (*Dolichos lablab*).

Salt Tolerant Cover Crops

Strawberry Clover (*Trifolium fragiferum*), White Clover (Trifolium repens), Burr Medic (*Medicago polymorpha*), Field Pea (*Pisum sativum*), Barley 'Salina' are all ideal for use in areas of high salination or heavy salt spray.

Legume Cover Crops can Alter Soil pH

Legumes commonly have 15-30% more protein than grasses, giving them better food value for livestock. Another advantage of legumes as a cover crop is the production of the Rhizobium bacteria which legumes can be inoculated with, resulting in production of hydronium ions in the soil. These ions in turn lower the soil pH, making the soil increasingly acidic.

The decomposition of organic residue also has an acidifying affect on soil. Increased organic matter does however buffer (i.e. sort of slow down) this acidification. Nevertheless, excessive and continual use of cover crops, especially legumes, without liming or use of a similar treatment can result in soil becoming too acid, and losing productive capacity.

6. CROP ROTATION

Growing the same type of plant continuously in an area will encourage the development of a problem (e.g. when you grow one crop of cabbages, pests which attack cabbages build up in that part of the garden. When a second crop of cabbages is planted in the same area, lingering pests are present, which attack the new plants and breed up into large numbers faster).

In addition, the same crop in the same spot year after year will cause a decline in the nutrients which are used by that crop. For example, heavy nitrogen feeders such as lettuce or wheat will quickly deplete the soil of nitrogen if regularly grown in the same location. Other nutrients not consumed by that crop will remain fairly constant. In order to make use of the available soil nutrients, crop rotation is a sensible practice. If an area is left free of plants (i.e. fallow), or a different crop grown the next season, pests which are specific to a previous crop will die out.

Crop rotation involves growing a series of different crops in a particular organised succession, to improve various aspects of crop and soil health. Crop rotation is more than just a seasonally progressive production system (such as a farm that grows lettuces in summer and cabbages in winter).

Crop rotation can be used to:

- Help reduce disease and pest problems.
- Each plot should be planted with crops from a different family group each year i.e. potatoes shouldn't follow tomatoes (same family). Cabbages shouldn't follow mustard (also same family). Also try to choose disease resistant varieties or plants that are not prone to the diseases and pests that the previous crop is prone to.
- Minimise weed problems.
- Grow crops that suppress weeds i.e. large leaves that exclude light before growing crops that are sensitive to weed competition in the same plot. Grow crops that can cope with weeds at the end of the rotation when weeds may have built up.
- Utilise the fertility you have added to the soil by growing a succession of crops that have different fertility requirements i.e. follow leaf crops with carrots.
- Maintain and improve soil quality by growing plants that have differing root structures and increasing the amount of organic matter returned to the soil.

There are various types of crop rotation systems used. It all depends on your needs and the size of the garden.

The following is an outline of considerations to help prevent build-up of pests, diseases and weeds in soils as well as effectively utilising soil fertility.

- Gross feeder (e.g. tomato), then legume (e.g. beans), then light feeder (e.g. coriander), then green manure, then gross feeder again.

- Flower crop (e.g. broccoli), followed by fruit crop (e.g. peas), followed by leaf crop (e.g. lettuce) followed by root crop (e.g. carrot).
- Grow a crop or crops for half of the year, and graze the same area for the other half.
- Fallow areas between crops (i.e. do not graze or grow a crop).
- Grow cover crops for green manure at least annually to revitalise the soil.

Rotations should also be designed so that crops from the same family, do not follow one another (in some cases, gaps even of several years may be necessary to get rid of pest or disease problems). In order to develop these kinds of rotations properly, it is necessary to know a little about the scientific names of the plants you are growing.

Example of plant families (vegetables)

- Brassicaceae (Cruciferae): broccoli, Brussels sprouts, cabbage, cauliflower, sea kale, kohl rabi, turnip, swede, radish, horseradish, rocket etc.
- Cucurbitaceae: cucumber, marrow, pumpkin, squash, cantaloupe (i.e. rock melon), zuchinni
- Liliaceae: onion, leeks, garlic, chives.
- Fabaceae (legumes): peas, beans, clover.
- Poaceae: corn, other grains.
- Apiaceae (Umbelliferae): celery, carrot, parsnip, fennel.
- Asteraceae (Compositae): chicory, lettuce, endive, globe artichoke, sunflower.
- Chenopodiaceae: silver beet, red beet (i.e. beetroot) and spinach.
- Solanaceae: tomato, capsicum, potato, egg-plant (aubergine).

SOIL DEGRADATION

When vegetation is cleared from a site, soil is exposed to sunlight, soil aeration is decreased and the rate of weathering increases.

The proportion of organic matter in the soil gradually decreases, through the action of microbes in the soil which use it as a source of energy, unless the new land use provides a replacement for the material being used, as the natural system was providing before it was cleared.

A number of major soil related problems occur throughout the world these include:

- Loss of soil fertility (see lesson on nutrition)
- Erosion
- Salinity
- Soil compaction
- Soil acidification
- Build-up of dangerous chemicals

EROSION

Soil erosion which is the movement of soil particles from one place to another by wind or water is considered to be a major environmental problem in many farming areas throughout much of the world. Erosion is responsible for river valleys and shaping hills and mountains. Such erosion is generally slow however the actions of man have caused a rapid acceleration in the rate at which soil is eroded. This has resulted in loss of productive soil from crop and grazing land, layers of infertile soils being deposited on formerly fertile crop lands. The formation of gullies, siltation of lakes and streams and mass land slips etc. Man has the capacity for major destruction of our landscape and soil resources.

Causes of Human Erosion

- Poor agricultural practices such as ploughing soil to poor to support cultivated plants, or ploughing soil in areas where rainfall is insufficient to support continuous plant growth. Exposing soil on slopes.
- Removal of forest vegetation.
- Overgrazing
- Altering the channel characteristics of streams causing bank erosion.

Types of Erosion

The two types of erosion are:

- Water erosion
- Wind erosion.

1. WATER EROSION

With water erosion soil particles are detached by either splash erosion caused by raindrops or by the effect of running water. Several types of water erosion are common in our landscapes. These are:

- Sheet erosion where a fairly uniform layer of soil is removed over an entire surface area; this is caused by splash from raindrops with the loosened soil generally transported in rills and gullies.
- Rill erosion this occurs where water runs in very small channels over the soil surface with the water itself the abrading effect of the transported soil particles causing deeper incision of the channels into the soil surface. Losses consist mainly of surface soil.
- Gully erosion this occurs when rills flow together to make larger streams. They tend to become deeper with successive flows of water and can become major obstacles to cultivation. Gullies only stabilize when their bottoms become level with their outlets.
- Bank erosion this is the erosion by cutting banks by streams, rivers, etc. It can be very serious at times of large floods and cause major destruction to property such as buildings, roads and bridges.

2. WIND EROSION

Wind forces are strong enough if it reaches what is known as the "critical level" and this is the point at which it can impart enough kinetic energy to cause soil particles to move. Soil that lacks vegetation and/or is dried out is especially prone to wind erosion.

Control of Erosion

As erosion is caused by the effects of wind and water, then control methods are generally aimed at modifying the effect of these two factors. Some of the most common control methods are listed below.

- Prevention of soil detachment by the use of cover materials such as plants i.e. trees, mulches, stubbles crops, etc.
- Crop production techniques such as fertilising to promote plant growth and hence surface cover.
- Ploughing to destroy rills and contour planning to create small dams across a field to retard or impound water flow
- Filling of small gullies by mechanical equipment or conversion into a protected or grassed waterway.
- Terracing of slopes to reduce rates of runoff.
- Prevention of erosion in the first place by careful selection of land use practices
- Conservation tillage agricultural methods.
- Armouring of channels with rocks, tyres, concrete, timber etc. to prevent bank erosion
- The use of wind breaks to modify wind action.
- Ploughing into clod sizes to0 big to be eroded or ploughing into ridges.

SALINITY

When a plant uses a nutrient from a chemical "salt" molecule supplied in a nutrient solution, it is in fact only using one part of that molecule.

The remaining part of the molecule generally stays in the soil or nutrient solution (in the case of hydroponics). Some may be used by the plant, but more commonly, it builds up and can reach a level where it causes damage to the plant. This is referred to as "salt build up" or a "salinity" problem.

Salinity problems are most common in soils, or other media, which have a high cation exchange capacity or when using a closed hydroponics system with the same nutrient solution for an extended period.

Salinity problems will sometimes be visible. If you see a white caking around the edges of drainage outlets, or on the surface of media, this indicates the problem is reaching a danger level.

High salt levels in soils reduce the ability of plants to grow or even to survive. This is can be caused by natural processes, but much occurs as a consequence of human action. Salinity has been described as the 'AIDS of the earth' and its influence is spreading throughout society; particularly in rural communities, where crop production has been seriously affected and caused economic hardship.

Salinity problems have been grouped into two main types:

1. Dry land salinity

Dry land salinity is that caused by the discharge of saline groundwater, where it intersects the surface topography. This often occurs at the base of hills or in depressions within the hills or mountains themselves. The large scale clearing of forests has seen increased 'recharge' of aquifers (where groundwater gathers in the ground) due to reduced evapotranspiration back to the atmosphere. The result has been a rise in groundwater levels, causing greater discharges to the surface.

2. Wetland salinity

Wetland salinity occurs where irrigation practices have caused a rise in water tables, bringing saline groundwater within reach of plant roots. This is common on lower slopes and plains and is particularly common on riverine plains. The wetland salinity problem is exacerbated by rises in groundwater flow due to dry land salinisation processes higher in the catchment.

General crop symptoms:

- Poor germination
- Poor plant growth
- Plant leaves appear smaller and darker in colour
- The edges of the leaf can die, followed by yellowing of the whole leaf

Sources of Salt

Salts are a naturally occurring by product of the weathering of bedrock and soil materials. Salts can be accumulated in a number of ways, which may have varying importance from area to area. These include:

- Cyclical movement: this is salt carried in evaporating ocean water that is later precipitated in rain.
- Marine incursions: at various times in the geological past, large areas of the land were under sea level. Salt deposits may be remnants of these incursions.
- In Situ weathering: the natural weathering of bedrock and soil resulting in the movement of salts through a soil profile.
- Aeolian deposits: salt that is believed to be material picked up and transported by wind from salt pans, playa lakes, etc., in times of arid weather during the past, when saline groundwater evaporated leaving salt deposits.

Control Methods for Salinity

Many of the control methods for salinity are very expensive and require strong commitment by governments if they are to be undertaken. But it also requires regional community cooperation, as such problems don't respect artificial boundaries.

One of the major problems with salinity is that the area in which occurs may be a fair distance from the cause.

Thus we have saline groundwater discharging on the plains as a consequence of forest clearing high in adjacent hills where salinity is not apparent.

Some of the main control methods are:

- Pumping to lower groundwater levels, with the groundwater being pumped to evaporation basins or drainage systems.
- Careful irrigation practices to prevent or reduce a rise in groundwater levels.
- 'Laser' grading to remove depressions and best utilise water on crop and grazing land.
- Use of saline resistant plant species.
- Re-vegetation of 'recharge' areas and discharge sites.
- Engineering methods designed to remove saline water from crop land.
- Leaching with water can be effective in areas where high groundwater tables are not a problem.
- Reduce applications of artificial fertilisers.
- Use different fertiliser types, for example organic types such as compost and manures.
- Use deep rooted plant species that will help lower the local water table.
- Often the only way to overcome this problem in a farm is to grow salt tolerant plants.

The main cause of increasing salinity problems is the rising groundwater levels due to the large scale clearing of deep rooted plants and over irrigation.

As the groundwater level rises it dissolves natural salts, bringing salty water into contact with the roots of plants causing them to die.

Tell-tale signs of salt affected soils include dieback of plants and a white crusty layer of salt which is deposited on the soil surface as water is evaporated away. Salinity can also be a problem in gardens that have been excessively fertilised using artificial fertilisers and in coastal areas.

SOIL ACIDIFICATION

Soil acidification is a problem becoming increasingly more common in cultivated soils. Soil acidification is the increase in the ratio of hydrogen ions in comparison to "basic" ions within the soil. This ratio is expressed as pH on a scale of 0 14 with 7 being neutral. The pH of a soil can have major effects on plant growth as various nutrients become unavailable for plant use at various pH levels (see lesson on nutrition). Most plants prefer a slightly acid soil, however an increase in soil acidity to the levels being found in many areas of cultivated land in Australia renders that land unsuitable for may crops or requires extensive anelicration to be undertaken.

Causes of Soil Acidification

Acid soils can be naturally occurring, however, a number of agricultural practices have expanded the areas of such soils. The main causal factors are when plants that use large amounts of basic ions, such as legumes, are grown or when fertilisers that leave acidic residues are used. Soil acidity is generally controlled by the addition of lime to the soil, by carefully selection of fertiliser types and sometimes by changing crop types.

COMPACTION

Compaction of soils causes a reduction in soil pore space. This reduces the rate at which water can infiltrate and drain through the soil. It also reduces the available space for oxygen in the plant root zones. Major consequences of compaction include poor drainage, poor aeration, and hard pan surfaces causing surface runoff of water. Compaction is caused generally by human use of the soil i.e. foot traffic on lawn areas or repeated passage of machinery in crop areas. Repeated cultivation of some soils leads to a breakdown of soil structure which increases the likelihood of compaction. Compaction can be prevented by farming practices that minimise cultivation or the passage of machinery. These include conservation tilling, selection of crops that require reduced cultivation, irrigation, etc. and use of machinery at times less likely to cause compaction i.e. when soils aren't wet or when some protective cover e.g. vegetation may be present. For heavily compacted soils deep ripping may be necessary.

CHEMICAL RESIDUES

Although not as large a problem as some of the other types of soil degradation, the presence of chemical residues can be quite a problem on a local scale. These residues derive almost entirely from long term accumulation after repeated use of pesticides etc. or of use of pesticides or other chemicals with long residual effects. Some problems that result from chemical residues include toxic effects on crop species and contamination of workers and livestock and adjacent streams. Control is often difficult and may involve allowing contaminated areas to lie fallow, leaching those areas, trying to deactivate or neutralise the chemicals involved, removing the contaminated soil or selecting tolerant crops.

Herbicides are applied to most soils used in agriculture and horticulture, and in many other situations where weeds are problems. Some herbicides are applied directly to the soil (for pre- emergence weed control) while others reach the soil because they are not intercepted by foliage. In both cases, chemical and biological processes in the soil are responsible for removing them from the environment. There are several concerns about herbicides in soils:

- Whether they actually kill the weeds and whether their persistence in the soil will damage valued species that follow in the cropping systems.
- Whether residues will persist in the soil and for how long.

Soil is not an inert receptacle for herbicides. Rather, there are chemical and biological reactions between soil and herbicide that determine the extent herbicides move, persist and are phytotoxic. Although not as large a problem as some of the other types of soil degradation, the presence of chemical residues can be quite a problem on a local scale.

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- Allowing contaminated areas to lie fallow.
- Leaching affected areas.
- Trying to deactivate or neutralise the chemicals.
- Removing the contaminated soil.
- Selecting tolerant crops.

CHAPTER 3 PRODUCTION SYSTEMS

Farms grow animals or plants. At a certain stage of growth, produce is obtained from the animal or plant, sometimes by killing the organism (e.g. to obtain meat), and sometimes removing something (e.g. eggs, fruit, wool, etc.), without killing the organism.

For most farm products, there are different ways of producing the "final product" (i.e. different production systems).

Examples:

- Meat or plants may be grown fast or slow (quality and tenderness of food may be affected by speed of growth)
- Most things (e.g. meat, fruit, wheat, etc.), can be grown in a natural situation with minimum human intervention; or a more unnatural situation, with greater human intervention.
- Produce may be grown on a small scale, or on a large scale
- Systems can be monocultures (producing one thing only) or polycultures (where different animals and plants are integrated so that different products are taken from the same enterprise).
- Some systems are more labour intensive; others (e.g. mechanised systems) may be more manageable
- Land-care considerations may restrict the systems available (e.g. to prevent land degradation, it may be necessary to use a particular type of system).
- (Generally polycultures are less likely to cause land degradation).

CHOOSING A PRODUCTION SYSTEM

Why choose one system rather than another?

- For marketing reasons (e.g. being able to say it is organically grown may make a product more marketable).
- Because it suits the property.
- Because it is less expensive.

ANIMAL PRODUCTION SYSTEMS

The type of system chosen may be influenced by several factors, including:

a) The availability of land - if the amount of land is limited, it may be necessary to use an intensive production method (e.g. lot feeding), if the farm is to operate on a financially viable scale.

b) Natural resources i.e. the quality of land, nature of climate, water and other resources.

c) Certain conditions may be needed to support a particular type of animal.

d) The desire to be able to expand in the future.

e) Available labour - some systems require more labour. It takes manpower to mend fences, muster stock, provide supplementary feeding or watering, or to move stock about; so by minimising these tasks, the labour required to manage the farm is also minimised.

One of the most common systems for many farms has traditionally been grazing.

Broken farm fence

PADDOCK GRAZING

Traditional farms are divided into paddocks. Paddocks may be used any of the following ways:

Animals are left in the same paddock for a year or longer (i.e. continuous grazing). Stock may then be mustered (rounded up) as required (e.g. for marking, veterinary treatments, shearing or selling).

- Set stocking leaves animals in the same paddock throughout the better part of the year, but not all year. It aims to minimise moving stock (and causing any stress), while providing the best feed. If and when pasture declines, the stock may be moved. This system is only appropriate on fertile sites.
- Grazing animals are rotated between paddocks (i.e. rotational grazing), usually every week or so. Paddocks are commonly rested for up to 5 weeks before grazing again. This system is particularly appropriate for fertile pastures, such as irrigated lucerne on a dairy farm.
- Cell grazing (i.e. time controlled grazing), places animals on a pasture for an "optimum" time period, designed to achieve the best benefit to the animal, and the optimum productivity from the pasture. It is similar to rotational grazing, but the period it is grazed for will depend upon various factors such as rate of pasture growth and the age and type of animal.
- Deferred grazing involves hand feeding stock in a paddock for about six weeks after rain, in order to allow the pasture to develop more quickly.