AS 90452(V2)

Describe how techniques used to modify soil water content optimise primary production

Student Learning Objective	I have done
Factors that affect the soil water/air ratio Organic matter Soil texture Soil structure Macropores Micropores Mineral matter Precipitation Evapo-transpiration Topography	
Management practices used to modify the soil water/air ratio Water scheduling Centrepivot irrigation Mole drainage Artificial mulching Cultivation Minimum tillage	
Optimising primary production Quantity of production Quality of production Timing of production	
Field capacity Available water Wilting point Saturation Gravitational water	

Name: ______________________

Form Class: ________

Year Level: ____________________

Describe management practice(s) used to optimise the soil water/air ratio for plant processes

Level 2; 4 credits

This achievement standard requires knowledge of factors that affect soil water content and techniques used to modify soil water content, and describing how these techniques optimise primary production.

Achievement Criteria

Achievement	Achievement with Merit	Achievement with Excellence
• Describe how techniques used to modify soil water content optimise primary production.	• Explain how techniques used to modify soil water content optimise primary production.	• Explain how techniques used to modify soil water content optimise primary production. • Justify the use of techniques to modify soil water content to optimise primary production.

Explanatory Notes

Factors could include: organic matter, soil texture and structure (proportion of macropores to micropores), precipitation, evapo-transpiration, topography

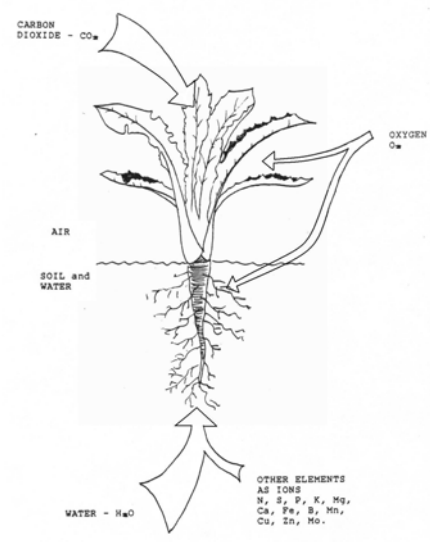
Techniques used to modify soil water content could include: water scheduling, centrepivot irrigation, mole drainage, artificial mulching, minimum tillage.

Optimise primary production refers to the quantity, quality, and timing of production.

Terminology for *soil water content* could include: saturation, gravitational water, field capacity, available water, wilting point.

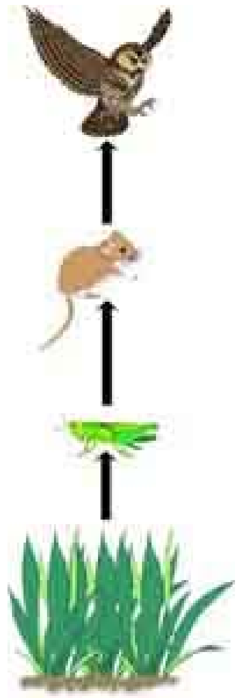
Justify means to demonstrate, by explanation and comparison, why a chosen course of action is better than the alternatives in terms of optimising primary production.

Introduction:



What are soils?

Soils form a constantly changing and evolving layer on the top of the Earth.
It is made through the environment and humans interacting with the physical, chemical and biological components that make up soil. It is a fragile and easily destroyed resource.



Why are soils important?

Without it, many plants and animals would die. Soil is the medium that most plants grow in. It forms the basic growing medium for many crops and animal feed crops.

Where do soils come from?

Soils are formed by the interaction of biological and climatic effects (erosion, weather) on a parent material. As the parent material breaks down it gathers new “parts”. These parts interact to form a soil containing organic matter, mineral matter, organisms, water and air.

What makes a good soil?

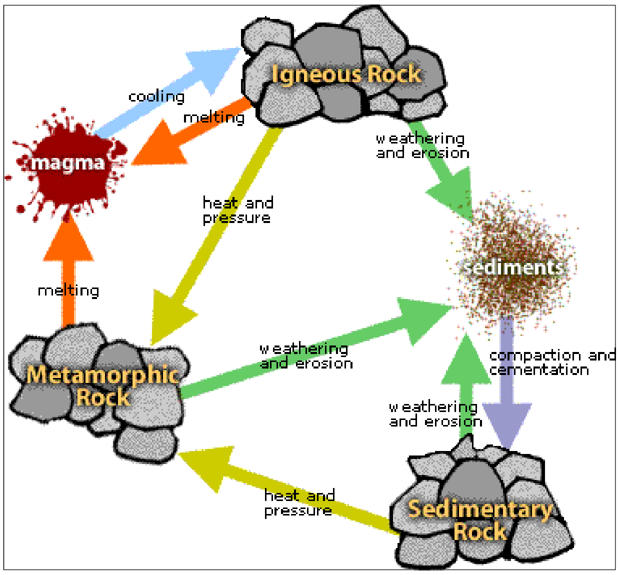
A good mixture of inorganic (mineral) matter, and organic matter, the right amount of air and water.

Why are soils different throughout NZ?

The formation of soils and type of soil formed has its roots in the parent material. What happens to the parent material determines the final type of soil formed.

Soil Formation:

Soils are formed ultimately from the rock materials that make up the Earth's crust. Over extremely long periods of time, erosion and weathering of the exposed rocks causes them to break up into smaller pieces.
The parent material determines the type of soil produced and its texture, structure, mineralogy, fertility and pH.
When these rocks break up, the mineral and chemical make-up is altered. Some of the broken up rocks remain close to their original position, but most of the broken up rock material is transported via natural weathering; ie it is moved by water, wind, ice or gravity (slips). As it moves it causes the landscape to change where it deposits. These processes can take many years to alter the landscape, there are more changes before they can develop into the soils we know today. This is the addition of organic components. I.e. the addition of humus and organisms.



<u>There are 3 main parent rock materials:</u>

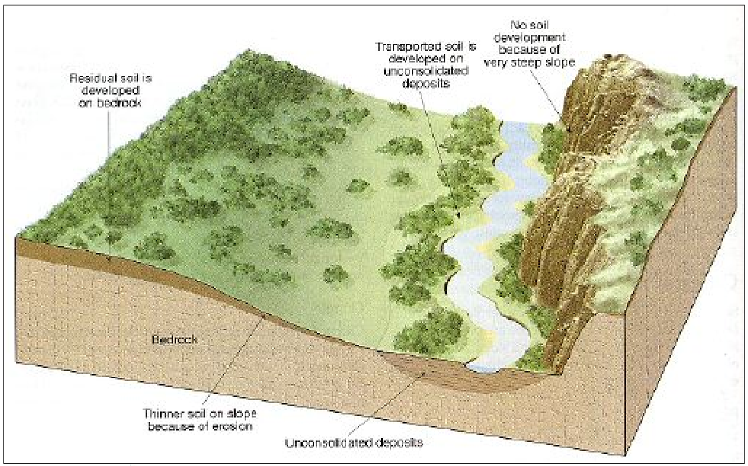
- Igneous: e.g. basalt, granite: formed from the molten material of the Earth's crust. When examined closely most igneous rocks are seen as a mixture of crystals.
- Metamorphic: e.g. slate, marble, gneiss: these are formed from igneous or sedimentary rocks which have been altered by extreme pressures and heat (associated with movements and fracturing in the Earth's curst or the effect of huge depths of rock on underlying strata over very long periods of time). Metamorphic rock is more resistant to weathering than the original rock.
- Sedimentary: e.g. sandstone, mudstone: made from accumulated fragments of rock. Most sedimentary rocks are formed in the sea or lakes to which weathered rock is carried by agents of erosion. The eroded particles settle in the still waters of lakes and the seabed, over time the layers become compacted and form a cemented structure.

Factors affecting the speed of soil formation:

Climate: rainfall and temperature have a major effect on soil formation by influencing:

Mineral weathering	movement of clay within the soil
Speed of chemical reactions	leaching
Clay formation	erosion

High rainfall promotes weathering, leaching and the creation of acidic soils. High temperatures promote OM breakdown and mineral weathering.
Topography: a slope can have one parent material, but along it you can find different soils and characteristics. At the top (steeper area) you can find shallow, stony profiles. Near the bottom the soils tend to be more developed due to the erosion and



downward movement of the soils from the upper (steeper slopes). They have a deeper profile and higher fertility levels. But, they can have drainage and water logging problems (that is why you will find swamps/bogs at the bottom of hills) Time: soils can take thousands of years to form, but it can take only a couple of years to destroy them.

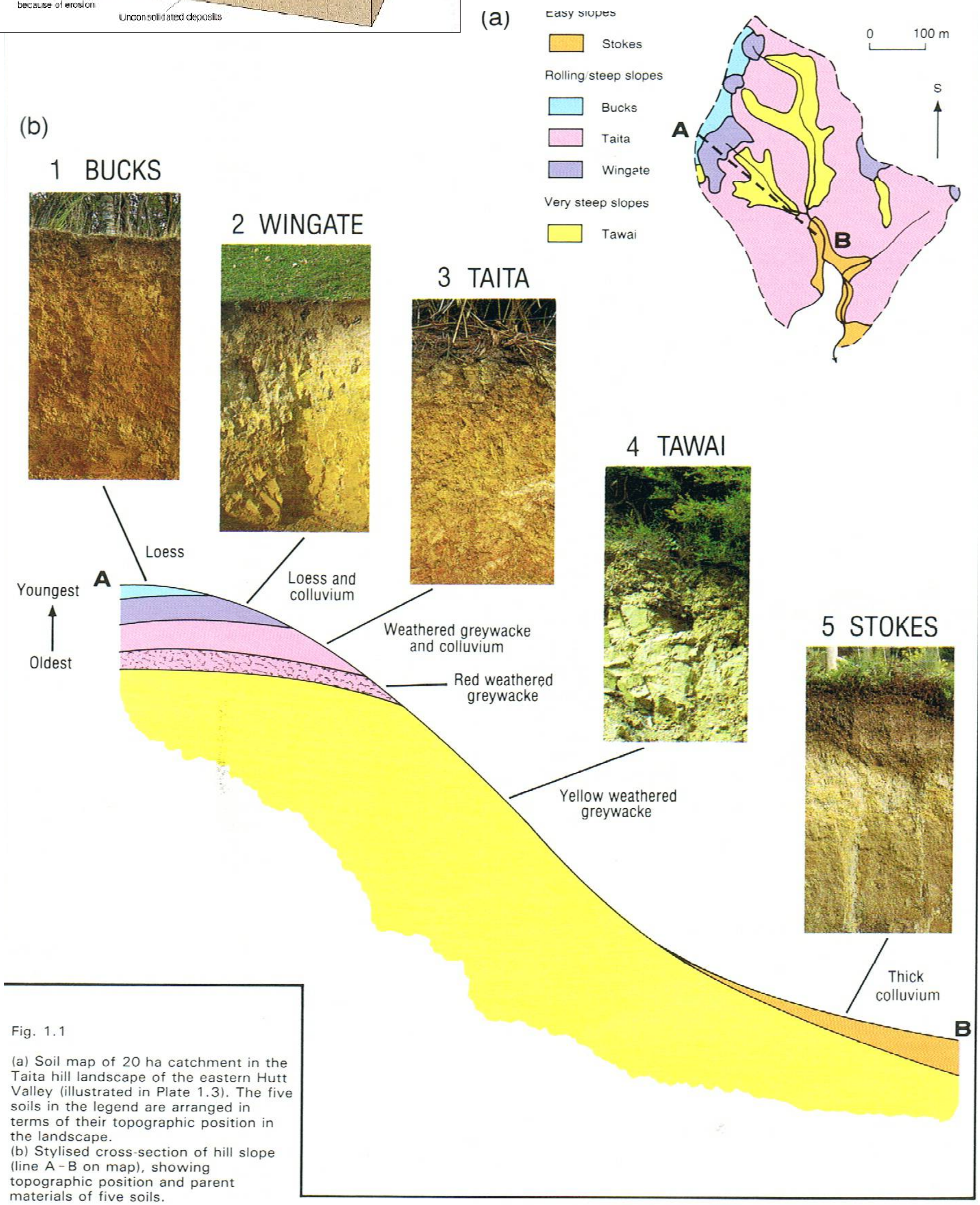


Fig. 1.1

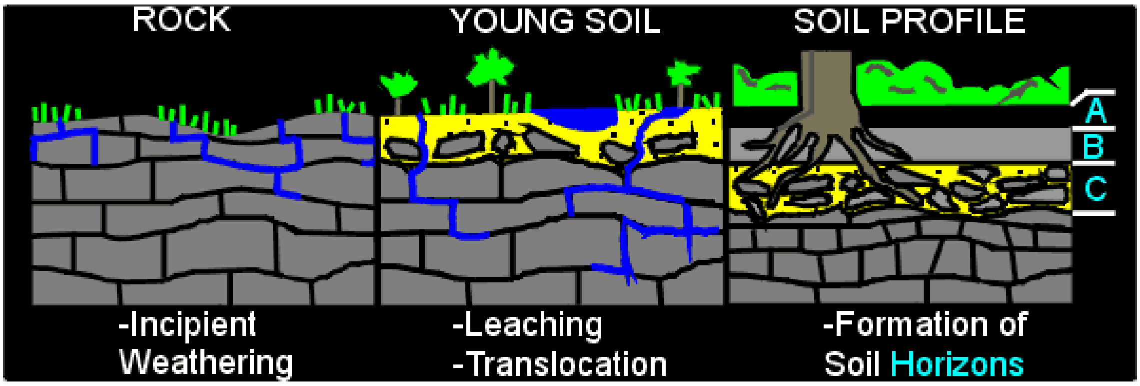
(a) Soil map of 20 ha catchment in the Taita hill landscape of the eastern Hutt Valley (illustrated in Plate 1.3). The five soils in the legend are arranged in terms of their topographic position in the landscape.
(b) Stylised cross-section of hill slope (line A - B on map), showing topographic position and parent materials of five soils.

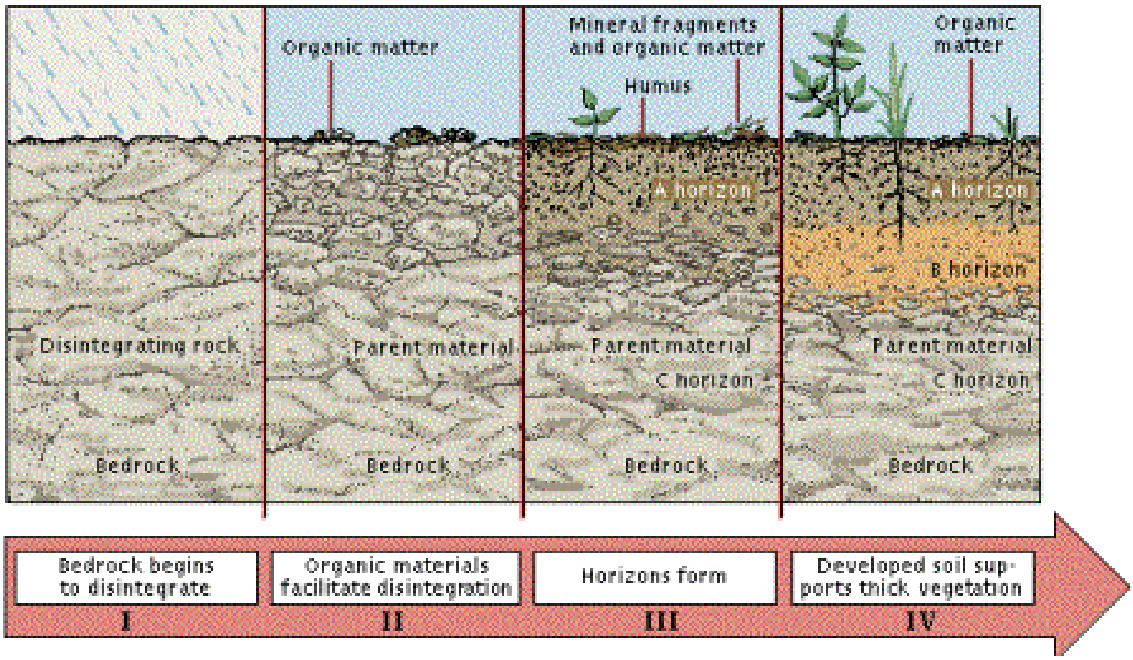
Weathering:

Weathering is the many processes concerned with altering the parent rock material. As the parent rock material is weathered it forms a regolith. The regolith is defined as: the soil, together with any underlying weathered debris and/or weathered bedrock.

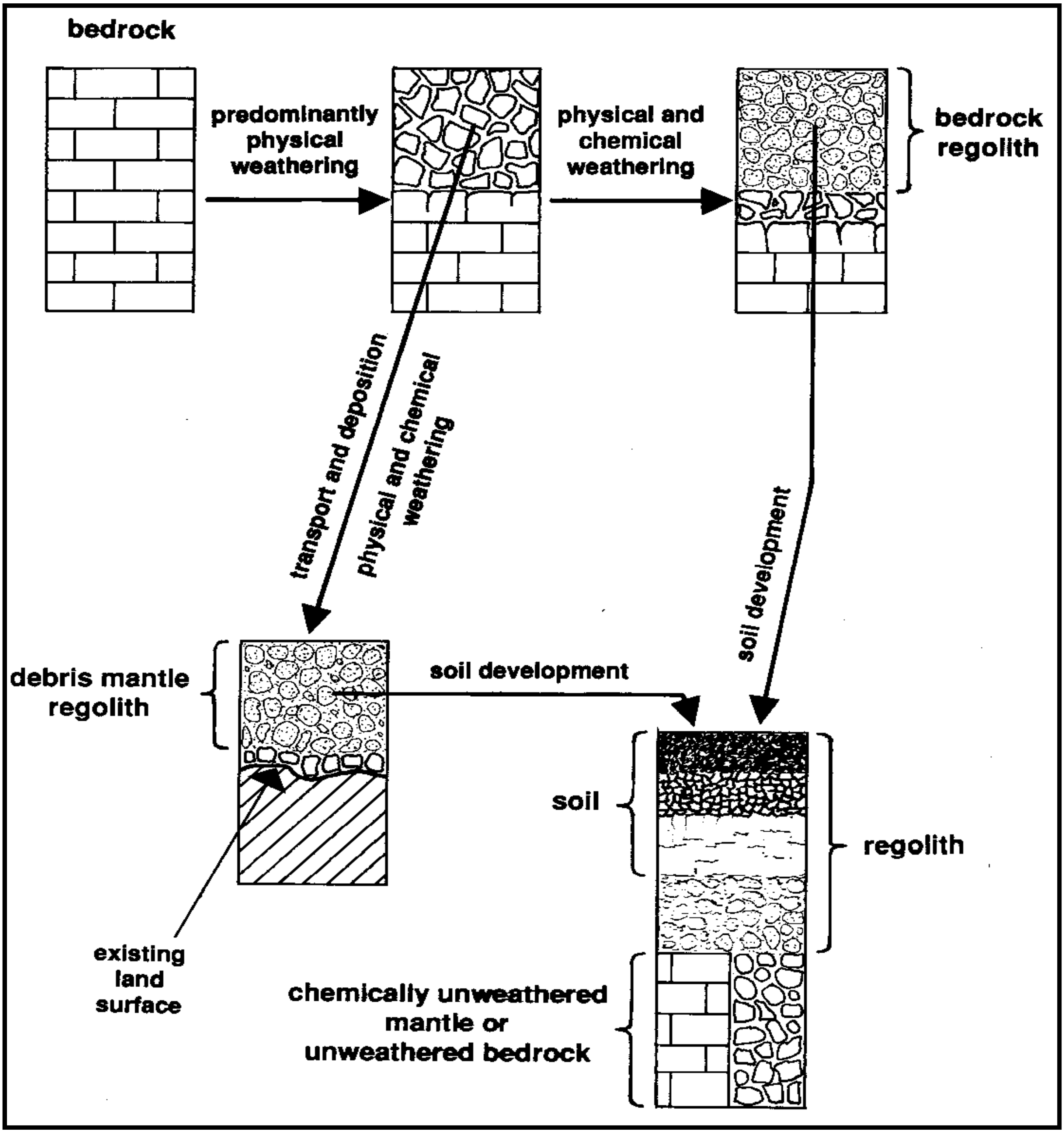
There are 3 main forms of weathering, chemical, biological and physical (or mechanical).
Chemical: water reacts with CO_2 in the soil to form carbonic acid, this acid breaks down silicate minerals and converts feldspars into clays.
Biological: Birds, burrowing animals, earthworms etc increase the rate of chemical weathering by moving soil to the surface and exposing it to the atmosphere; plants push their roots through rock crevices and microbes promote soil formation by decomposing OM, humus formation, oxidation reactions, mineralization reactions and cycling the nitrogen
Physical: there are 3 main forms of physical weathering: extreme temperature changes, mechanical action (wind, waves), expansion of freezing water.

All these processes occur at any one time in the soil. They are not independent of each other.





Pathways of soil formation showing the relationship between bedrock, regolith and soil



Soil Definitions:

Word	***Definition:***
alluvium	Sediments deposited by streams and rivers
bedrock	Divided into 3 main classes: igneous, metamorphic, sedimentary
climosequences	Where differences in soils is due only to climatic influences
colluvium	Deposits that are moved by gravity
colloids	Electrically charged soil particles (usually clay)
Debris mantles	Range of deposits from eroded parent materials
Field capacity	When the soil water is relatively stable, the excess water has already drained away and field capacity is left.
Fluvio-glacial deposits	Deposits from melted glaciers
fragipans	Dense brownish yellow horizon, found in yellow-grey earths
gleying	Process caused by the soil becoming anaerobic due to waterlogging.
Greywacke	a poorly sorted silica-cemented sandstone
humus	The broken down organic material present in soils
lapilli	A form of tephra
leaching	Water soluble chemicals move downwards due to water and gravity
lithosequences	Where differences in soils is due only to the parent material
loess	Deposits moved by wind
macronutrients	The larger amounts of nutrients present in plants (% dry matter)
macropores	Pores between soil particles
micronutrients	The smaller amounts of nutrients present in plants ($\mu g\ g^{-1}$)
micropores	Pores within soil particles
Pedogenic processes	The processes responsible for developing mature soil profiles (chemical, physical, biological, redistribution of materials, addition and subtraction of materials)
Permanent wilting point	Lack of water in the soil. Plants begin to wilt permanently
permeability	How easily water can move through the soil.
pores	Spaces in-between soil particles, can be filled with air or water; spaces within soil particles, usually filled only with water
Recent soils	Young and less developed soils. Less obvious horizons.
regolith	The soil, and any underlying weathered debris and/or weathered bedrock
Soil pans	A layer under the soil, which prevents the drainage of water. It also prevents plant roots from penetrating to deeper layers. Often formed below a ploughed field at plough depth
tephra	Airfall material from volcanoes
tilth	Word used to describe the soil when cultivated. A fine tilth is required to plant seeds in.

Soil Minerals

Soils contain the minerals that the parent rock contained. Depending on the type of parent material and the weathering that has occurred, then the proportions of these minerals will vary.

The main minerals that we are interested in are: sand, silt and clay. The amounts of each give our soils their basic characteristics. Often the types of soils are named for the proportion of each, e.g. sandy loam.

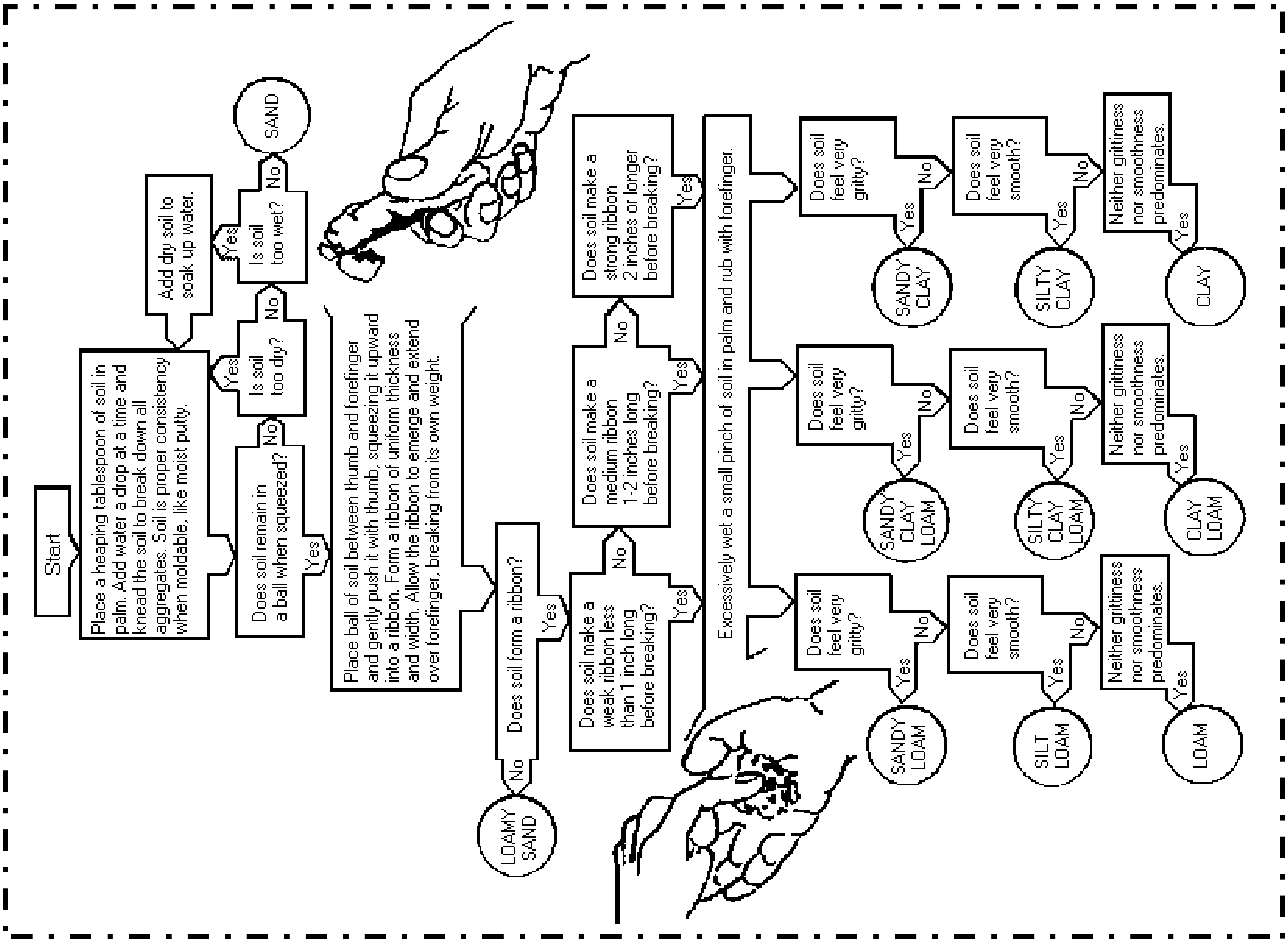
The relative proportions of these primary minerals will have a major effect on the soils:

- Fertility levels (clay is high in minerals)
- Water infiltration and drainage characteristics (sandy soils drain quickly)
- Water holding capacity (sandy soils have a low WHC)
- Ease of cultivation (plasticity and rigidity) (clay is plastic and is difficult to cultivate when wet)
- Ability to shrink and swell (clay soils swell and shrink with water)
- Susceptibility to erosion (sandy soils are more susceptible to erosion)

review: Experiment

Using the soil samples provided, work out the texture of each.

Soil A: ________________; soil B: __________; soil C: ___________



Constituents of Soil

Aim: to identify the constituents of a given soil

Background: sand, silt and clay can be separated in water because they have different sized particles. Sand has the largest sized particle and sinks to the bottom, whereas fine clay particles will float on the surface

Equipment:

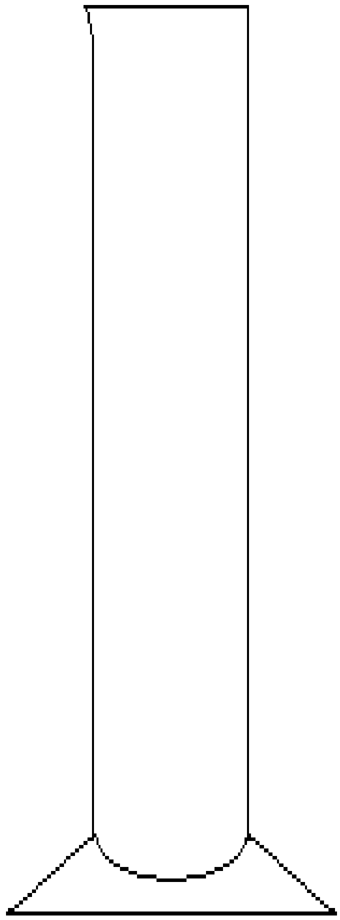
150 g soil (A, B or C) _____
Measuring cylinder (200 mL)
Water
Electronic scales

Method:

1. Measure 150 g of soil
2. Place the soil in a measuring cylinder
3. 2/3 Fill the measuring cylinder with water to help break down the particles
4. Cover the end of the cylinder and shake it vigorously
5. Leave the cylinder to stand for at least 24 hours

Results/conclusion:

1. Draw in the layers and label them (to scale if possible)
2. Look at the size of the different layers and calculate the relative percentage of sand, silt and clay present
3. Identify the soil type
4. Compare this to your earlier texture analysis.



Soil ___

Soil type: ___________________________________

Earlier analysis: ______________________________

Comparison: ______________________________________

____

____

____

Soil ____

Earlier: ____________________ Type: ___________________

Comparison: ______________________________________

____

Soil ____

Earlier: ____________________ Type: ___________________

Comparison: ______________________________________

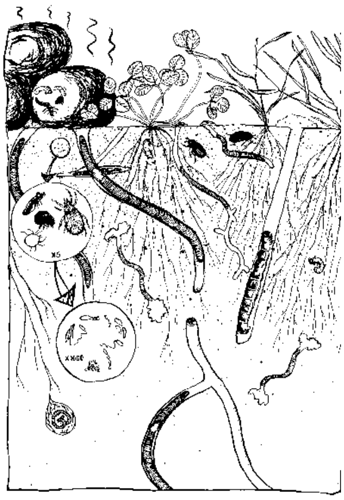
____

Soils:

Soils form the foundation of all plant growth. Without decent soils, plants don't reach their maximum potential. Soils characteristics are determined by the type of parent material (rocks) that they are developed from.
The correct management of your soils can result in improved quantity and quality of produce.
Soils are not all created equal, but they can be improved. The better soils are the loams. These have a good structure and tend to have reasonable drainage, nutrient retention etc.
Clay soils are high in nutrients, but often these are unavailable due to the lack of pore space.
Sandy soils tend to be low in nutrients due to their large pore spaces and ease of leaching.
The golden rule of gardening says, "If you treat your soil well, it will treat your plants well." Healthy, fertile soil is a mixture of water, air, minerals, and organic matter. In soil, organic matter consists of plant and animal material that is in the process of decomposing. When it has fully decomposed it is called humus. This humus is important for soil structure because it holds individual mineral particles together in clusters. Ideal soil has a granular, crumbly structure that allows water to drain through it, and allows oxygen and carbon dioxide to move freely between spaces within the soil and the air above.

Factors

Organic matter:



This is important in showing the health of the soil. Lots of OM leads to lots of organisms surviving in the soil. Organisms release the nutrients from the OM and make it available for the plants to absorb through their roots. Organisms also improve the macropore structure of soils. This is especially true of earthworms burrowing into the soils.
OM is important in improving the structure of the soil. It aids in nutrient retention, water retention, pore size and numbers.

Organic matter contributes to plant growth through its effect on the physical, chemical, and biological properties of the soil. It has a :

- *nutritional* function in that it serves as a source of N, P for plant growth
- *biological* function in that it profoundly affects the activities of organisms
- *physical* function in that it promotes good soil structure, thereby improving tilth, aeration and retention of moisture and increasing buffering and exchange capacity of soils.

Humus also plays an indirect role in soil through its effect on the uptake of micronutrients by plants and the performance of herbicides and other agricultural chemicals.

Availability of nutrients for plant growth

Organic matter has both a direct and indirect effect on the availability of nutrients for plant growth. In addition to serving as a source of N, P, S through its mineralization by soil micro-organisms, organic matter influences the supply of nutrients from other sources (for example, organic matter is required as an energy source for N-fixing bacteria).

A factor that needs to be taken into consideration in evaluating humus as a source of nutrient is the cropping history. When soils are first placed under cultivation, the humus content generally declines over a period of 10 to 30 years until a new equilibrium level is attained. At equilibrium, any nutrients liberated by microbial activity must be compensated for by incorporation of equal amounts into newly formed humus.

Effect on soil physical condition, soil erosion and soil buffering and exchange capacity

Humus has a profound effect on the structure of many soils. The deterioration of structure that accompanies intensive tillage is usually less severe in soils adequately supplied with humus. When humus is lost, soils tend to become hard, compact and cloddy.

Aeration, water-holding capacity and permeability are all favourably affected by humus.

The frequent addition of easily decomposable organic residues leads to the synthesis of complex organic compounds that bind soil particles into structural units called aggregates. These aggregates help to maintain a loose, open, granular condition. Water is the better able to infiltrate and percolate downward through the soil. The roots of plants need a continual supply of O_2 in order to respire and grow. Large pores permit better exchange of gases between soil and atmosphere.

Humus usually increases the ability of the soil to resist erosion. First, it enables the soil to hold more water. Even more important is its effect in promoting soil granulation and thus maintaining large pores through which water can enter and percolate downward.

Effect on soil biological condition

Organic matter serves as a source of energy for organisms.

Numbers of micro-organisms in the soil are related in a general way to humus content. Earthworms and other organisms are strongly affected by the quantity of plant residue material returned to the soil.

Organic substances in soil can have a direct physiological effect on plant growth. Some compounds have phytotoxic properties; others, enhance plant growth.

It is widely known that many of the factors influencing the incidence of pathogenic organisms in soil are directly or indirectly influenced by organic matter. For example, a plentiful supply of organic matter may favour the growth of saprophytic organisms relative to parasitic ones and thereby reduce populations of the latter. Biologically active compounds in soil, such as antibiotics and certain phenolic acids, may enhance the ability of certain plants to resist attack by pathogens.

Organic Matter: Revision:

This is an important factor in determining the properties of the soil.
Organic matter helps to improve the structure of the soil.

If a soil is high in clay, organic matter will ...

If a soil is high in sand, organic matter will ...

What affect does organic matter have on the water holding ability of a soil?

What affect does OM have on the structure of a soil?

What other positive effects does OM have on the soil?

Where does OM come from?

What kinds of OM are useful in the soil?

What is the ideal amount of OM in a soil?

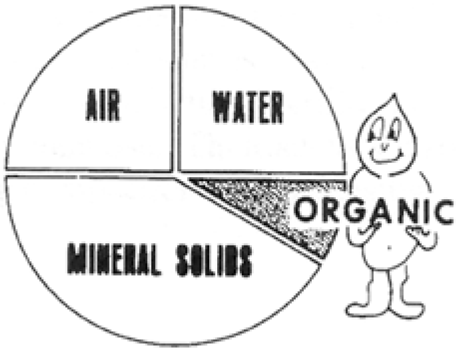
How can you improve the OM content of a soil on a small scale (backyard garden)?

How can you improve the OM of a soil on a large scale (commercial horticulture block)?

soil texture and structure

Soil Tilth

Gardening can be a challenge. Sandy soils hold little water and nutrients.
Some soils are clayey and compact readily. These soils may have poor drainage, which may lead to pugging problems. Due to low soil oxygen levels (roots only grow in soils with adequate soil oxygen levels) root systems are typically shallow reducing the crop's tolerance to drought and hot windy weather.
Special attention to soil management is the primary key to gardening success. While gardeners often focus their attention on insect and disease problems, 80 percent of all plant problems begin with



The "textbook" soil is composed of 45 percent mineral, 25 percent air, 25 percent water, and 5 percent organic matter.
The term soil tilth refers to the soil's general suitability to support plant growth or more specifically to support root growth. Tilth is technically defined as "the physical condition of soil as related to its ease of tillage, fitness of seedbed, and impedance to seedling emergence and root penetration

A soil with good tilth has large pore spaces for adequate air infiltration and water movement. (Roots only grow where the soil tilth allows for adequate soil oxygen levels.) It also holds a reasonable supply of water and nutrients.
Soil tilth is a factor of soil texture, structure, and the interplay with organic content and the living organisms that help make-up the soil ecosystem.

Urban Soils

Soils in urban settings differ greatly from field and natural soils in the following characteristics:

- Soil compaction is commonplace
- Less organic matter
- Greater variability (construction activities move and mix the soil)
- Frequent problems with surface crusting
- Higher pH
- Frequent drainage problems due to construction compaction and extensive hard surfaces (driveways, streets, parking lots, buildings)
- Less soil microbial activity
- Warmer soil temperatures- Faster organic decomposition- Longer root growth into fall- Drying
- Waste materials (asphalt, concrete, masonry, construction debris)

Texture

Texture refers to the size of the particles that make up the soil. The terms sand, silt, and clay refer to relative sizes of the soil particles.

Table 1. Size of sand, silt, and clay.

Name	Particle Diameter
Very coarse sand	2.0 to 1.0 millimeters
Coarse sand	1.0 to 0.5 millimeters
Medium sand	0.5 to .25 millimeters
Fine sand	0.25 to 0.10 millimeters
Very fine sand	0.10 to 0.05 millimeters
Silt	0.05 to 0.002 millimeters
Clay below	0.002 millimeters

A **fine-textured** or **clayey** soil is one dominated by tiny clay particles. A **coarse-textured** or **sandy** soil is one comprised primarily of medium to large size sand particles. The term loam refers to a soil with a combination of sand, silt, and clay sized particles.

Clay – Clay particles are so tiny it takes 4,800 in a line to make one centimetre. Clay feels sticky to the touch. As soil with as little as 20 percent clay size particles behaves a sticky clayey soil, with restricted water and air movement, good water and nutrient holding capacity and being rather prone to compaction issues.

Some types of clayey soils expand and contract with changes in soil moisture. These expansive soils create special issues around construction and landscaping. For homes on **expansive** clays, limit landscaping along the foundation to non-irrigated mulch areas and xeric plants that require little supplemental irrigation. Avoid planting trees next to the foundation and direct drainage from the roof away from the foundation.

Silt – has a smooth or floury texture. Silt settles out in slow moving water and is common on the bottom of an irrigation cannel or lakeshore. Silt adds little to the characteristics of a soil.

Sand – being the larger size of particles, feels gritty. When it comes to sands there is a major difference in soil characteristics between fine sands and medium to coarse sands. Fine sands add little to the soil characteristic and do not significantly increase large pore space. An example of fine sand is the bagged sand sold for children's sandboxes.

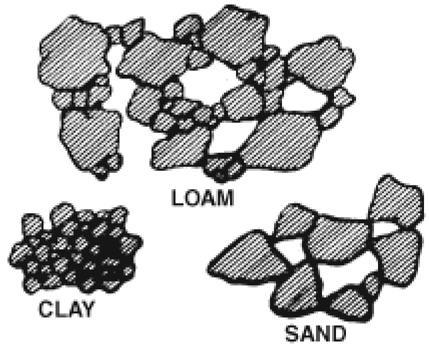
For a soil to take on the characteristics of a sandy soil it needs greater than 50 to 60 percent medium to coarse size sand particles. Sandy soils have good drainage but low water and nutrient holding capacity.

Texture directly affects plant growth and soil management as described in table 2. A soil with as little as 20 percent clay may behave as a fine-textured, clayey soil. A soil needs at least 50 percent to 60 percent medium to coarse size sand to behave as a sandy soil.

Table 2. Comparison of a fine-textured (clayey) soil and a coarse-textured (sandy) soil.

	Fine-textured Clayey	Coarse-textured Sandy
Water holding capacity	high	low
Nutrient holding capacity	high	low
Drainage	slow	fast
Warming in spring	slow	fast
Crusts and packs, restricting root growth	yes	no

Structure



Structure refers to how the various particles of sand, silt and clay fit together, creating **pore spaces** of various sizes. Sand, silt, and clay particles are glued together by chemical and biological processes creating **aggregates** (clusters of particles). Mycorrhizae, earthworms, soil micro-organisms and plant roots are responsible for driving this aggregation. The term **peds** describes the soil's individual aggregates or dirt clods. Soils that create strong peds tolerate working and still maintain good structure. In some soils, the peds are extremely strong making cultivation difficult expect when the soil moisture is precisely right. Soils with soft peds may be easy to cultivate, but may readily pulverize destroying the soil's natural structure.

To maintain good structure avoid over working the soil. Acceptable ped size depends on the gardening activity. For planting vegetable or flower seeds, large peds interfere with seeding. In contrast when planting trees, peds up to the size of a fist are acceptable and pulverizing the soil would be undesirable.

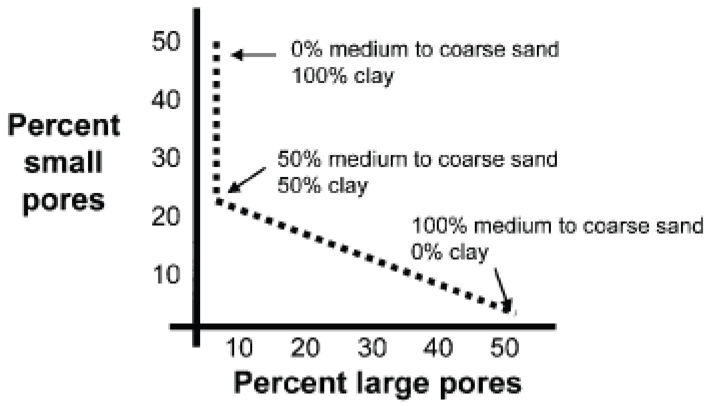
Pore Space

Pore space is a factor of soil texture and structure. *Water coats the solid particles and fills the smaller pore spaces. Air fills the larger pore spaces.*

To help understand pore space, visualize a bottle of golf balls and a bottle of table salt. The pore space between golf balls is large compared to the pore space between the salt grains.

The relative percent of clay size particles versus the percent of medium to coarse sand size particles influence the pore space of a soil. Silt and fine sand size particles contribute little pore space attributes. Note in the graph below how large pore space is non-existent to minimal until the sand strongly dominates the soil profile. Organic matter also plays a key role in creating large pore space.

The quantities of large and small pore spaces directly impact plant growth. On fine-texture, clayey and compacted soils, a lack of large pore spaces restricts water and air infiltration and movement thus limiting root growth and the activity of beneficial soil organisms. On sandy soils, the lack of small pore space limits the soil's ability to hold water and nutrients.



Soil Profile

The soil profile describes how the soil changes in structure and texture (and thus pore space) as one moves down through the soil layers. Changes in soil structure and texture are readily observed in road cuts or construction excavations. Sometimes the change may be dramatic; other times it is minimal.

Activity: Soil Profile

Aim: To draw a soil profile

Method:

1. View an exposed surface beside the stream
2. Draw the layers with depths marked
3. Make notes explaining the soil colours/textures etc, use the soil analysis chart.
4. On returning to the class, draw up a scale drawing of the soil profile.

Results: Draft Version:

Final Copy:

Water Movement: A Factor of Pore Spaces

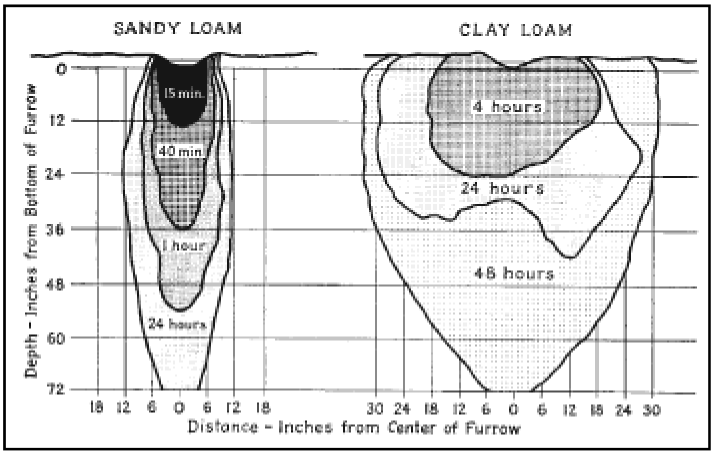
Soil water coats the mineral and organic particles and is held by the property of **cohesion** (the chemical process by which water molecules stick together) in the small pore spaces. Air fills the large pore spaces.

Water movement is directly related to pore space. In the small pore space of clayey soils, water slowly moves in all directions by capillary action. The lack of large pore space leads to drainage problems and low soil oxygen levels. On sandy soils, with the large pore space, water readily drains downwards by gravitational pull. Excessive irrigation or precipitation can leach water-soluble nutrients, like nitrogen, out of the root zone and into ground water.

Down through the soil profile, wherever there is an abrupt change in texture (actually pore space), known as a soil texture **interface**, it creates a line that impacts the movement of water, air infiltration, and root growth.

When water moving down through a sandy soil layer (primarily large pore spaces) hits a clayey or compacted soil layer (primarily small pore space) water accumulates in the soil just above the change. This back up is due to the slow rate that water can move down through the small pore spaces. It's like a huge 4 lane highway suddenly changing into a country lane; traffic backs up on the highway.

Likewise, when a clayey or compacted soil layer (primarily small pore space) is on top of a sandy soil layer (primarily large pore space), water accumulates just above the change. Water backs up in the bottom of the clayey layer, being slow to leave the small pore space, due to the water properties of cohesion (water molecules binding to water molecules).



This change in water movement creates a **perched water table** (overly wet layer of soil) generally 15cm thick or greater just above the change line.

Managing Soil Tilth

<u>Gardening on Coarse-Textured, Sandy Soils</u>

The major limitation of sandy soil is its low capacity to hold water and nutrients. Plants growing on sandy soils don't use more water; they just have to be irrigated more frequently but with smaller quantities. In order to avoid wasting water in sandy soils, the quantities that would be applied to a clayey soil must be reduced because excessive water quickly moves below the reach of plant roots. Water-soluble nutrients, like nitrogen, readily leach below the rooting zone with excessive irrigation or rain.

The best management practice for sandy soils is routine applications of organic matter. Organic matter holds at least 10 times more water and nutrients than sand. Sandy soils with high organic matter content (up to 5 percent) make an ideal gardening soil.

Gardening on Fine-Textured, Clayey Soils

The limitations of clayey soils arise from a lack of large pore spaces, restricting both water and air movement. Soils easily waterlog when water can't move through the soil profile. During irrigation or rain events, the large pore spaces in fine-textured soils quickly fill with water, reducing the roots' oxygen supply.

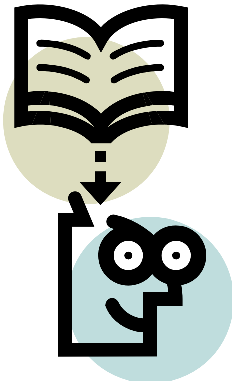
The best management practice for clayey soils is routine applications of organic matter and attention to fostering the activity of soil microorganisms and earthworms. As soil microorganisms decompose the organic matter, the tiny soil particles bind together into larger clumps or *aggregates*, increasing large pore space. This improvement takes place over a period of years. A single large application of organic matter does not do the trick. A gardener may start seeing improvement in soil conditions in a couple of years.

As the organic content increases, earthworms and soil microorganisms become more active, which over time improves soil tilth.

On clayey soils, also take extra care to minimize soil compaction. Soil compaction reduces the large pore space, restricting air and water movement through the soil, thus limiting root growth. *Soil compaction is the primary factor limiting plant growth in urban soils.* Soils generally become compacted during home construction.

The use of lime with clay soils will also help by flocculating the clay particles to form larger aggregates, thus improving the presence of pore spaces.

Task: Collect a text book (dynamic agriculture).
Read pg 233-250.
Answer the following questions in full:
- Pg 234: #1, 4, 5
- Pg 239: #6
- Pg 240: #10, 11
- Pg 241: #13
- Pg 245: #14, 15, 16,17
- Pg 249: #19, 20
- Pg 250: #21, 22



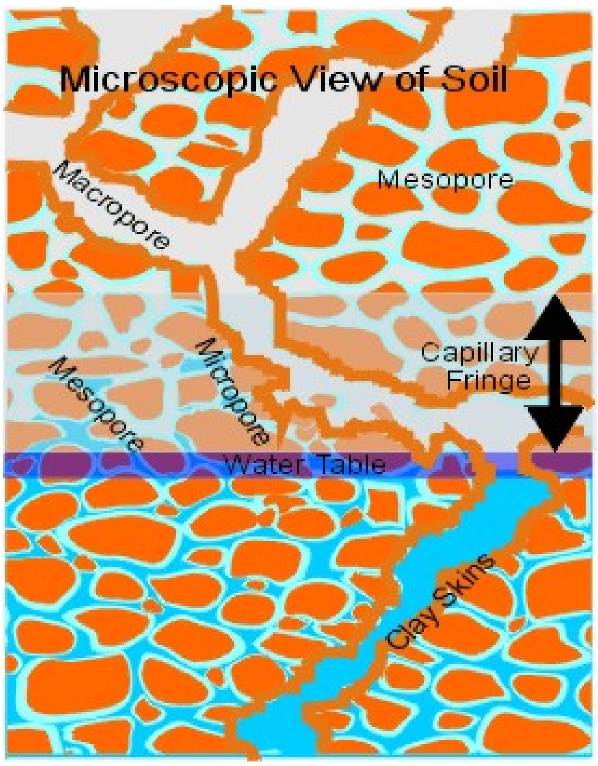
Macropores vs Micropores:

What is the difference between macropores and micropores?

Macropores are larger and found between soil aggregates. These are the main pores for infiltration and drainage.

Micropores are small and found within soil aggregates. These pores are too small and contain unavailable water. The water is held too tightly inside the pores due to capillary action.

Both macro and micro pores affect the soil structure.



Mineral matter:

This is the sand, silt and clay part of the soil. This has an effect on the soil structure and texture.
Sand is the larger particles, with clay being the smallest particles.
Most soils contain all 3 particles. The proportions vary.
The mineral matter comes from the parent material. The type of sand etc will vary depending on the parent material that it has come from.
The surface of each particle has a different charge and nutrient availability.

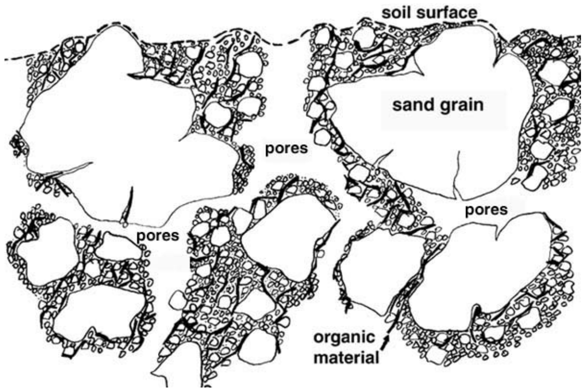
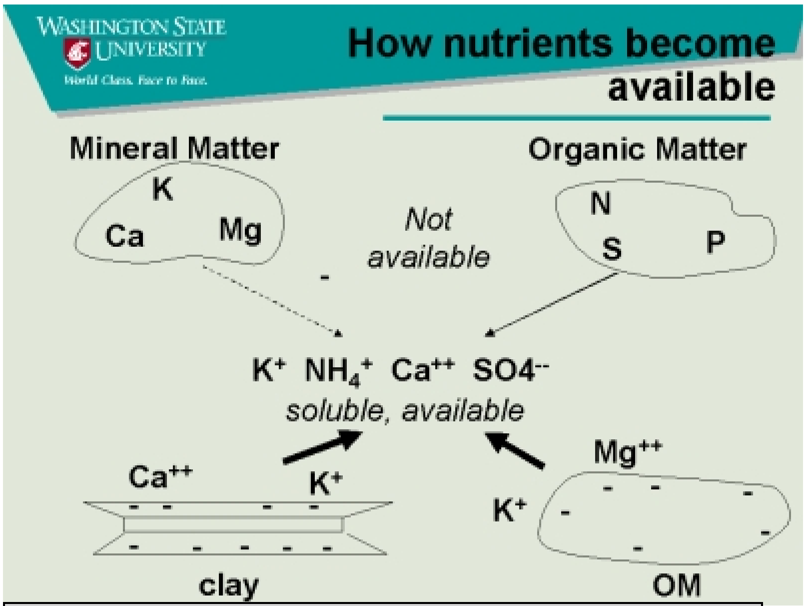
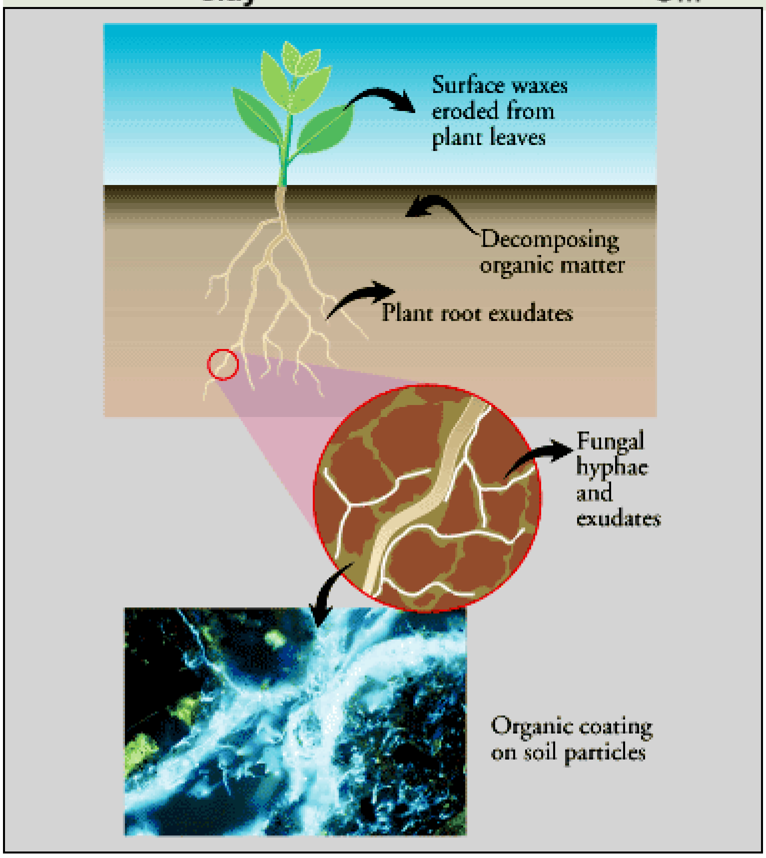
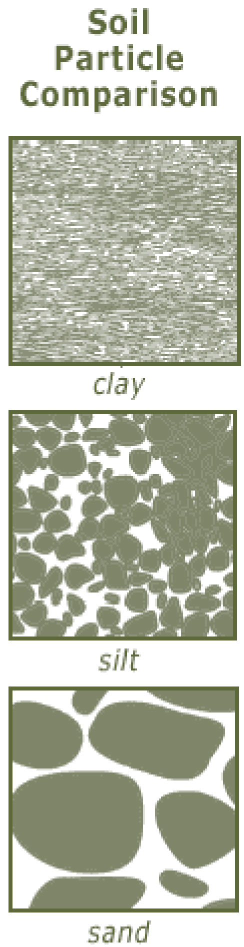


Figure 3. An example of a well structured soil (x30)
Solids range from sand size particles down to clay sized particles. They are joined together into aggregates by various chemical forces organic fibres and biological glues. Water will drain readily from the large pores and subsequently allow ready air movement. Moisture will remain in the smaller pores for use by micro-organisms and plant roots.

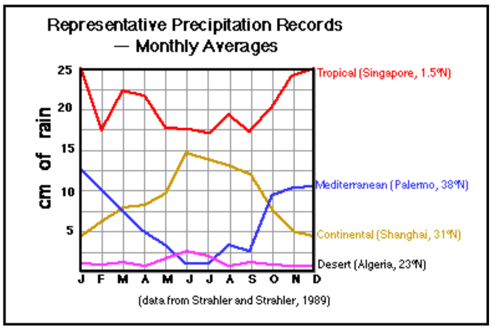




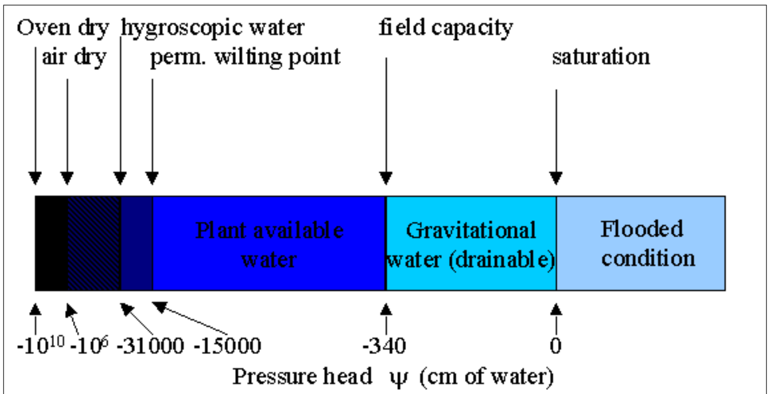


The particles in the soil become coated with organic matter. This alters the chemical availability of the soils.
In the case of clay soils, the organic matter helps to hold the clay particles together and alters the charge on the particles.

Precipitation:

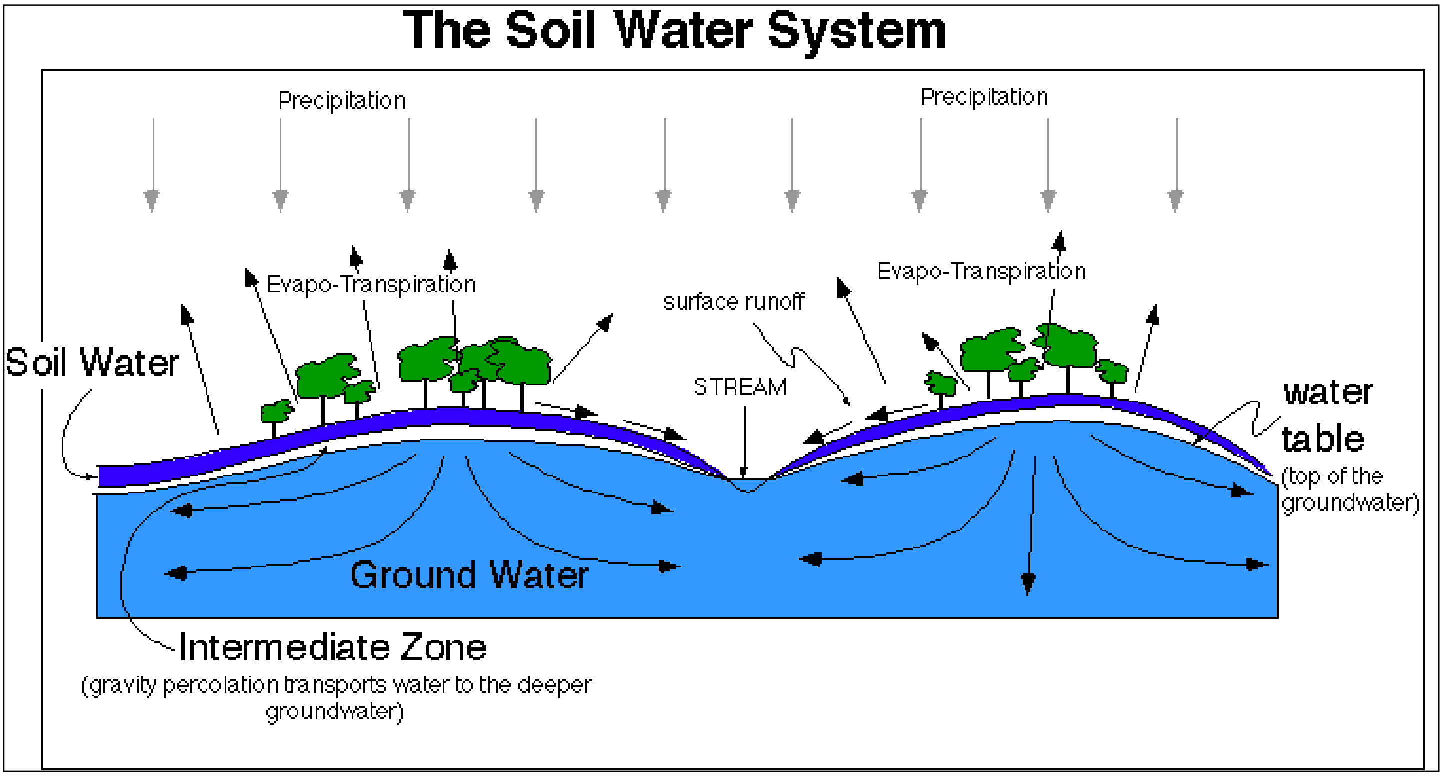


This is just another word for rain.
Precipitation affects the soil water to air ratio directly. When there has been rain, then the water in the soil increases. If there is a shortage of water (drought), then there is a greater amount of air in the soil. We can adjust for incorrect amounts of precipitation through irrigation (adding water) or drainage (removing water).
The precipitation that falls in an area is graphed using average amounts.
Task:
Using the data on the next page, graph the monthly average rainfall for Blenheim.



Soil-water status as a function of pressure (tension). Natural soils do not have tensions exceeding about -31000cm; in this range water is absorbed from the air (after Donahue et al., 1983)

The amount of water in the soil changes constantly. Look at the diagram to the right. The best volume of water is the plant available water, this is the water that plants can uptake via their roots. Above this is too much water and the air availability becomes low, plants have trouble respiring. Less than this and there is not enough water for the plants to absorb into their roots for photosynthesis.
The soil water system diagram below shows the placement of water. Ground water is the water found (usually) well below the root systems of plants. The water table is the “line” at the top of the ground water.

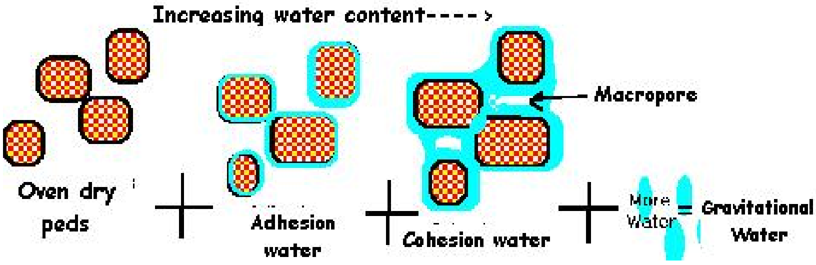


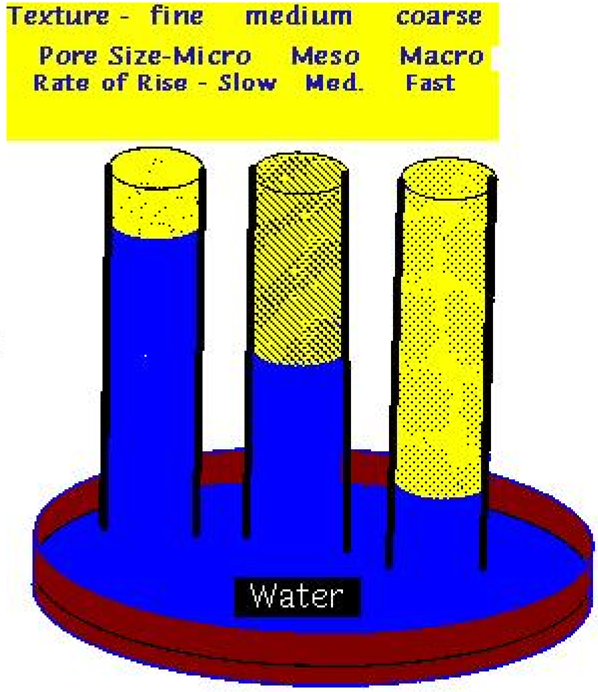
MEAN MONTHLY RAINFALL (mm)													
Data are mean monthly values for the 1971-2000 period for locations having at least 5 complete years of data													
Station details are available in separate table													
LOCATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
KAITAIA	82	79	78	95	119	149	166	152	133	93	94	97	1334
WHANGAREI	90	112	142	129	120	179	151	146	130	116	80	92	1490
AUCKLAND	75	65	94	105	103	139	146	121	116	91	93	91	1240
TAURANGA	74	78	128	105	91	128	122	115	104	94	85	87	1198
HAMILTON	85	71	87	95	102	119	126	117	102	96	93	95	1190
ROTORUA	99	101	115	112	104	134	130	148	119	122	102	115	1401
GISBORNE	54	78	99	103	97	125	119	93	101	63	65	67	1050
TAUPO	85	77	83	74	87	99	105	109	90	102	85	108	1102
NEW PLYMOUTH	97	95	117	131	124	145	143	127	110	124	108	103	1432
NAPIER	48	62	85	75	62	81	92	67	65	55	57	56	803
WANGANUI	62	65	68	71	81	82	88	70	72	81	74	70	882
PALMERSTON N	65	62	74	76	94	87	94	82	83	90	78	83	966
MASTERTON	55	59	84	70	97	101	104	96	83	83	77	72	979
WELLINGTON	72	62	92	100	117	147	136	123	100	115	99	86	1249
NELSON	72	57	78	86	77	85	86	90	73	92	82	75	970
BLENHEIM	**47**	**27**	**54**	**64**	**58**	**56**	**71**	**70**	**44**	**70**	**43**	**54**	**655**
WESTPORT	189	133	171	192	209	199	187	187	201	198	183	215	2274
KAIKOURA	47	59	92	81	71	75	80	78	70	74	60	54	844
HOKITIKA	250	172	217	249	245	233	232	224	250	286	240	278	2875
CHRISTCHURCH	42	39	54	54	56	66	79	69	47	53	44	49	648
MT COOK	411	255	422	362	365	287	278	298	310	452	390	461	4293
LAKE TEKAPO	41	35	52	52	50	58	52	62	51	57	41	48	600
TIMARU	46	38	52	66	42	41	43	45	35	55	48	53	573
MILFORD SOUND	717	499	640	585	641	440	418	427	523	688	522	648	6749
QUEENSTOWN	78	58	80	75	89	82	65	73	69	95	72	77	913
ALEXANDRA	29	22	40	34	35	26	23	24	27	41	26	43	360
MANAPOURI	89	90	87	99	104	107	93	102	82	131	97	107	1164
DUNEDIN	72	63	70	60	72	74	69	65	53	71	63	82	812
INVERCARGILL	114	79	94	100	114	99	88	71	80	95	81	100	1112
CHATHAM ISLANDS	54	55	74	70	93	99	95	76	71	63	59	55	855

Rules for graphing:

1. Title
2. Axis correct
3. Axis labelled
4. Scale even
5. Ruled lines
6. Prefer pencil
7. Refer back to previous page for ideas.

Water clings to the soil particles through the action of capillary forces.

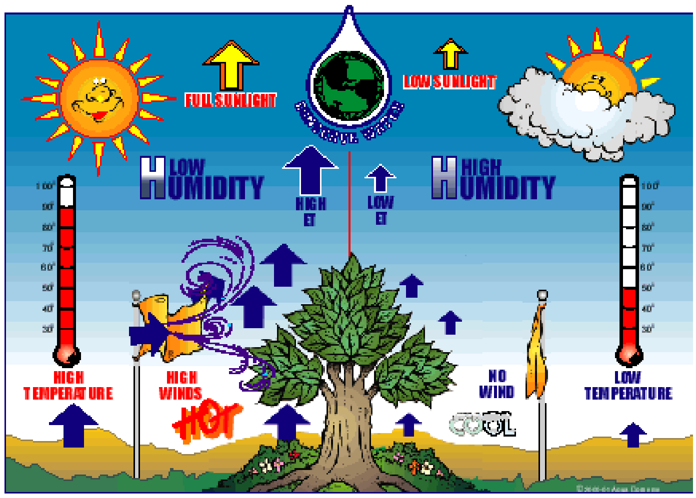




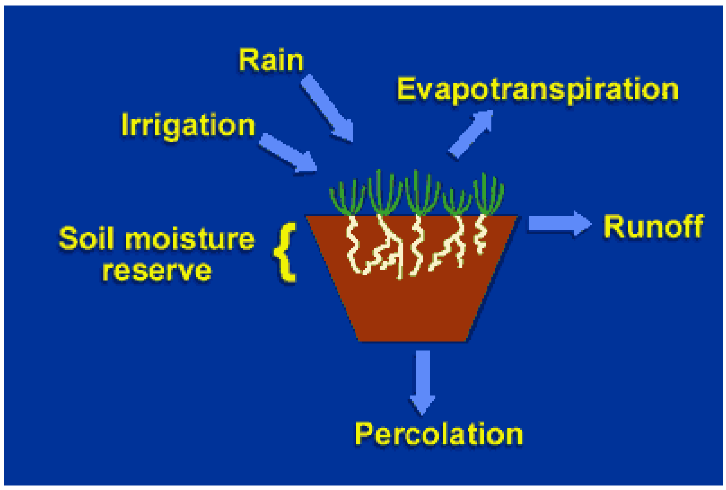
The smaller the particles, or the pore spaces, the higher the water can rise; and the more strongly the water is held to the particles. This means in a clay soil that the clay particles hold onto water more strongly than sand in a sandy soil.

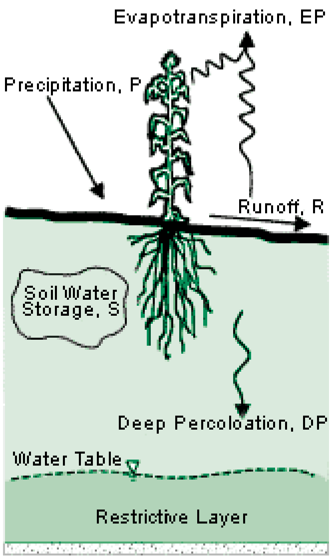
Task:
Collect 3 different capillary tubes.
Sit them in 50mL of water in a beaker.
What happens?

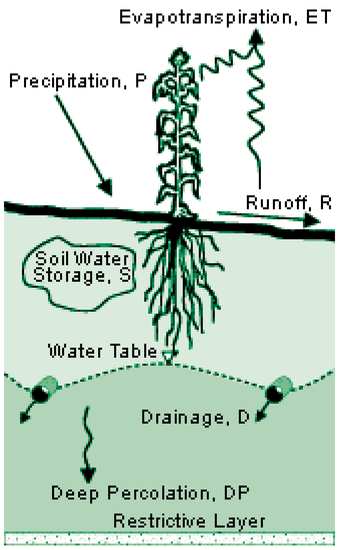
Evapo-transpiration:
This is the amount of water that is lost to the atmosphere.
It is similar to evapo-transpiration in plants. Heat and wind have an effect on the rate of loss of water from the soil. Plants also have an effect. Plants remove the water from the soil via their roots for photosynthesis.
On a hot windy day the evapo-transpiration rate is increased as the water is evaporating from the soil and the wind helps to move it away.

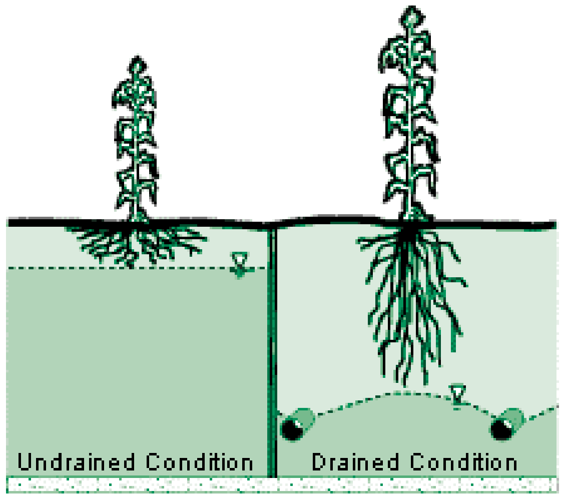


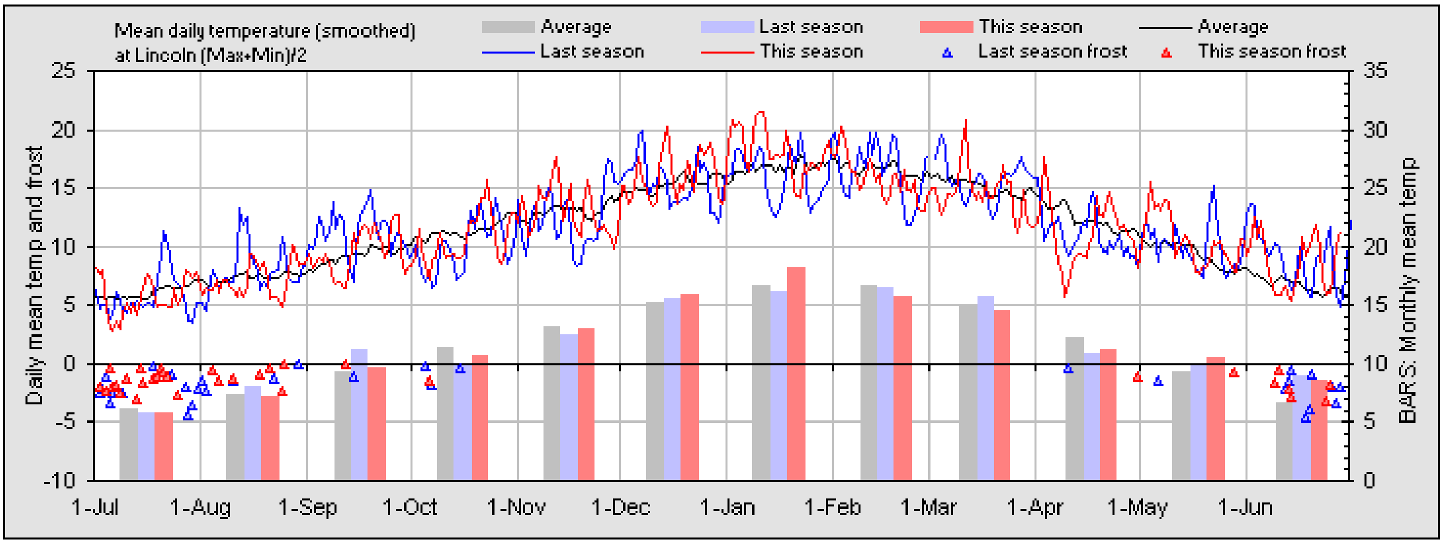
When it rains or there is high humidity, the evapo-transpiration rate decreases as the soil water can’t evaporate.
When evapotranspiration rates are high, the water needs to be replaced via irrigation, but the timing of the irrigation becomes important. It needs to be done at night to reduce the immediate loss of water into the atmosphere due to more evapotranspiration.

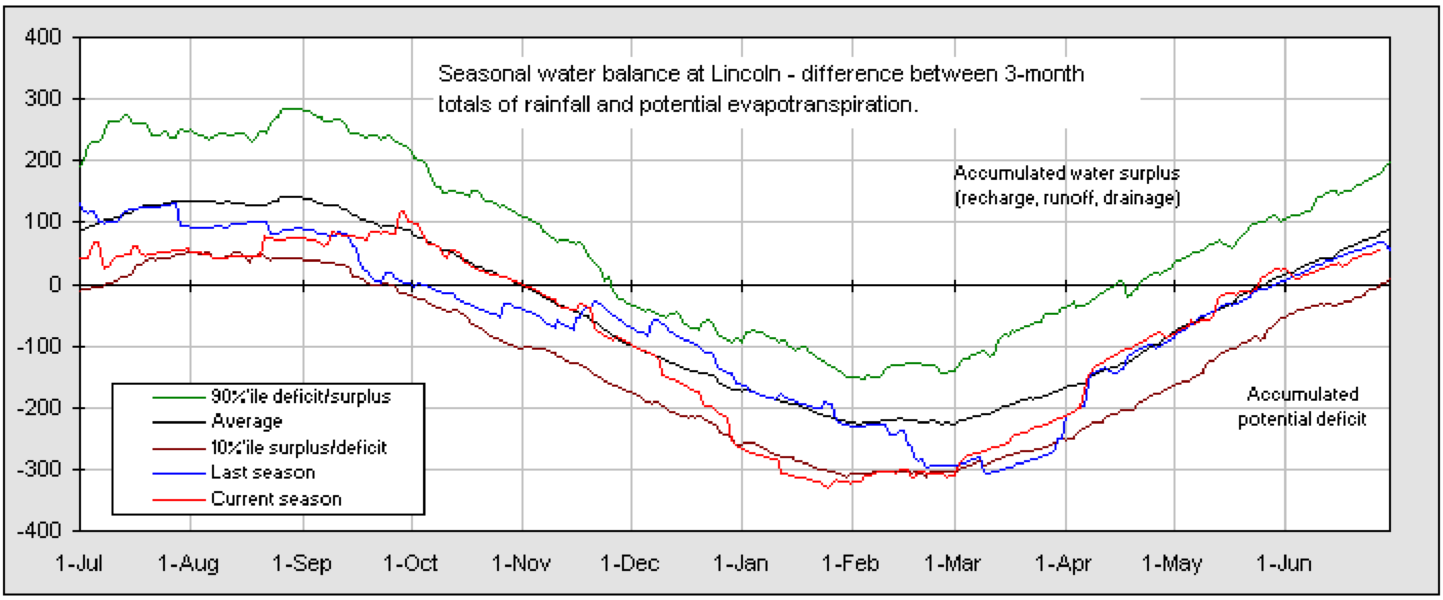










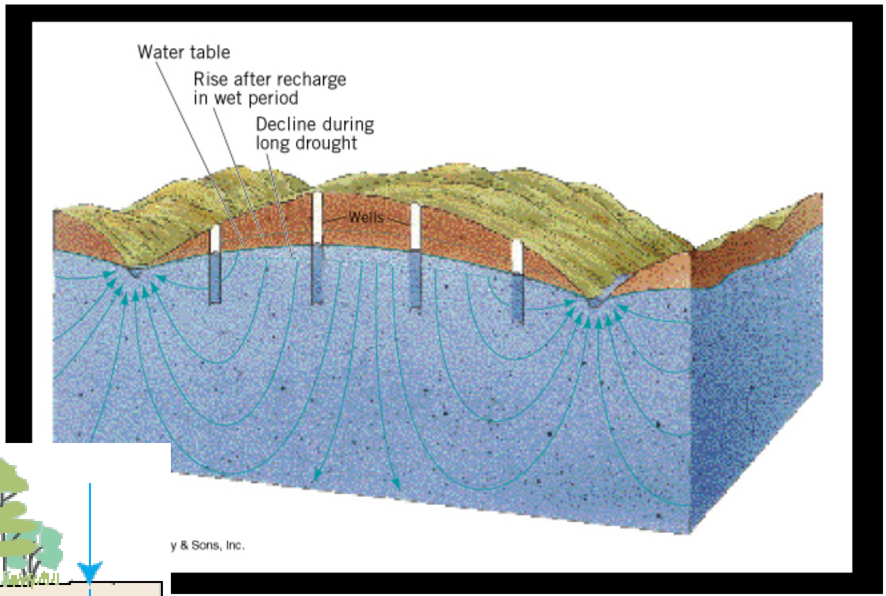


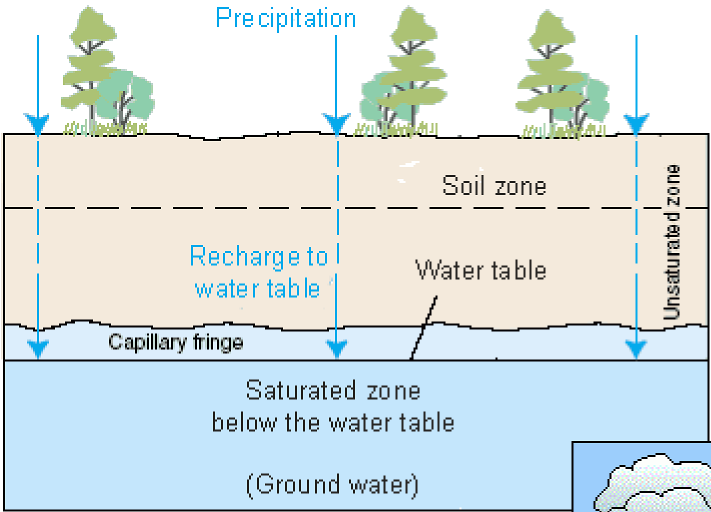
The above graphs show the evapo-transpiration that can occur in areas. As the temperature goes up, the evapo-transpiration goes up. (The rainfall also tends to be lower during the summer months, this adds to the lack of water during the summer months)

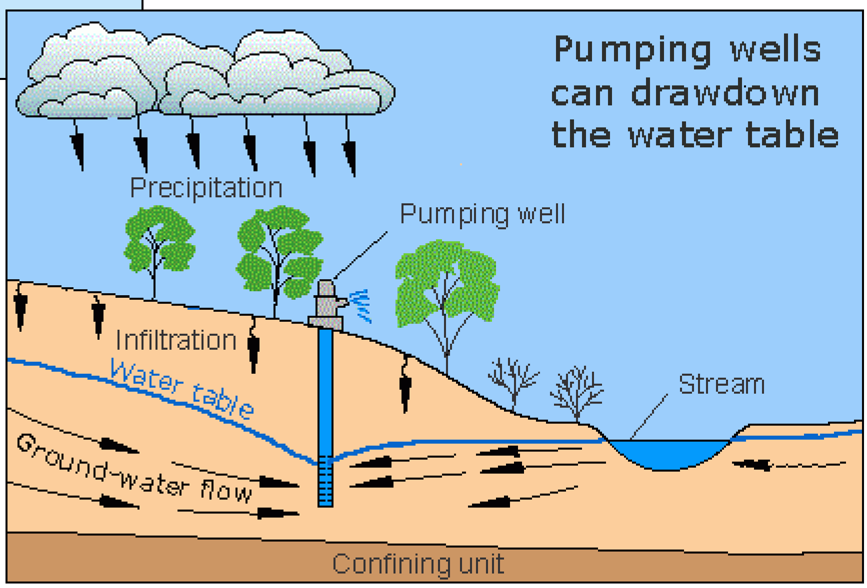
Topography

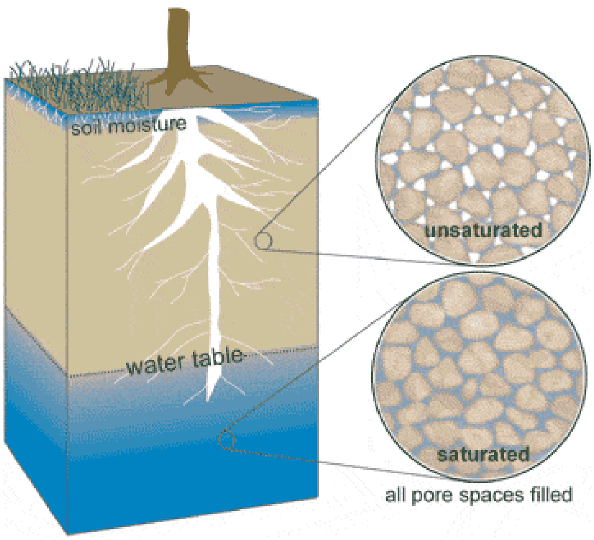
The topography can have a major effect on the water availability in a soil.
Water is pulled down by the force of gravity.
This means that there is a greater loss of surface water from a soil at the top of a hill compared to the bottom of a hill due to gravity pulling the water down the hill, this is easily seen in rivers and streams.

The water table is a lot lower compared to the bottom of a hill. This is because the water in the water table is pulled down by gravity also.









Management Practices

Management practices used to modify the soil water/air ratio include

- Water scheduling
- Centrepivot irrigation
- Mole drainage
- Artificial mulching
- Cultivation
- Minimum tillage

City of Denton Water Utilities
Drought Contingency Plan

Five-day Watering Schedule

- based on the last digit of your address -

Last Digit of Address	Allowed Watering Dates
0 and 5	5th, 10th, 15th, 20th, 25th, 30th
1 and 6	1st, 6th, 11th, 16th, 21st, 26th
2 and 7	2nd, 7th, 12th, 17th, 22nd, 27th
3 and 8	3rd, 8th, 13th, 18th, 23rd, 28th
4 and 9	4th, 9th, 14th, 19th, 24th, 29th

No watering on the 31st. The lowest address number will identify apartments, office building complexes or other property containing multiple addresses.

Please follow this schedule for all outside landscape irrigation and recreational water use. The schedule is voluntary for all retail customers under Stages 1 & 2 of the Drought Plan and mandatory under Stage 3. **No** outside irrigation or recreational water use is allowed under Stage 4. To find out if Denton is in a drought stage and/or what stage we are in, call (940) 349-8449 or go to www.cityofdenton.com.

Produced by Utilities Public Communications 5/00
ADA/EOE/ADEA TDD (800) 735-2989

Lack of Water:

When there is a lack of water (deficiency), then the farmer needs to consider adding water via irrigation. Before doing this they need to work out the deficiency. Adding too much water is just a waste of water (and in some cases a waste of money).

Water scheduling is one method of achieving the correct balance.

It involves looking at data from NIWA (or other source) on average rainfalls, temperatures, transpiration rates etc and working out what the deficit is for an area. The farmer then works out the amount of water that needs to be added to bring the available water up into the useful zone (plant available water) for plants. A schedule is then worked out as to the irrigation to be applied.

Look back on the information given on page 22-23.

When does Blenheim have a water deficit? ______________________________

Water scheduling can also have an effect on the days and amount of water you are allowed to remove from the water supply (e.g. Wairau river)

Irrigation Water Scheduling

Irrigation water management or scheduling involves more than just turning on the machine because it has not rained for a few days or the neighbour is irrigating. Irrigation scheduling is a decision-making process to determine when and how much water to apply to a growing crop to meet specific management objectives (Rogers, 1989). To be successful requires the blending of the latest scientific information, technologies, and personal irrigation experiences into an effective and sound water management program.

A sound irrigation scheduling program can help an operator:

- prevent economic yield losses due to moisture stress.
- maximize efficiency of production inputs.
- minimize leaching potential of nitrates and other agrichemicals below the rooting zone.
- conserve the water resource and maximize its beneficial use.

Leaching of chemicals cannot be totally eliminated by proper irrigation scheduling, according to some specialists (Kranz, 1989; Fishbach et al., 1988; Ritter et al., 1988; Hergert, 1986; and Ritter, 1986). For example, if a significant rainfall occurs shortly after an irrigation, the excess water will percolate deep in the soil and may carry some agrichemicals below the root zone. Likewise, large rainfall during the off-season may leach some agrichemicals that remain in the root zone.

Effective irrigation is possible only with regular monitoring of soil-water-plant conditions in the field, predicting future crop water needs, and following the best recommended water management strategies. This also requires a basic understanding of soil-water-plant relationships and soil moisture monitoring techniques.

To set up and operate an effective irrigation scheduling program these sequenced procedures need to be followed for each field:

1. Determine the crop's active rooting depth and the corresponding available water-holding capacity for each soil type in the field.
2. Select the predominant soil type(s) that should be used for irrigation water management purposes.
3. Define the allowable soil water depletion limits for the selected soil types and the crop(s) to be grown.
4. Establish a soil moisture monitoring system and regularly (at least twice a week) keep track of the soil water deficit.
5. Initiate an irrigation when the soil water deficit is expected to approach the selected allowable soil water depletion limit by the time the irrigation cycle is completed.

Vineyard practice - UNDER THE MICROSCOPE

By **DAN HUTCHINSON**

Millions of dollars of funding is being poured into a research programme designed to improve grape growers' understanding of their vines and ultimately their wines. Three Marlborough vineyards have been selected for the Focus Vineyard project along with two Hawkes Bay operations.

Their vineyards will be probed, analysed and subjected to peer review and public scrutiny. The project aims to find out "what best practice is and how to improve the adoption of best practice".

Vineyards have been selected to give a good spread of geography, soil types and rootstocks. The three-year, $1.4 million project is funded by MAF's Sustainable Farming Fund and New Zealand Winegrowers. In Marlborough, the Grape Grower's Association and the Marlborough Research Centre are also contributing funds.

Tohu Wines, Tyntesfield and Stembridge Vineyards are all under the spotlight in Marlborough, with the first field day held at Max Gifford's Stembridge last December. Around 80 industry people heard an outline of the project, which is split into six different areas; vine nutrients, yield assessments, disease management, vine water requirements, economic analysis and benchmarking.

Choosing Stembridge as the site of the first field day is fitting, with Mr Gifford being one of the first to establish a vineyard in Marlborough as a supplier for Montana in the 1970s. He now supplies Montana, Nobilo and Spy Valley. Describing himself as more of an "old-school" type grower, Gifford says he is eager to see what comes from the research.
"As much as anything, the field days are a chance for growers to stand around and swap ideas. I am already thinking a bit more about a couple of things I was planning to do."

Having experienced the "highs and lows" of the industry over the last 30 years, Gifford says he is now at a stage of fine-tuning, rather than expansion. Stembridge includes 40ha of sauvignon, 6ha of chardonnay, 3ha of gewürztraminer and 4ha of Riesling. Gifford says he is currently looking at his existing plantings and re-thinking some of the older blocks. In 1994 the brothers were seeking diversification and decided to establish a vineyard on the flat, stony river terraces of the Waihopai River. Edward manages the 50ha vineyard with all grapes grown under contract for Villa Maria, including 31ha of Sauvignon Blanc and the balance evenly split between Riesling and Pinot Noir.
He says the focus vineyard project presents an opportunity to challenge some of his "set ideas" and he is not deterred by the scrutiny he will receive.

Like the other growers, Ensor has set aside a block of Sauvignon Blanc which will be intensively monitored by the various researchers involved in the project. Tyntesfield also adds to the geographical spread of the project and, at 130 metres above sea level, it is more elevated than most. "They are measuring everything so it will be interesting to see how it compares with my own monitoring and water scheduling." Ensor is no stranger to this type of project, having participated in various monitor farm projects - a similar concept and one that is well supported by pastoral farmers. He is also an accredited member of the Sustainable Wine Growing programme.
"I am interested in learning new things and doing things better and I am quite open to suggestions."

Tohu Wines in the Awatere Valley is managed with a “guardians of the land” approach, in line with the philosophies of its collective Maori owners. Viticulture manager Jeremy Hyland says the focus vineyard project aims to take sustainable wine-growing to the next level and that is very important to the owners of Tohu Wines. The vineyard was planted in 2001 and had its first crop last season. With an average altitude of 200 metres, the vineyard has a long growing season and is the most elevated site in the project. The vineyard produces 50ha of Sauvignon Blanc, 20ha of pinot noir and three hectares of Riesling.

The project’s Marlborough coordinator, Richard Hunter, says there is a range of monitoring activities taking place on each of the selected vineyards, including soil moisture and nutrient monitoring and pest and disease monitoring. Sap analysis is a common technique used overseas and involves testing grapes to find the nutrient values of a particular plant. Growers can look for any nutrient deficiencies that arise from climate and soil conditions. Unlike soil testing, which measures the nutrient values in the soil, sap testing gives an accurate assessment of the nutrients actually being absorbed by the vine. Sap-testing equipment has not previously been available in New Zealand, with samples having to be sent overseas. Hunter says they now have a machine at the Marlborough Wine Research Centre which should do the job and give results immediately.

“Soil testing takes a week to get an answer back and only tells you what is in the soil. Sap testing is much better and you get the answer back straight away,” Hunter says.
Vineyard monitoring, including yields and quality will be linked back to the economics of the specific vineyard to give an accurate assessment of costs compared with quality and earnings. Hunter says the project is “huge” and many systems will not be fully functioning until later in the year. A full-time technician is employed to monitor the vineyards and create a database of information and there are 10 project leaders involved with various aspects of the project.

“Once we have all the information together we will get a benchmark so growers can see where they fit in that system,” Hunter says.
The project will compare different techniques under various environmental conditions. It is focused on providing the best possible platform for industry to implement best practices under one research umbrella. Once the information has been gathered it will be possible to compare different commercial vineyards and compare economics, including the comparative costs of different vineyard practices, the “time and effort” and linking it back to quality. Hunter says the quality issue is a difficult element of the project because many wineries pay a premium for certain characteristics, but these characteristics were often commercially sensitive.

Growers nation-wide will eventually be able to access cost and benefit information for sustainable practices and even specific templates for costs of production - such as mowing, pruning, pest and disease programmes. Certain issues have emerged from the industry’s Sustainable Winegrowing scheme where Hunter says only a disappointing one third of all growers are involved. Many consider there is little economic justification for new “sustainable” methods while others lack the confidence that they can successfully implement these methods into their vineyards.
“We are trying to keep it all as simple as possible because it has to be practical, applied stuff. If it is too complicated or people don’t understand the concept then the (practices) won’t be widely used.”

Some of the specific issues identified during past research include quantifying costs of production related to better management of scarce resources, optimising water usage while improving wine quality. Hawkes Bay has its own specific problems, including improving the low levels of yeast-available-nitrogen (YAN) in juice grown from grapes planted on Gimblett Gravels. Other specific areas to be looked at during the project will be improving soil condition, integrating biological control of pests and diseases, the relationship between soil health and plant health and tackling the reduction of pesticide use without compromising plant health and production.

Hunter says the three vineyards chosen for the project offer the researchers a good diversity of soil and climate types, as well as varietals and rootstock mixes. A desire for good information in the viticulture sector is behind the good attendance at the first field day, says Hunter, and those attending had requested the next day be sooner rather than later.

Dan Hutchinson is a journalist based in Marlborough - the heart of New Zealand's Sauvignon Blanc country

Problems:

After having read the previous pages on vineyard practice, answer the following questions:

1 What factors are being measured and observed during this research?

2 what do the growers hope to get out of the research?

3 what else do you think should be observed/measured? Why?

5 What information is needed to determine the amount of water needed for irrigation?

Below is a table showing the responses to a specific question on a survey on irrigation in NZ. It shows that there is no one method used to determine when to start irrigating.

The responses to the question "how do you decide when to start irrigating at the beginning of the season?" are summarised by district in the following table.

Percentage of the Total Number of Respondents (overall and by district)

	Overall	AK	GB	TAS	MARL	N.C.	M.C.	C.C.	S.C.	N.Ot	C.Ot.
Measure soil moisture	***23.7***	27.9	47.8	36.8	21.6	18.8	21.7	14.9	11.0	17.9	18.0
Scheduling service	***10.7***	0.0	4.3	5.3	12.4	12.8	11.8	17.5	13.2	13.4	16.4
Water budget	***4.9***	2.9	8.7	1.8	4.1	10.5	9.1	4.6	3.3	1.5	2.6
Inspect soil conditions	***68.0***	70.6	60.9	64.9	80.4	62.4	73.0	63.9	57.1	76.1	70.4
Inspect crops	***41.5***	48.5	52.2	54.4	60.8	39.8	45.2	41.8	28.6	17.9	25.4
Weather forecast	***25.2***	19.1	26.1	29.8	30.9	28.6	29.7	28.4	17.6	25.4	16.9
Other	***13.4***	13.2	17.4	15.8	9.3	16.5	10.6	9.3	12.1	11.9	18.0
Watch neighbours	***5.2***	1.5	0.0	5.3	2.1	7.5	6.8	9.8	9.9	4.5	4.2

Clearly farmers take a number of factors into account when deciding whether or not to start irrigation. For a clear majority of farmers, these factors are qualitative assessments of the state of the soil and crop, and how these might change with the weather.

Using the table: answer the following questions:

6 Which method is the most popular?

7 which method/s are the most popular in Marlborough? Why do you think it is more popular than other methods?

Timing and amount of irrigation:

This is very important. You have worked out when your soil is going to be deficient using climate data. Is this enough? For most home gardners this is fine. For commercial growers, no it is not.

You will need to work out the *soil water content*. This can be done using gravimetric analysis (measuring the volume of water in your soil). Measure a sample of soil from the field, record its mass. Dry overnight at 105^{o}C, re-measure the mass. Work out the amount of water lost from the soil. Remember that not all of this water would have been available for the plants to use.

$$\frac{\text{(mass of wet soil - mass of dry soil)}}{\text{Mass of dry soil}} = \text{soil water content (g g}^{-1}\text{)}$$

The next step involves using a *soil water budget*. This can be worked out using a simple calculation:

Current amount of available water in soil (mm)	=	Previous amount of available water in soil (mm)	-	Net evapotranspiration loss (mm)

You need to know the amount of daily (or weekly) rainfall, the amount of daily (or weekly) evapotranspiration, and the available water capacity of the soil. Most of this information can be found on the net (e.g. NIWA, Metservice) for the climate information. The soil water capacity can be found through DSIR or via more complex measurements (also the above information could be useful: soil water content).

The *soil water potential* is also important. This is due to the fact that not all of the water in a soil is available to the plant roots. The soil water potential is the ease of water use (removal) by plants. When plants can't remove any more water from a soil, the soil is said to be at? ____.

The point at which this happens is related to the soil texture. The water between field capacity and ____ is said to be "available" water, not all of it is equally available.

Soil water potential can be measured by instruments called "tensiometer".

The results from the soil tensiometer are compared with values listed in a supplied table. This then helps to decide when irrigation is needed.

Often 2 tensiometers are used at each area. One is set for a shallow reading, while the other is set at a greater depth. This is so the irrigation knows when to turn off, when the greater depth one registers a set amount of water, there is enough in the soil for the plants needs and any more would be a waste.

There is a similar device over in the Hort potting sheds on the heat tables. It is used to detect moisture, when the moisture gets too low, the sprinklers come on.

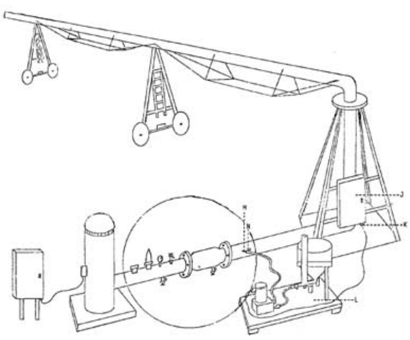
The last method that farmers may use is *plant water stress*. This is when you can visibly see the plants wilting. This is not the best method to use as the plants have already suffered (and thus a loss of production) once they get to wilting stage.

All of the information given is just an outline of the choices farmers have to make when it comes to irrigating. When there is a serious drought, and there is a shortage of water, decisions are harder to make, worse case scenario: plants don't get watered, animals do for drinking purposes, people do for all household purposes. The next stage from this is: drinking water and hygiene water (toilet and washing dishes, not people all the time) only for people, animals have to fend for themselves or get culled (to my knowledge we have never got to this stage, Aussie has).

Now that we know its time for irrigating, how will we irrigate?

Irrigation

There are many different types of irrigation.
Centre-pivot is just one.
With the centre-pivot, the water is distributed about a central point, similar to a garden sprinkler that goes around.
This is a simple version to set up and can usually be moved easily from place to place.



Other irrigation systems include: micro-irrigation, dripper systems, fixed sprinklers etc.

Task:

To find out more about different irrigation systems. You will need to find pictures, notes etc. Find out about the positives and negatives of each. When is each system appropriate, when is another more appropriate.

Use your books to write up your final analysis of at least 3 different systems. One has to be centre pivot systems.

Use the headings below to help plan out the info you need to find. You will have a maximum of 2 periods to do so.

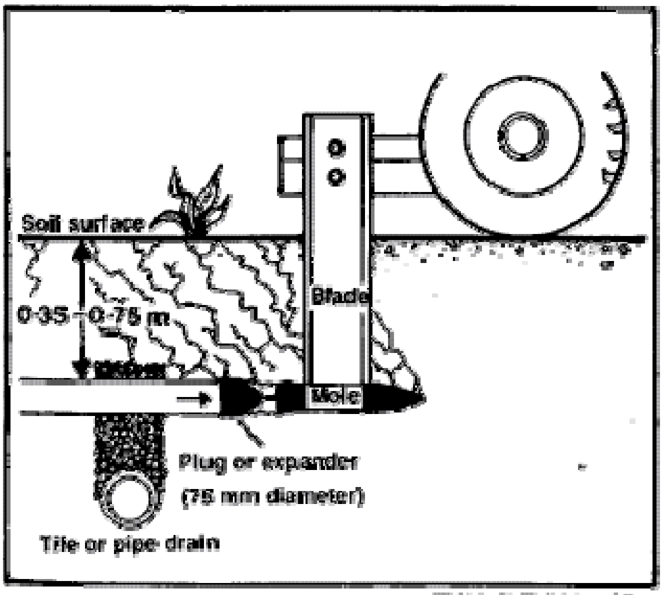
Irrigation system:
Positives:
Negatives
When to use
When not to use
Other

Irrigation system:
Positives:
Negatives
When to use
When not to use
Other

Irrigation system:
Positives:
Negatives
When to use
When not to use
Other

Drainage:

There are many forms of drainage available for farmers to choose from. The more common methods include: tile drains, mole drains, open ditches.
The main function of drainage is to remove excess water from around the roots of plants. This is because too much water equals no oxygen for respiration, thus the plants will die.
All drains need to be installed properly: water only flows downhill and so all drains need to be draining down and away from the area.

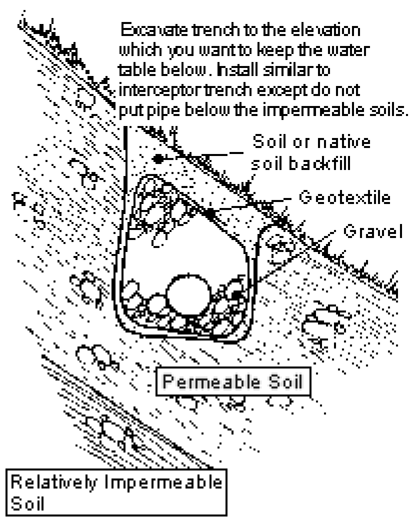


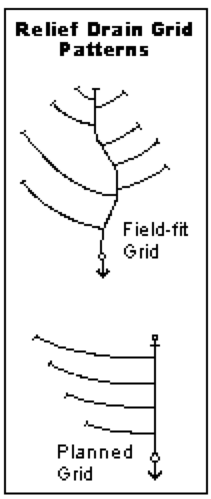
Mole Drains:
These involve the use of a specially designed mole that is pulled through the ground just below root level. It is not permanent and needs to be done again after several years as the mole drains will collapse.
A tractor (or similar) pulls the mole through the soil forming a tube (similar to the tunnels a mole would make). The mole drain is usually above a tile drain.
Task: go to the following websites:

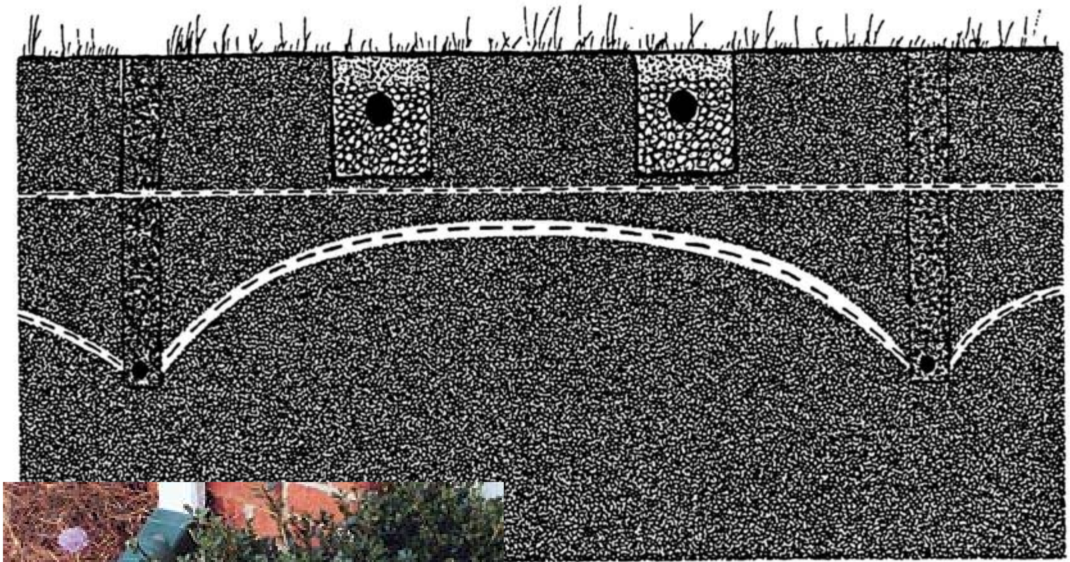
http://www.maf.govt.nz/mafnet/schools/activities/swi/swi-05.htm
http://www.regional.org.au/au/asa/1998/7/179johnston.htm
http://www.ecy.wa.gov/programs/sea/pubs/95-107/drainsys01.html

Read the information given, make notes on the different types of drainage for soil management.

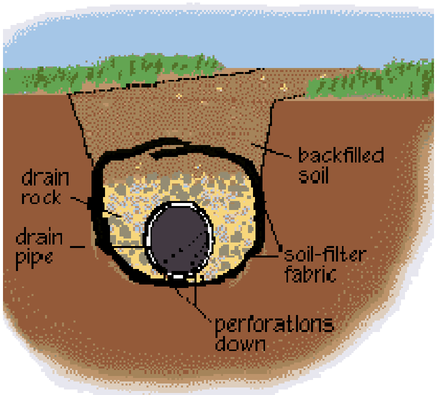
Tile drains tend to be more permanent and have to be carefully planned. There are different patterns that can be used when designing the layout. The most important factor is the lie of the land. Water needs to go downhill.
Tile drains are often under mole drains and at right angles so as to remove deeper water from the soil
The tile drains and mole drains need to lead into another drain, usually an open ditch.







Water table line after tile drains are installed.



Drainage comes in many shapes and sizes. This is because there are many different areas that need to be drained.

Think about the land around Blenheim. Does this need to be drained? Why/why not?

IF it does need to be drained, what form would be best and why.

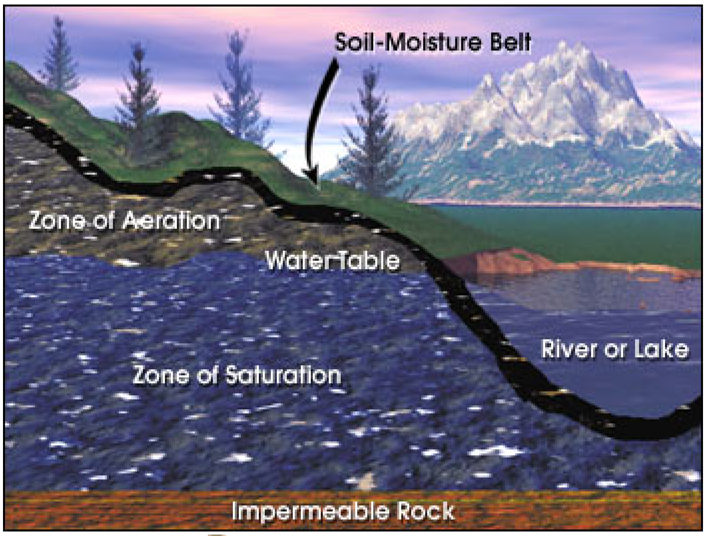
Putting it together

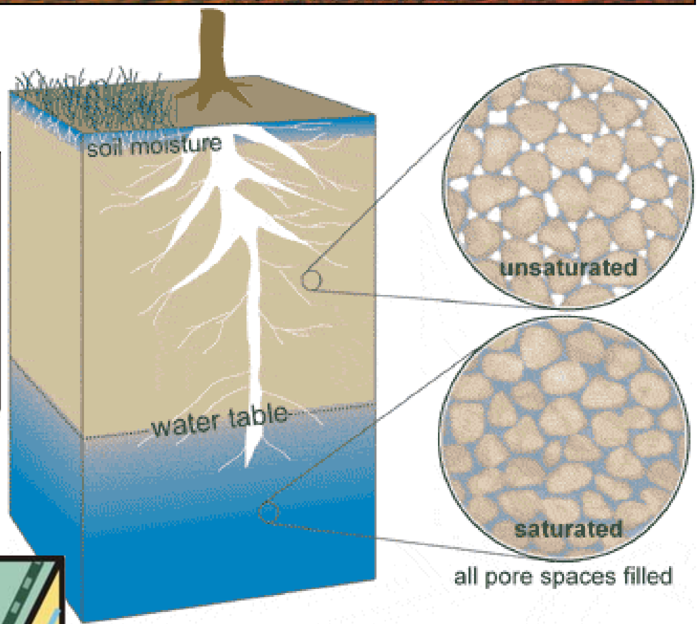
Plants have a requirement for a certain amount of water and air in the soil. The ideal amount is 25% water and 25% air. These numbers are influenced by the texture and structure of the soil, the amount of organic matter present and even more importantly by what the farmer does.

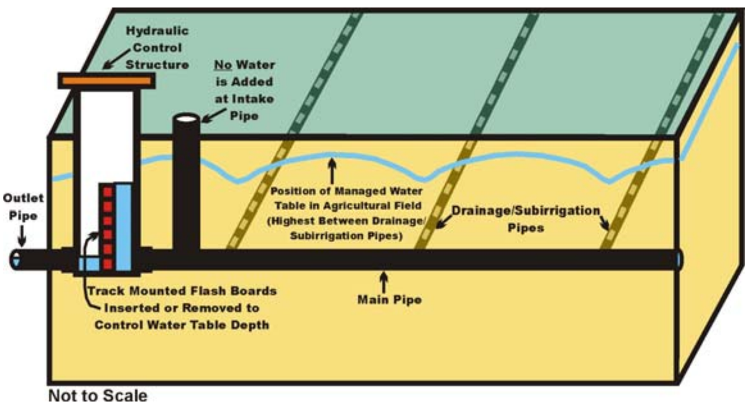
The amount of water/air present can be changed by the management practices carried out. To date we have looked at the 2 most obvious methods for altering the ratio between the soil water and air.

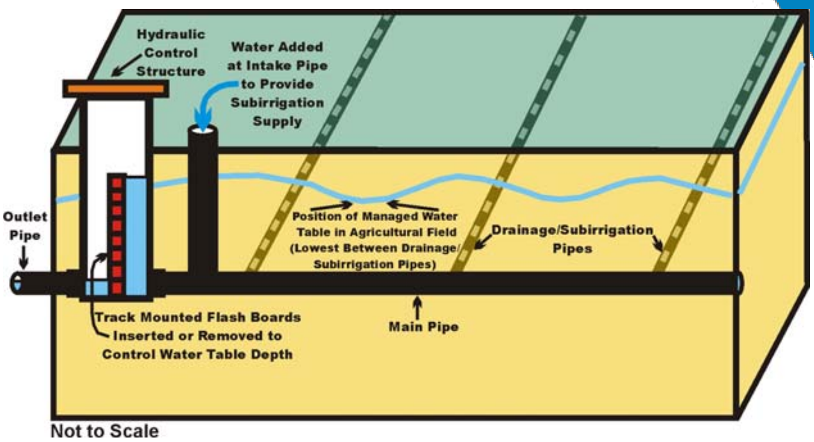
Irrigation increases the amount of water present (and therefore decreases the amount of air); drainage has the opposite effect: less water (more air). Controlling the amount of irrigation water supplied is easier than controlling the amount of water removed via drainage. With drainage the placement of the drains is important in determining the amount of water that can be removed.

If the drains are too far down the soil profile, then too much water can be removed as the water needed to build up above this level is too high. But if the drains are placed well below the water table then they won't work due to there being no where for the water to go.

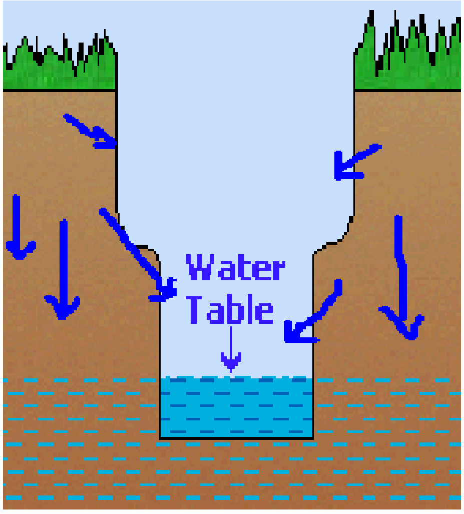




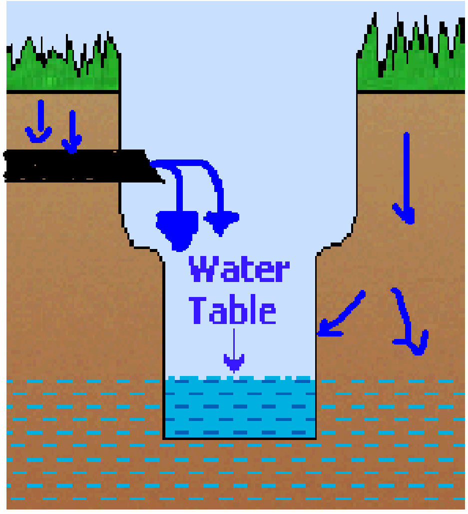




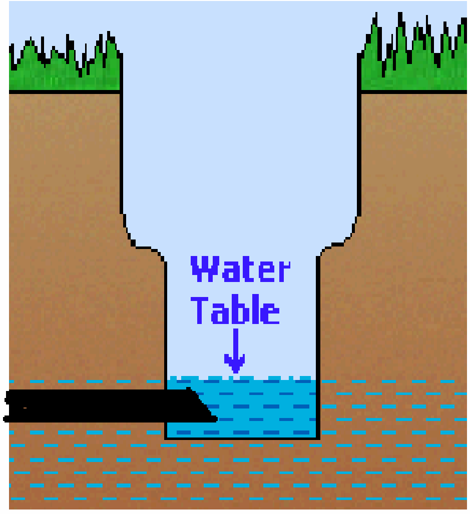
The diagrams to the left show how drainage and irrigation can be controlled using the same system.
In the top picture drainage can be altered by controlling the depth of the water table (in this method it can be raised or lowered, as the water drains into the main pipe it has to be higher than the flash boards to overflow and go out through the outlet pipe). With the irrigation (subsurface), water is added this means that it backflows up the drainage pipes and goes into the soil.



This first diagram shows what happens when there is no artificial drainage: the gravitational water flows down until it reaches the water table (the water can really go any lower as there is usually some form of impermeable layer underneath). We can see the water table in ditches as it shows the height of the water table



The second diagram shows what happens when there is drainage added: the water flows into the drains and then flows into another larger drain (in this case an open ditch) this is quicker than waiting for gravity to have its way. The water above the drain flows into the drain; the water below the drain flows away due to the gravitational pull on the water



The third diagram shows what happens if the drains are placed below the water table: NOTHING. This is because the drains are full of water and there is nowhere for the water to go.

Artificial Mulching

Artificial mulching means to add a mulch to an area. Whereas natural mulching is what happens in nature (bush) when the leaves from a forest are dropped onto the forest floor by the trees and naturally develop into a mulch.

Why do we add mulches?

What are the long term effects of using mulches?

Using mulches:

Mulch is used in the garden for many reasons. It helps the soil retain moisture, provides nutrients, discourages weeds, provides drainage, insulates the soil in winter and cools it in summer, provides food for soil creatures and improves soil structure

Artificial mulches aid in water retention. This is because they work like sponges and hold onto water (think about the effects OM has on a soil). They also prevent water from the soil below evaporating into the air on hot sunny days.
Mulches can be organic (bark, pea straw etc) or inorganic (sand, stones).
In ornamental garden areas, mulches can aid in weed control as the weeds become smothered by the mulch above them.
Mulches can also be a feature of the garden and can serve to improve the looks of bare soil.

A well-mulched garden can yield 50 percent more than an unmulched garden the same size. Space rows closer as there is little or no need to cultivate the soil. Plant food is more available in cooler soil, and the extra soil moisture increases plant growth and yields. You will harvest more fruit because of less fruit rot. Fruit does not touch the soil, and soil is not splashed up on the fruit. See figure 6. This is true for tomato fruits that rot easily when resting on the soil surface. Potatoes can be mulched heavily as the vines grow. This causes tubers to form in and under the mulch layer. These potatoes are less susceptible to soil rot, easier to harvest and less likely to be bruised during harvest.

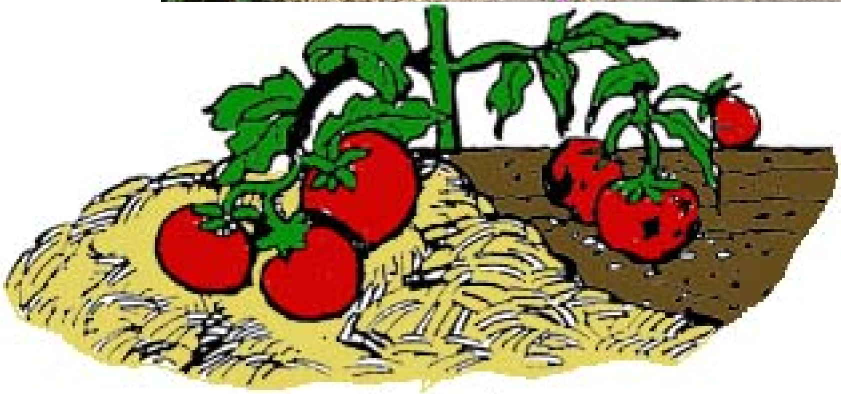


Figure 6

Garden mulching reduces maintenance. A good mulch layer eliminates the need for weeding, and mulched vegetables are cleaner at harvest time. Fruits of tomato, melon and squash plants never touch the soil.

Mulching Materials

Many materials are available for mulching a garden. Some examples are: compost, straw, gin trash and sawdust.

- **Compost** is generally the best mulching material for the home garden. It is usually free of weed seeds and is inexpensive. Prepare compost from materials present in your yard. It is not necessary to purchase expensive materials for mulching.
- **Straw** is short lived and coarse textured. More straw is needed for the same effect as compost or lawn clippings. Generally, less of the finer-textured materials is required to provide a 8 cm layer of mulch after settling. compost, however, usually requires only about 10 cm to provide a 8cm mulch layer.
- **Sawdust** is commonly available especially in East Texas. If well managed, it can be a good mulch. It can result in a temporary, but sharp, decrease in soil

nitrogen. Add a small amount of garden fertilizer to the soil after applying sawdust directly to a garden. Even better, add nitrogen to sawdust, then compost it before spreading it on your garden.

Plastic is an effective mulch if used properly. Use black plastic in the spring and early summer to warm the soil. Black plastic keeps light from the soil and prevents weeds from growing. Clear plastic warms the soil, but weeds can grow beneath the plastic. A disadvantage of plastic is that it cannot be turned into the soil at the end of the season. See figure 7.

Figure 7

A thin layer of mulch on the soil surface (especially in sloping gardens) reduces the washing away of soil particles by rushing water. Also, mulches prevent raindrops from splashing on the soil surface. See figure 1.

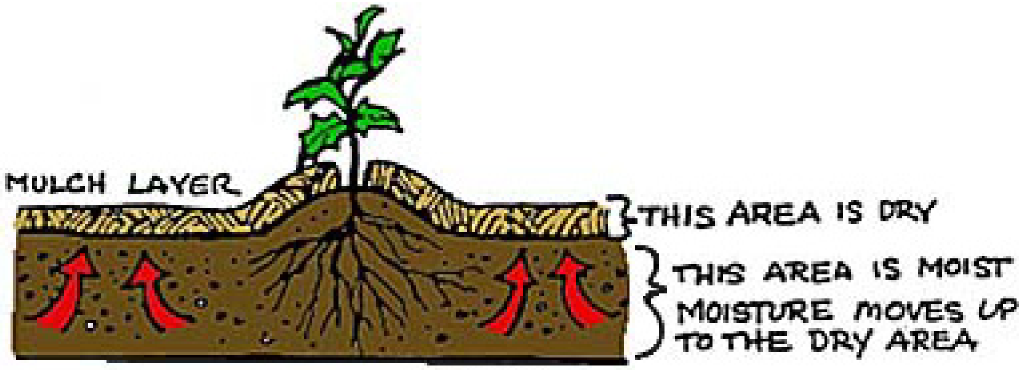


Figure 2

Saving soil moisture is an important use of mulch. A mulch layer on the soil surface allows the soil to soak up more water. Mulch also reduces the rate of water loss from the soil. A 8cm layer of mulch on the soil surface dries much faster than the soil below it. Thus it prevents water from moving into the air. See figure 2.

Figure 1

Cultivation

How can cultivation aid soil water and air?

Cultivation initially tends to aid in the aeration of soil. This is because it breaks up the soil particles and improves the amount of air spaces in a soil.

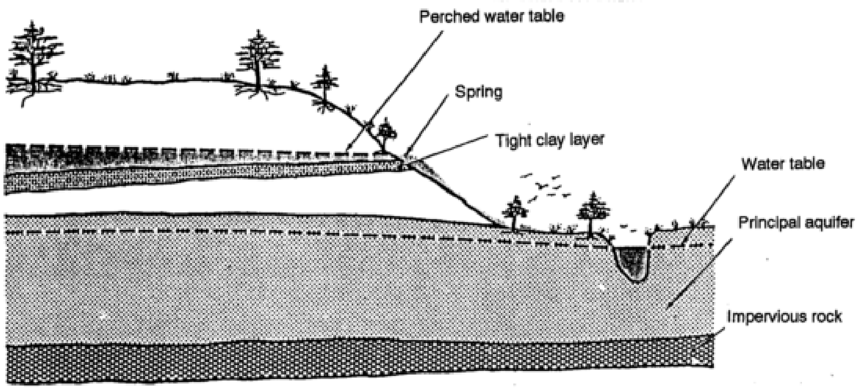


Figure 2-14. Perched water table

The down side to this is that soil structures can be destroyed by cultivation. Thus the aeration is decreased and the water found in the spaces increases. The size of the pores decreases and the soil can develop a clay pan below the cultivation depth. Above a clay pan, a perched water table can develop, this means that the soil is unable to drain and the plants become water logged.

Minimum Tillage

Minimum tillage is sometimes also known as “direct drilling”.
In other words, the soil is not dug up, but planted directly as is. A special direct drill is used to place the seeds at the required depth without ploughing up the paddock. This means that minimal damage is done to the soil structure as it is left alone. Minimum tillage retains the current soil water ratio, it doesn’t necessarily improve them, but it doesn’t make them worse, and in drought prone areas it reduces water loss to the environment by keeping the water below the surface, less exposed.. Minimum tillage also reduces the incidence of soil erosion as the soil is left with a certain amount of cover from the last crop. Previous crops and weeds are often controlled using herbicides, this means that in the long run there will be more OM in the soil, especially in the top soil layers. Over time this will cause an increase in the micro-organisms and worms present in the soil. The organisms will ensure that the OM is spread throughout the top soil (and possibly lower). With an increase in OM present in the soil comes an increase in the water availability and improved soil structure. This means that over many years of minimum tillage there will be an improvement in water retention and water holding capacity. But there won’t be a drop in the air spaces due to the fact that OM in a soil improves the pore spaces as well as holding onto the water.

The diagram to the left shows the sharp edge that cuts into the soil. A seed is placed at the right depth and wheels/rollers press the 2 sides back together.

Tasks:

Read the supplied information on cultivation, direct drilling and minimum tillage. In the space below write about how each method is useful or improves the soil water/air ratio and then write about how each method is not useful or destroys the soil water/air ratio.

Think about which method you think would be best in NZ (or Blenheim) for our soils and the types of crops we grow. JUSTIFY your choice. (look back over all the work we have done not just the 3 above for this answer)

optimising production

Optimising production is not as easy as it sounds.
The timing of fertiliser application, water (irrigation), how much drainage is necessary, planting (sowing), cultivation, addition of OM etc all need to be taken into consideration.

When do we sow seeds?
Usually in the spring (or in some cases in autumn). This is because the soil is warming up, and there is usually plenty of water available due to the spring rains.
Seeds need: water, warmth and air to germinate. These are all provided for by the soils. If any one is lacking, then germination will be delayed or prevented.
How can we improve the chances of germination?
Wait until the soil starts to warm up (after frosts have finished), air spaces help improve the soil temperature as air heats up quicker than water; ensure that the soil air ratio is correct for the seeds to have maximum water and air. If water is lacking irrigation may be an option. If there is too much water then drainage may be an option. Think about the other choices that are available to farmers to improve the soil air water ratio. Which ones may also improve the chances of germination? How?

The better the germination rate the better the chances of a successful and fruitful crop. Germination relates to quantity of plants.

To work on the optimum quality and quantity then we need to consider the air water requirements of the plants as they are growing and the timing of water application.
Do plants need more water and air as they grow? Simply yes.
This is because they become bigger and so need more of both. The timing of the water needed can become important. Plants have different needs at different stages of growth, this means that the amount of water needed changes at each stage.
For optimum quality and quantity of fruit (seeds etc) we need to take into consideration the requirements at these stages. Many plant books tell farmers when they need to ensure the water requirements are being met.

Task: choose a crop (e.g. wheat, tomatoes, lettuces, oranges etc)
Find out the growing requirements and amount of water needed for that crop.
Which method is best for optimising water requirements for the plants. Justify your choice.