Biointensive Farming Training Manual

Joshua Machinga
Common Ground Program
P. O. Box 2487- 30200 Kitale, Kenya
254-726-016-353

Global Corps Service
Arusha, Tanzania
May/June 2007

Introduction

People have been growing crops using methods employed over many generations. However, although these methods are valuable, increasing demand for food in our countries require adaptation of improved methods. This increase in demand is due to several factors, including an increase in the human population which means less water and less land for each person; the changing global weather patterns, resulting in irregular rainfall and more frequent droughts; and an increased rate of diseases such as HIV/AIDS, malaria, and TB, which make it more difficult for people to work hard, walk long distances to fetch water, or to cultivate land.

What's wrong with chemicals?

1. Chemicals are expensive to make. They use up a lot of the earth's resources, such as fuel.
2. Chemical fertilizers do not feed the soil; they provide a treatment like "medicine" for the plants or animals so that it can survive in poor soils.
3. Chemical can be toxic to humans, especially children, the elderly, and those who have reduced immune systems, such as with HIV infection.
4. Special training is needed on how to handle chemicals without getting positioned or burnt.
5. Chemicals can poison the environment, especially our water sources and soil.

6. Chemicals can kill beneficial insects, worms, and microorganisms either directly or by the effects the chemical have on their environment.
7. Insects and diseases can develop resistance to chemicals.
8. There are better options for designing our agricultural systems and homes, so there is no need for these chemicals in the first place!

What is Biointensive Agriculture?

Biointensive farming is a self-help food raising method based on building and maintaining soil fertility and using NO chemicals. It is simple to learn and use, based on sophisticated principles dating back 4000 years in China, 2000 years in Greece, and 300 years in Europe. It was synthesized and brought to the U.S. by the English master horticulturist, Alan Chadwick, then further developed and documented by Ecology Action.
Important aspects of the method include:

1. ☐Double-dug, raised beds
2. ☐Composting
3. ☐Intensive planting
4. ☐Carbon farming
5. ☐Calorie farming

The use of open–pollinated seeds
The whole gardening method
Chemicals are generally promoted when the soil is degraded, or the plants, trees, or animals are unhealthy. The biointensive farming model aims at restoring soil health and designing an environment that creates healthy plants, trees and animals. Biointensive training provides specific ideas on reducing and eventually eliminating the use of chemicals fertilizers, pesticides, herbicides, fungicides, and the like. It addresses the healing process of the soil's fertility and structure to put nutrients back into the soil and the give the soil the ability manage different levels of water.

Chapter 1
About Double Dug Beds

Double-digging has been practiced by at least two main groups of people, the French market gardeners of Paris and some groups in China. In both cases it was developed as a result of lack of space due to high population densities with little available land. Both groups developed double digging as a way to increase their yield from a small area. This intensive farming method has been received in the United
States of America during recent years, most notably at the University of California at Santa Cruz and with an organization, Ecology Action, founded by John Jeavons. Double-digging is also currently practiced by many individual home gardeners.

We often see in conventional gardening situations that people grow their plants in rows and walk around them to cultivate, weed, harvest, etc. The soil is being continuously compacted right on to the roots of the growing plants. It is easy to see that it is a waste of energy to dig the soil, aerate the soil, and then undo your work by walking among the plants. Each year you must re-dig, working against the compaction you have created during the previous growing season. In the Biointensive method you have a permanently raised bed and a permanent path to walk on in the growing area. In this way we maintain the aeration of the bed. This is a major reason that working with permanently raised beds will become, with time, much easier to work with than conventional digging and gardening methods. The other major improvement is the addition of organic matter to the soil. It may take 8 hours or so to double dig a bed the first time, but in later years it can take only 20 minutes to dig the same bed.

The purpose and benefit of double digging is the aeration of the soil. When you dig, whether it is using conventional or double-digging methods, you are bringing air into the soil. Aeration is the major reason that we

practice digging. Often with conventional digging or tillage methods, you get a layer of loosened surface soil and then a hardpan, or hard compacted, layer of soil underneath which receives no air.
Double-digging aerates the soil 2-3 times the depth of conventional digging methods. It eliminates any hardpan in the soil to aerate the subsoil.

In double digging we are fighting against the compaction of the soil. Compaction is caused by heavy machinery, heavy rains and irrigation, walking on the soil or anything that puts weight on the soil. Soil compaction is detrimental to the plant growth. Soil compaction is a reduction of the amount of air in the soil. Air is necessary in the soil for plant respiration. Plants breathe as animals do. Both the roots and leaves of the plant are breathing. In heavily compacted soils especially wet areas, roots can fail to get enough air. Plant roots will suffocate and their growth will slow or stop. Compacted soil creates a physical resistance to root growth; plants roots have to push harder to grow. This physical resistance is lessened when we aerate the soil; roots are able to grow fully and easily. In addition to plant roots being dependent upon air, a good portion of the soil microbial life is dependent on air. They are aerobic organisms. This soil life is largely responsible for the texturing, structuring and cycling of nutrients in the soil. One cannot have good soil without some kind of microbial life.

Deep cultivation allows plants' roots to strive deeply for water and nutrients; they do not encounter a compacted subsoil or hardpan layer. With compacted subsoil roots grow downward, hit this area and then grow laterally from there. Each plant needs more lateral space in which to gather nutrients and water. With double digging plant roots strive downwards and take up less space laterally. Therefore plants can be spaced closer together. This is a key to the bio-intensive method; close plant spacing means more produce from less area.

Water retention, absorption and conservation are important benefits of the deeply aerated soil. Plants are spaced closely so that leaves should just touch another at maturity. The plants will shade the raised bed and keep it cooler helping to conserve moisture in the bed during the dry season. We can call this living mulch. Water penetration is improved because of the greater amount of pore space and looseness of the double dug bed. As you irrigate or as the rain falls, water soaks easily and quickly into the soil. The deeply aerated soil acts as a sponge, absorbing water quickly. This is important for a variety of reasons. It allows a better use of rainfall. On more compacted soils, there is less water absorption capacity of the soil, so in heavy rains especially, water begins to run off and is wasted for agricultural purposes. The deep dug bed will make a better use of rainfall, establishing a greater reserve of water for drier periods.
Finally soil erosion becomes less of a problem as there is less water run-off and not as much valuable topsoil carried within it.

LAND PREPARATION

Preparing a lazy bed by double digging

The key to a productive, healthy garden is the preparation of the growing beds. A well-prepared bed with loose soil to a depth of 24 inches allows the roots of the plants to grow evenly and to provide a steady supply of nutrients to the rest of the plant. Water is able to move through the soil freely, and weeds are easy to pull out. The plant roots have so much loose soil to grow into that more plants grow in an even area, and this means more food from a smaller garden.

The goal of double digging is to produce a "living sponge-cake" in the soil, to a depth of 24 inches, with 50% pore space for air and water – optimally half of the pore space for each. (The other 50% of the soil is mineral matter, including rock fragments, and a small amount of organic matter). In a new garden, the sponge-cake may turn out to be only 15 or 18 inches, deep, but the microorganisms, the worms, the plant roots and water will usually cause it to become a little deeper each year.
So we see that double digging is a method of growing vegetables more intensively meaning more crop yield from a smaller space. Growing in this way we can get 4 -6 times the yield we get from growing vegetables through more conventional methods. This method is labor intensive rather than relying on mechanized animal labor. It primarily relies on human labor.

The double dug bed requires a high input of labor. Digging one bed can take up to 8 hours. We are creating however, a permanently improved soil. With proper care the labor requirements of the double dug bed becomes less and less through time. The initial digging is really the hardest part, from there on it is easier to maintain. This is due to the improved structure and texture of the soil that double digging brings about. Healthier and more abundant crops result from this improvement of the soil. At this point we find that double dug beds are most appropriate for the cultivation of vegetable crops. Such as sukuma wiki, onions, tomatoes, cabbage, greens etc. it s feasible to grow space inefficient grains in great quantities bio-intensively. One cannot double dig two acres for maize for instance.

STARTING A NEW BED

Tools:
Hoe
Plank for standing (roughly 6ft or 2m)
Measuring string
Good wooden stakes of approximately 75cm

The best time to double dig is in the spring, just when seedlings are ready to be transplanted into the bed. Seedlings grow best in a newly loosened soil. If you are starting a new bed, it is also possible to single dig (loosen the soil 12 inches deep with a fork) and sow compost crops. Then in the spring, the double digging will be that much easier.

The area to be selected is most important as it will be a permanent gardening area. A raised bed should not be so wide that the middle cant be reached from both sides. Paths should be as narrow as is comfortably possible so that the growing space is maximized. The bed length can be whatever desired however if they are too long you can spend a lot of energy walking around the beds. A reasonably sized bed can be 6x1+ ½ meters with a 45cm wide path. This is roughly the same as 100 square feet. This is a convenient area for calculating fertilizer applications and crop yields.

Before starting a new bed, put in stakes to mark each corner and connect them with a string. Depending on the condition of your soil, you may also need to do one or more of the following things in the order indicated.

1. Clean area before digging. This material can be used to make a compost pile.
2. Measure beds. Place a stake at each corner. Set up a line to trace the edges of the bed to be dug.
3. If the soil is dry and hard, water it well; thoroughly soak the bed to depth of 2 feet or 65 cm. If water is not available, waiting for the rain is advisable or one can try dry digging after the bed is soaked. It's best to wait until the soil is a proper moisture for digging two days after watering. The soil should not be sticky and muddy nor should it be so dry that it won't form a ball when squeezed in the hand.
4. Loosen the soil 12 inches deep with a spading fork.
5. Remove any grass and weeds, including their roots. These can go into the compost pile.
6. Water lightly for a day or two (5 minutes or so per 100 square feet), or even longer if the clods are particularly large.
7. Let the soil rest for 1 day
8. Spread a layer of compost or manure on the area to be dug 1-3 in or 2-8cm, depending on how fertile the soil is.

The process of double digging

Stand on a digging board so that your weight is distributed evenly and does not re-compact the soil.

1. Across the narrow end of the bed, dig a trench 1 foot wide and 1 foot deep with a spade. Put the soil into buckets or a wheelbarrow or pile it on the ground. It can then be put in a bin to use for making compost and flat soil, or it can go back into the bed after double digging is completed to fill the last trench. The last trench will not really need this soil because of the increased volume of aerated soil in

the bed, while soil that is used in making compost will be returned to the bed as part of the cured compost.

2. Loosen the sol in this trench an additional 12 inches with a spading fork**.** Dig the fork onto its full depth (or as deeply as possible) and push the handle downward so the fork tines lever through the soil, loosening and aerating it. If the fork will not go through easily, pull it out a little and then push down. You should go only as eep as the tool will loosen easily. The next time you double dig that bed, you will be able to go a little deeper. If the soil in the lower trench is dry, water the loosened soil well before continuing. It is easier to get water down into the lower 12 inches of soil at this point that is after the bed preparation has been completed.

3. Dig out the upper part of the second trench 1 foot deep and 1 foot wide with the spade. Dig the spade in to its full depth (or as deeply as possible), lift the soil out on the loosened, aerated soil into the upper part of the first trench. Try to mix the soil layers – the less their living quarters are disturbed when the bed is dug, the more ready they will be to get on with their business of providing nutrients to the newly planted seedlings. Move each spade full of soil forward in the same way until you have dug across the entire trench.

4. Loosen the lower 12 inches of soil in the second trench with the fork.

5. Continue in this way with the third trench and as many more trenches as you need to finish the bed.

6. After the third or fourth trench (and every 3 to 4 trenches after that), rake the accumulated soil forward and level the double dug portion of the bed. There will be less soil to move round when you reach the end of the bed and have less energy to move it! (You will not need the soil from the first trench to fill in the last trench, if you are using that soil for compost and flat mix).

7. When you have loosened the lower part of the last trench, rake the whole bed level. (Add the soil from the first trench, if you are not using it for other purposes).

8. Spread a 1-inch layer of cured compost over the surface of the bed.

9. Sift it into the top 2-inches with a spading fork. It is a good idea to put compost on your bed and plant your seedlings as soon as possible after double digging. If you cannot transplant your seedlings immediately, cover the double-dug bed with a shade net and keep the soil evenly moist to keep microorganisms alive. Put the compost on the bed just before transplanting.

TIPS

Avoid Recompacting the soil

Once the bed has been dug, try not to walk on it. One of the reasons for double digging is to put air in the soil. Walking on the bed will re-compact the soil. When planting the seedlings in the bed, using a digging board will allow you to distribute your weight over a wider area and minimize compaction.

Compaction destroys the structure of the soil**.** You have very little control over the texture of your soil it is either sandy or clay like or something in between. But there are several things you can do to improve the structure of your soil. One of them is aerating the soil by double digging. Another is adding organic matter to the soil in form of compost.

Do it by hand

Some people prefer to let a machine do their digging for them but your garden soil will not benefit from rototilling. A rototiller destroys the earthworms and other soil creatures that help make your soil fertile. It also

compacts the subsoil and destroys the soils structure. Dr. Robert Parnes, author of *Soil Fertility,* notes that if we are to be sensitive to soil processes, we should avoid rototillers.

How long should it take?

An expert can double dig an established bed in 1-2 hours but the first time you double dig, it may take you the whole dayto prepare a 100 square foot bed, especially if the soil has never been double dug before. As you become familiar with what double digging is all about, and as your garden gets more used to being double dug, it will gradually take less and less time and effort to dig a bed. The important thing is to take your time and learn to do it well. Increased speed will come from experience and skill – not from rushing which will only tire you out.

Take care of your back!

When double-digging is properly done, your whole body weight does most of the work, with a little help from your knees and arms. If you feel excessive pressure on your back, you should stop and think about how to put less pressure on it. Use your body weight to push the spade and the fork into the soil. Be sure to place your foot on the spade or the fork so that it is under your arch just in front of your heel. Your body weight is used more efficiently that way. Lift the spade only as high as you need to and let the soil slide off on its own as you tip the spade. When loosening the soil in the lower trench, use your body weight, rather than your leg and arm muscles, to push the fork through the soil.

If double digging really seems like it will be too much for you, try to have a friend or neighbor do it for you. You might also consider single digging and using much wider spacing for the plants.

There are a number of shapes to make your bed:

1. Flat top with sloping edges.
2. Rounded bed without any abrupt edges.
3. Flat bed with a raised lip around the edge. This is highly recommended for dry conditions. It will catch rain most effectively and make irrigation easier.

A DOUBLE DUG BED = A LAZY BED

When some people hear the term double digging, they groan: “it’s too hard.” “It takes too much time.” “It’s too much work.” “It isn’t worth it.” when other people hear double digging, they smile. They think of it as exercise, rather than work. They know that a double dug bed really is a lazy bed, because they can get a good yield in a much smaller area with less digging overall. They like the fact that double digging keeps them in touch with the soil in their garden. They know lazy beds are fun!

TERMS USED

- Extensive agriculture-agriculture requiring a large area to produce a crop (e.g., maize, wheat, etc.)
- Intensive agriculture-agriculture requiring a smaller area to produce the same amount of crop. For example home gardener, raised beds, rice paddies of South East Asia.
- Aerate-to supply with air. We see the importance if this with composting, soil preparation, growing in containers.
- Compaction-to pack together, to make denser. In the compaction of soil we reduce the pore spaces and aeration.
- Hardpan-a harder layer of compacted soil that may lie anywhere from 6 inches to 2 ft below the soil surface. A hardpan makes it difficult for plant roots and water to penetrate downwards.
- Respiration-the process of breathing. Soil aeration affects plants ability to respire.
- Mulch-a layer of material placed on the soil to consume moisture and hold down weeds. Living mulch applies to plants themselves shading, protecting, and holding down weeds in the bed.

- Absorption-the process of absorbing. We say that the absorption of water into a double dug bed is better than that of a road.

Chapter 2
Compost Making

For people who are used to depending on the supermarket for food, it is easy to forget that what we eat depends entirely on fertile soil, Sir Albert Howard, a pioneer of the organic agriculture movement, considered that the fertility of the soil determines the future of civilization. The North African desert for example, used to be the grain growing area for Rome—until it was strip mined of nutrients by improper farming practices.
Nature manages the fertility other soil quite effectively with her natural cycles of life and death, growth and decay. Plants and animals live and grow their leaves, roots and residues enriching the soil of their environment. When they die, moist soil decomposes their bodies and transforms them into organic matter that replenishes and promotes new life and growth. Nature is an expert at recycling all of her wastes -- "living" recycling – so that organic materials, major minerals and trace minerals are continually being returned to the soil to nourish new growth.

THE BENEFITS OF COMPOST

□□ Improved structure: It breaks up clay and clods and binds together sandy soils. It helps proper aeration clay like and sandy soil possible.

□□ Moisture retention: It holds 6 times its own weight in water. A soil with good organic matter content soaks up rain like a sponge and regulates the supply to plants. A soil stripped of organic matter resist water penetration, thus leading to crusting, erosion and flooding.

□□ Aeration: Plants can obtain 96% of these nutrients they need from air, water, and the sun (through the process of photosynthesis). A loose, health soil assist in diffusing air and moisture into the soil and exchanging nutrients.

□□ Fertilization: Compost is much better for the soil than chemical fertilizers, which do not add organic matter and some of which can leach out of the soil if the plants do not use them immediately. Compost contains both macro and micro nutrients, which are essential to plant growth as opposed to chemical fertilizers, which only contains specific soil nutrients such as DAP or CAN.

□□ Nitrogen Storage: the compost pile is a storehouse for nitrogen. Because its is tied in a compost break down process, water soluble nitrogen does not leach out or oxidize into the air a period of 3-6 months or more depending how the pile is constructed and maintained.

□□ pH buffer: A good percentage of compost in the soil allows plants to grow better in less than optimal pH situation.

□□ Soil toxin neutralizer: Important recent studies shows that plants grown in organically composted soils take up less lead, heavy materials and other urban pollutants.

□□ Nutrient release: Organic acids dissolve soil minerals and make them available to plants. As the organic matter decomposes it releases nutrients for plants uptake and for the soil microbial population.

□□ Food for microbial life: Good compost creates health conditions for soil organisms. Compost harbors earthworms and beneficial fungi that fight nematodes and other soil pest.
□□ Ultimate in recycling: The earth provides us with food, clothing and shelter. And we also close the cycle in offering fertility, health, and life through composting. The pile recycles garden debris, leaves, and kitchen waste into food for the soil.

THE DECOMPOSITION PROCESS

The decomposition process that goes on in the compost pile is carried out by a succession of microscopic organisms including bacteria and fungi, and larger organisms, including earthworms. Providing ideal conditions for these organisms is what makes a good compost pile.

The compost pile needs:

Air – Beneficial bacteria need air to breathe, so compost materials should be piled up loosely, but not too loosely – too much air is not good, either.

Moisture – Soil organisms need enough water to keep them alive, but not too much – you do not want to drown them! The pile should be wet, but not too wet – like a well-wrung-out sponge.

A variety of materials – The greater the variety of materials in a pile, the greater the variety of microbial life, and therefore the higher the quality of the compost and soil. In addition, greater microbial diversity reduces the likelihood of plant diseases.

Warmth – Microorganisms are most active during the warmer months of the year when the rate of decomposition is greater. It is important to build compost any time you have materials, however, even when the weather is cooler and decomposition is slower.

As the decomposition process begins, the activity of the microorganisms will cause the pile to heat up. Some microorganisms will die and others will take over, continuing the process. Eventually, the soil organisms will change the original organic materials into a more stable form of organic matter called humus. Humus is a living fertilizer, alive with microorganisms consuming other microorganisms that have broken down, recombined and transformed the original organic matter. The nutrients in the humus are easily available to the pants in a slow, natural, continual process. What wonderful gardens there will be when we all develop a better sense of humus.

MATERIALS FOR A COMPOST PILE

The compost pile needs three kinds of materials:

1. Dry vegetation—Dry grass and weeds, leaves, straw, hay, dry compost crops, including some woody materials, such as broken-up corn stalks. Dry material provides carbon that is the energy source for all life forms.
2. Green vegetation – fresh weeds, green grass, kitchen wastes including a small amount of bones (but not meat – you do not need dogs and raccoons digging through your compost pile – or large amounts of oil), green compost crops. Green material provides nitrogen that enables the microorganisms to develop their bodies which are necessary to digest their carbon energy source.
3. Soil – good bed soil with valuable microorganisms to start the decomposition process. The soil will keep down flies and odors help the pile to hold water, and therefore allow the pile to decompose more slowly, which will ensure an easier-to-maintain compost pile. Some people like to keep their compost under control in a bin and a few uses a drum or an enclosure of some kind. This is not necessary, but if you prefer to use some sort of container, make sure the compost has enough air to breathe, so that the correct kind of decomposition can take place.

The following materials should not be included in the compost pile:

□□ Plants infected with disease or a severe insect attack, where eggs could be preserved or where the insect themselves could survive in spite the heat from the compost.

□□ Poisonous plants such as hemlock, which harm the soil.

☐☐ Plants that take too long break down such as the leaves grevillea robust

☐☐ Plants that have toxic to other plants and microbial life such as eucalyptus, cypress and whistling pine

☐☐ Plants that may be too acidic or contain substances that interfere the decomposing process such as pine needles, which are extremely acidic and contain a form of kerosene (however, especially compost pile are often made of acid materials, such as pine needles and leaves. This compost will lower the soils' pH and stimulate acid loving plants like strawberries.)

☐☐ Cat and dog manures which can contain pathogens harmful to infants. These pathogens are not always killed in the heat of the compost pile.

BUILDING A COMPOST PILE

When building your pile think about the layers that make up a dinner casserole like lasagna.

1. With a spading fork, loosen the soil 12 inches deep where you will build your pile. This area should be at least 3 feet square (4 feet or 5 feet would be even better if you have enough mass to ensure good decomposition), so that the pile will have enough mass to ensure good decomposition. Loosening the soil helps to provide good drainage and aeration. Remember to leave enough space to turn the partially decomposed pile

2. Put down a 3 inch layer of rough materials which can help aerate the pile: twigs, small branches, corn or sunflower stalks, cane berry or rosebush prunings, and so on.

3. Make your compost "lasagna" layers, watering each layer as you go:
    a. A 2″ layer of dry materials.
    b. A 2 layer of green materials.
    c. A layer of soil which lightly covers the materials, or about ½ of a 5-gallon bucket for a 3-foot by 3-foot compost pile.

4. Continue to add layers until your pile is about 3-feet high. If your pile is bigger at the base, you can pile the materials 4-feet high or more (but watch that the top of the pile does not start to slide). You can use a pitchfork to pull out the sides of the pile as you add layers, to keep the pile square.

5. Cover the top of the pile with extra soil, to maintain the moisture in the pile. A light layer of straw on top of the soil during the rainy season will keep out excess moisture and will prevent the pile from becoming soggy.

6. Water the pile as needed to keep it moist. Check the moisture in the middle of the pile from time to time—it is easy to either underwater or over water the pile.

7. Turn the pile after about 3-6 weeks. The purpose of turning is to bring the drier, less decomposed material on the outside. A good tool to use is a pitchfork, since it is lighter than a spading fork and is shaped to allow easy turning of the material. Start by loosening the soil in an area about one half to two thirds the original area (since the pile has shrunk), and add a layer o rough materials at the bottom. Move the materials from the original pile to the new pile, bringing the drier materials to the inside. Add water as you go, if necessary, to be sure that the turned pile is evenly moist.

8. Let the pile decompose- or "cook", for a total of 3-6 months. The compost is ready to use when:
    a. Most of the original ingredients are unrecognizable.
    b. Its smell is fresh and woodsy like fresh spring water and

c. The material is dark brown or black, soft and crumbly

9. If you are not ready to use the compost when it is cured, spread it out and let it dry. It is important not to let the pile decompose too long, or the materials will turn into topsoil rather than compost and will lose the high quality organic matter that has been so carefully built up.

This recipe may make building compost sound more complicated than it is. The important thing is just to go ahead and build your compost pile as the materials become available, without worrying too much about the details at the beginning. We recommend this low maintenance approach, since it is easy and produces such a good result.

The three most important elements in building compost are:

1. Have enough air in the pile.
2. Use as many different compost materials as you can and
3. Keep the compost moist enough.

As you learn to better understand the compositing process and as you garden produces more and more material for you to use. You will be able to improve your technique.

USING YOUR COMPOST

The best time to put compost in your growing beds is the spring, just before transplanting the seedlings for the growing season. As a general rule, you can spread ½ inch of cured compost over the surface of the bed. This comes to approximately six 5-gallon buckets per 100-square-foot bed. Then work it evenly in to the top 2 inches of the soil, using a one application of compost per 4-month growing season is adequate.

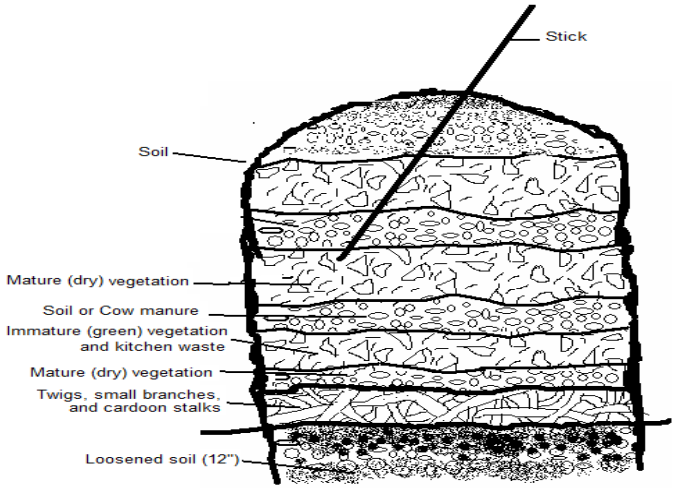

Figure 1: Compost pile- some people prefer to use more soil in their compost, as described in *How To Grow More Vegetables*.
If your compost pile has more soil than the one described here, you may cover the bed with 1inch of cured compost (app 12 five gallon buckets)

Chapter 3
Seed Propagation

SEED COLLECTION & SAVING
(Some important things to know when beginning a seed saving program)

What is a seed?
It is a dormant embryo; a living, resting plant whose life processes is operating very slowly. It maintains internal metabolic activity by consuming small amounts of energy from its endosperm. Within a protective seed coat. It contains all the necessary instructions for the making of a new plant as well as a reserve supply of carbohydrates, fats, proteins, and minerals to nourish the dormant, encased seedling.

Kinds of seeds

1. Dicots-majority of flowering plants. They have two seed leaves or cotyledons which store food for the young germinating plant for example-legumes, brassicas, and Solanums.
2. MONOCOTS-contain only one cotyledon. Food is stored in the endosperm tissue which surrounds the embryo, rather than leaves. For example- Alliums and Graminaceae.

Seed formation

Every flower's purpose in life is to produce seed. Though differing greatly in many respects, each contains the two essential ingredients for manufacturing seed.

Stamen-the "male", pollen bearing part of a plant. Containing a long thin stalk (filament) and pollen sacs (anthers).

Pistil-the "female" organ which receives pollen and nurtures future seeds. It contains a pollen receptive region (stigma) and a long, thin tube (style) leading from the stigma to a cavity (ovary) which contains one or more eggs (ovules). Grains of pollen after landing on the stigma must travel to the ovary. In doing this, they form long tubes of tissues which grow cell by cell down through the style. A growth hormone (auxin) from the pollen causes the ovary to begin to enlarge once it's pollinated, even before actual fertilization occurs. As a pollen tube approaches an egg, its tip bursts open and releases two sperm cells. One of these unites with an egg cell to produce the embryo (also called zygote). The other fuses with polar nuclei and develops into the endosperm. This dual process of sperm cells uniting with female cells is known as fertilization.

Types of pollination

1. **Self pollination-** The flower is capable of pollinating itself with the aid of wind or insects. Pollen rarely travels from plant to plant. They all have COMPLETE flowers. A gardener may easily grow more than one variety at the same time, feeling confident that the next generation will resemble the parents. For extra precaution, simply plant another crop between different varieties of same vegetables. Includes: Solanums, Legumes, Wheat, and Lettuce.

2. **Cross pollination**- The pollen from one flower fertilize another flower, either on the same or on a different plant. Pollen is carried by wind or insects (usually bees). Some cross pollinated plants may be complete flowers yet be SELF-STERILE, thus requiring pollen from other plants for pollination. Insect-rassicas, cucurbits, carrots, onions. Wind-maize, beets, swish chard, spinach.

Many of these vegetables easily cross with other varieties of their family. So caution should be taken if saving seeds from them. Minimal distance is usually recommended to prevent undesired genetic combinations. If required separation is impossible, hand pollination may be applied. This involves caging and isolating plants you want to propagate. Specific techniques will be covered in a lesson later.

Understanding the pollination process of each of the vegetables you raise for seed is necessary for a successful seed saving program. For fertilization to take place, pollen must be of correct kind and it must arrive at the right time, when the plant's parts are well enough developed to enable it to reproduce. Pollen from an unrelated species will be rejected. Some plants will not receive pollen from other plants in their species. Some flowers can discharge pollen before their stigma is ready to receive it while others are simply sterile to their own pollen. Fertilization is fascinating, complex process posing an exciting challenge to anyone interested in seed production.

Why save seeds?
There are many good reasons. Here are a few: economics, security, increased self reliance, production of plants best suited to your climate and conditions, preservation on genetic diversity, gaining knowledge, personal satisfaction and adventure.

Careful selection is the key to a successful seed saving program. It allows you not only to increase the quantity of garden plants but also to improve and refine their quality. Choose the superior plants whose seed will produce another generation with the same desirable characteristics. It is important to observe plants throughout their entire growing season to be able to rate their full performance. Take into consideration the whole plant**.** For example save a seed from a tomato plant with many excellent fruits, not just one, or from African spider flower with vigorous growth and not too quick to set flower. As a general rule, I advise to save seeds from more than one plant in order to maintain a broader genetic base. Most seeds remain viable for several years, so it is necessary to save seed from every variety each season. Take into account those plants which may cross with each other and plan to save seeds from only one variety each season.

Some qualities to consider:
Flavor, yield, color, size, vigor, storage life, disease and insect resistance, drought tolerance, good germination, early bearing (fruits, heads, etc.), late in bolting, quality of seed, texture, juiciness, etc.

PROPAGATION USING SEED FLATS

Why use seed flats?
1. Permits growing crops in succession
2. Protects small seedlings from bad weather and insect attack
3. Gardener ca control soil texture
4. Conserves water
5. Benefits the growth of fibrous rooted vegetables
6. Enables gardener to transplant only the healthiest seedlings

Sowing mix

Just like sowing seeds directly into a garden bed, the growing medium is very critical for the healthy germination of your crop. It does not need to be as rich in nutrients as a bed in which the crop will remain throughout its maturity. Young seedlings simply require a nutritious "breakfast", proper moisture, good drainage, air circulation, and the proper amount of heat and light. A well prepared, fertile flat/seedbed will result in strong, healthy seedlings. The sowing mix is a moist combination of sifted soil, compost/aged manure, and sand. Approximately 1/3 each by weight makes for a fertile, loose-textured mixture.

Preparing flat

Lay down a ¼" layer of leaf mulch or straw on the bottom of the flat. This provides and prevents loss of soil. A fine layer of crushed eggshells may be placed upon the straw for calcium loving plants (i.e. tomatoes, cabbage, and kale). Next fill the flat with the moist soil mixture, tap down, slightly firm down edges, add a bit more oil if necessary, then level flat with a long stick.

Sowing method

Broadcast your seed evenly over the surface of soil in the flat. The size of seed and plant variety will determine the proper spacing. Many herb and flower seeds are very small, requiring careful sowing so that an over-abundance of seedlings doesn't result. With the vegetables that we will be most frequently sowing, the average spacing is ¼- ½″ between each seed. John Jeavons suggests placing seeds at a distance so that seedlings leaves will barely touch when at transplanting stage. Close spacing helps encourage growth by creating a complete mini-climate.

Remember skillful broadcasting takes time to learn. Cover the seeds with the same soil mixture or sifted compost to a depth of ¼- ½ ″. Water gently, going over the flat 2-3 times, being careful not to miss the corners and edges. A simple watering can may be made by placing small, closely-spaced holes in the bottom of a tin, providing and even, gentle flow. The flat should never be allowed to dry out completely. Knowing just how much water germinating seeds and young seedlings need also comes with gardening experience. The proper amount of water is critical. Too much or too little can lead to death or disease (such as damping off). Finally, covering the seed flat with light straw mulch helps retain moisture.

Construction of flats

The common measurements for a flat of a workable size and manageable weight are 3″deep, 14″wide and 19-23″long. The bottom slats should be strong and spaced ¼ ″ apart. Allow for drainage and aeration. The depth is the important factor. If the flat is too shallow, the plants roots will touch the bottom, resulting in slower growth and early, weak maturity. Jeavons calls it "premature senility". To help prevent disease of the soil mixture, flats should be kept clean and dry between different sowings.

Most commonly sown in flats:

- Brassicas (Collards, Kales)
- Alliums (Onions, Leeks)
- Solanums (Tomatoes, Eggplant, Peppers)

NURSERY BED

A nursery bed is well dug and fertilized portion of land, provided with good drainage and protected by shade, made structures. Roofs of grass, mats, polythene, etc. it is used for growing seeds or seedlings of vegetables, fruits, trees, etc. Contrary to a lath house, a nursery bed is a simple structure which takes less time, money and energy to prepare.

Preparation

☐☐ Depending on the amount of land you plan to use to grow your seedlings of either vegetables or fruits, scrape off shrubs, grass and weeds from the area where you want to make a nursery bed.
☐☐ Using sticks tied on a string and using a measuring tape or unit. Measure an area between 4.5-9 square meters (1.5m x 3-6m) or even more.
☐☐ Dig the area well to a depth of not less than a foot deep, thoroughly loosening the soil and removing weeds such as couch grass in the process.
☐☐ Rake or shape the area into a raised bed or beds to limit run-off due to excess rain or force of water at watering and to provide better water infiltration.
☐☐ Fertilize the 9 square meter bed with 3 wheelbarrows of a mixture of sharp river sand and old manure or compost at the rate of one wheelbarrow of manure/compost and 4 spadefuls of sharp river sand.
☐☐ Distribute the mixture at various places in the bed and spread it evenly, then mix it thoroughly into the top 3 inches of the soil. This kind of mixture provides the soil with good drainage and ample nutrients for growing seedlings in the nursery bed.
☐☐ Using a watering can or any other available water implements water the bed and observe the rate of

infiltration. If it sinks uniformly, then your mixture is perfect then your mixture is perfect- if not add half again the amount of mixture of old manure or compost and sand to improve drainage.
□□ Spread the mixture all over the bed and work it into the upper 3□ of the soil thoroughly mixing it with the soil. Then water well and again watch the rate of infiltration. If okay, then go ahead and sow your chosen seeds.
□□ To provide cover or protection of the nursery bed, the following structures or things should be done:
1) At all corners of the bed put strong support sticks measuring 1.2 meters high, ideally forked sticks. Tie the sticks across from each corner to the other.
2) Then tie on smaller supports horizontally and lightly cover the top with grass, banana leaves, Mats, etc. or you can simply cover your nursery bed with some dry grass to provide moistness in the soil. This is okay when your nursery bed is situated near a large tree or someplace with good shade all day long.

Maintaining a nursery bed

□□ Newly planted seeds need adequate moisture, shade and air. Water your seeds at least twice a day for quick germination.
□□ Once seedlings attain two true leaves prick them out to a new spot for better, strong, and healthy growth. (Sow seeds thickly in your nursery bed).
□□ At 4 true leaves, transplant your seedlings into a well prepared shamba.
□□ Transplant seedlings after moistening the seed bed.

TRANSPLANTING

Definition: The transplanting of seedling to a second flat, nursery area, or garden bed in order to provide adequate space and essential nutrients for optimal growth. The challenge facing the gardener is to complete the transplanting process without interrupting the plants growth. The goal is to stimulate growth rather than slow it down. Proper timing, good bed preparation, and careful water application are critical factors affecting successful transplanting.

Transplanting can be done in several stages, small seedlings, particularly those sown using the broadcast method, are often placed in a second flat or nursery bed after they have produced two true leaves or have become overcrowded. Here, provided a slightly more nutritious soil mixture and increased space, the plants grow until the final transplanting. This initial transplant is also known as “pricking out”. By the final transplant, seedlings have 3-5 true leaves and a fairly developed though shallow root system, and are usually 3-5 ˝ tall. The gardener should choose those seedlings which have good root leaf balance**.**
Example: crowded conditions in a seed flat will result in long, spindly, “top heavy” seedlings with shallow, weak, and often interwoven roots. For a plant to undergo a healthy transplant, it roots must be able to provide adequately for top growth.

To help reduce transplant shock:

1. Don’t let the seedlings get too much manure. Studies have shown that smaller plants have a higher survival rate. This is partially due to their limited surface area which reduces water loss. Their smaller roots are also less likely to be damaged.
2. Expose roots to the air for shortest time possible.
3. Carry soils with roots.
4. Minimize handling of seedlings and handle them gently.
5. Harden off” the seedlings by reducing watering and introducing them to slightly harsher environmental conditions several days before transplanting.
6. Place seedlings into a more nutritious, moist flat/garden bed.
7. Transplant in the early evening, or on a cool, cloudy day, and avoid windy, very dry conditions.
8. Provide shade if necessary.

Procedure for transplanting

First transplant: Prepare flat with proper soil mixture, mark out where seedlings will be placed, using a diagonal offset pattern and 2˝ spacing, and then make small holes in which to place the roots. Carefully drop a rowel full of seedlings on the ground or working surface. Their soil mix should be fairly dry, allowing roots to easily separate. Handling the seedlings by their leaves, place them in new flats. Firm in gently and water lightly. Newly transplanted seedlings should remain out of direct sun and strong wind for 2-3 days.

Final transplant: Prepare bed, laying down mulch if desired, and mark the location where seedlings are to be transplanted. The diagonal offset pattern is again used making the most efficient use of bed space and helping create an eventual living-mulch. Dig holes large enough to place seedlings up to their first true leaves. This is done for several reasons:

- As the soil settles with time, the roots will remain covered.
- Members of the cabbage family as well as tomatoes form adventitious roots from their stems; and
- It prevents seedlings from bending over.

Press down firmly, but not too tightly, allowing for aeration, water penetration and nutrient uptake. As soon as possible, give the seedlings a gentle yet thorough watering, enough to settle the soil around the roots, eliminate excess air space, and provide an adequate amount of water for growth. Again, if one can provide the seedlings with some form of sun and wind protection for days, a more successful transplant will result.

When transplanting use diagonal off spacing planting method as shown below:

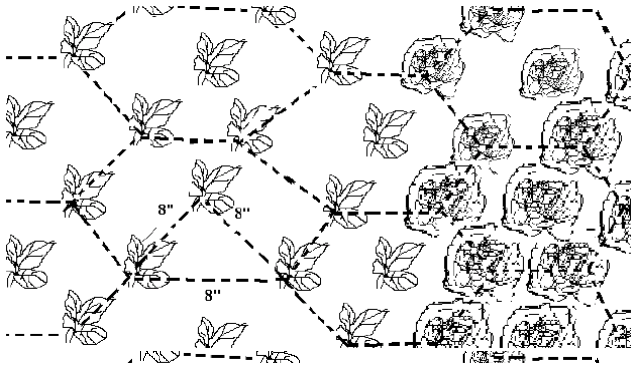

Figure 2: Hexagonal spacing- Leaf lettuce is spaced on 8" centers.

Water necessity

Lack of water is a major cause of death to transplants. What are some of the reasons new transplants can lack water?

1. Simply not enough water.
2. Improper shading; seedling loses water faster than it can absorb it.
3. No protection form wind.
4. Soil ball, with good aeration and drainage, is placed into a garden bed lacking these qualities, resulting in poor absorption of water.

SOIL MIXES FOR PROPAGATION

Healthy plant growth in the first stage is very important. If plants are sickly or undernourished in this stage, they will have a poor growth subsequently. With a soil mix we try to provide the ideal soil environment for young plants.

Soil mixes can be used for either a nursery bed or for use in containers. These containers include seed boxes (flats), pots, cans, plastic bags, etc. There are special problems of aeration and drainage caused by growing in

containers. The walls of the container cause air to be kept out of soil in the pot. Containers are usually constructed with some kind of drainage holes in the bottom to increase aeration. Additionally, a layer of material with good drainage properties is laid on the bottom of the container. Materials commonly used are: small stones, charcoal, partly decayed leaves, compost or dried grass. Materials containing water for instance, fresh green materials, will stop drainage and also produce ammonia that is toxic to the plant.

Qualities of soil mix

Drainage and aeration: Because of the poorly aerated conditions that containers create, the soil mixture must fight to improve these conditions. It must be a material with many pore spaces to maintain aeration. Putting regular garden soil into containers is not ideal. The material with the extra aeration qualities that we want is organic matter.

Moisture holding capacity: It is important that the soil mixture be able to hold on to some moisture. We don't want to use pure sand, because although it has good drainage properties, it would dry out so quickly that it would not be practical to use. We want a material that can hold a balance of water and air in the soil. This will be best for plant growth. The sponge like quality of organic material makes it ideal for this purpose.
A loose and aerated soil mix will reduce physical resistance to root growth and seed germination.

Fine texture: By passing all the material through a sieve, we reduce the physical obstruction of larger clouds of soil and introduce air into it.

Nutrients in the soil mixture: There must be plenty of nutrients in the soil mix. You are growing many plants in a small area; it is a very intensive growing situation. If you do not supply enough nutrients, plant growth will be poor.

Source of nutrients:

- Compost-supplies a balanced amount of nutrients. Sometimes it will not contain enough nitrogen.
- Manure-does not contain all of the nutrients that compost does. It is often high in nitrogen, so a little manure is added to the soil mix to supply nitrogen. Manure must be used when it is old. Otherwise it will burn the plants.
- Lime-used especially if the soil is in an acidic condition. It raises the soil PH (makes it less acidic) and supplies calcium.
- Bone meal-if soil is thought to be poor in phosphorus, bone meal is a source.
- Fish meal-can be used to supply nitrogen if the mix is low in nitrogen.
- Artificial fertilizers-these are quite often used in nursery situations.

Different types of soil mixes

There are different types of soil mixes for different growing situations. The type of mix depends upon the stage of plant growth and how long it will remain in the container.
The three main types of soil mixture are:

1. **Sowing (seed transplanting) mix-**in the Biointensive method, we usually do 2 transplanting. Weplant the seed, move the seedlings to a roughly 5cm spacing, then transplant again to the final growing area. The sowing mix does not need so many nutrients. During early seedling growth, the plant uses nutrients from the soil. We fertilize the sowing mix less. The sowing mix really needs good drainage, moisture holding, and textural qualities.
2. **First transplanting mix-**plants begin to need more nutrients approximately when they get their first leaves. At this time they are transplanted. We make this mix richer in nutrient content.
3. **Potting mix-**often used to grow trees or perennial plants. The plant is being grown in the container for a long period of time, so it requires a lot of nutrients. More manure, compost, fish meal, etc. can be added to help this problem.

Nursery beds do not have the same aeration problems that containers create. So they are easier to work with, 1 wheelbarrow manure or compost and 4 spades sand should be a good mix. Bone meal, fishmeal, lime can also be added if required. This mix should be put on at about 1 or 2 inches, or 2-5 cm covering the surface of the bed. It is then mixed with the top 3 or 4 inches, or 7- 10cm. of the bed. If you mix the material any deeper, it will not be usable to the plant.

Other ingredients

- **Soil-**loam, good garden soil, or topsoil. A fertile topsoil supplies nutrients and good structure. A poor soil can supply little nutrients and cause problems with aeration. To obtain good topsoil you can take a little from a bed each time you dig. Otherwise, you will have to search for good soil elsewhere.
- **Sand-**sand increases drainage. Rivers are often the best source of sand.

How to make the soil mix
Compost, soil and sand are sifted through a ½ cm screen. The materials are then mixed thoroughly on any flat, convenient surface. As you mix the materials, you water to achieve good moisture.

SOWING MIX	**1st TRANSPLANT MIX**
5 parts of soil	5 parts of compost.
4 parts of compost.	4 parts of soil.
1-2 parts of sand	1 part manure (optional)
	Handful bone meal (optional)

Eventually you will be able to make a soil mix without having to count or measure out each ingredient. It is important to be able to see what mix will have good aeration qualities and to supply the necessary amount of nutrients for plant growth.

RECOMMENDED READING

N. Bubel, “The seed starter’s handbook”
Jeavons-How to grow more vegetables…
M. Rogers, “Growing and sowing vegetable seeds”
Seymour-Self Sufficient Gardener.
H. Rickett, “Botany for gardeners”
D. Patent and D. Bilderback, “Garden Secrets”
Hartmann, Kester-Plant Propagation, pp.190-193.
Hartmann, Flocker, Kofranek-Plant Science, pp.417-418.

Chapter 4
Companion Planting

A garden mini-ecosystem is part of a larger ecosystem, interacting with sun, shade, warmth, wind, birds, insects, and animals. Nature’s ecosystem is varied and balanced, with harmonious, beneficial relationships. While our main focus is on growing a healthy soil, an additional goal is to make our garden reflect nature’s diversity. Even weeds have a key role to play.

Companion planting involves choosing which crops to put beside each other for the best results, keeping in mind the garden as a whole.

GOOD NEIGHBORS

Although scientific documentation is scarce, gardeners have observed that some plants do better if they are grown with certain other plants. Since plants roots extend over a much wider area than can be observed with the eye, it is possible that plant roots react to each other underground, stimulating or hindering growth.

Experienced gardeners have noticed that the crops proposed here for your first lazy bed have the following likes and dislikes when it comes to neighbors. The suggested layout of your lazy bed takes these into account.

	Close neighbors	Distant Neighbors
Bush beans	Potatoes, Lettuce, Tomatoes	Onions
Carrots	Leaf lettuce, Onions, Tomatoes	
Corn	Potatoes, Beans, Cucumbers	
Cucumbers	Beans, Corn	Potatoes
Lettuce	Carrots, Cucumbers.	
Onions	Tomatoes, Lettuce	Beans
Potatoes	Beans, Corn. Cucumbers, Tomatoes	
Tomatoes	Onions, Carrots	Potatoes

BENEFICIAL INFLUENCES

Following are some plants that have been found by experience to be good for gardens in general. They are perennial, so they might be planted at the end of the beds where they will not get in the way of double digging. Some are herbs that can be enjoyed for tea or seasoning; others are weeds that we would do well to encourage in our gardens instead of trying to get rid of:

Lemon balm (tea)	Oregano (herb)	Dandelion
Chamomile (tea)	Marjoram (herb)	Stinging nettle
Valerian (root is medical)		

CROP ROTATION

For a number of reasons, it is good not to plant the same crop in the same plot year after year. Different plants take different nutrients, and different quantities of nutrients, out of the soil. Planting the same crop in the same piece in succession creates soil nutrient deficiencies and also encourages insect and diseaseproblems.

Compost helps replenish soil nutrients and planting different crops over time will help to maintain the nutrient balance in the soil. Planting a winter compost crop that includes both grains, with their extensive root systems, and legumes (beans, vetch, clover, and so on, with their nitrogen fixing ability,) will greatly benefit the soil.

SUN/SHADE

It is easy to forget that tiny seedlings that can turn into tall plants such as corn can be put where it will shade a plant that enjoys less sun, like peas or potatoes or cucumbers. Sun-loving tomatoes can provide a cooler mini-climate for onions or parsley. Notice that the potatoes in the lazy bed will be shaded by the corn, and the tomatoes, will shade the onions, if the bed is oriented as indicated. Cool weather crops, like lettuce, carrots, onions, and potatoes, will do well in partial shade in warmer weather.

ATTRACTING “GOOD BUGS”

Bees and butterflies play an important part in the life cycle of plants, so a garden will benefit if it includes their favorite meals. Bees can account for one-third of the United States crop yield through pollination they accomplish. Bees love blue flowers, especially Borage and Rosemary. Butterflies are attracted to purple, red, yellow, and orange flowers and will beautify our garden along with the flowers you plant to attract them. Other beneficial insects are attracted to the flowers of parsley, dill and cilantro/coriander. Try letting a few of those plants go to seed to serve as feeding stations for helpful insects.

KEEPING THE GARDEN HEALTHY

Beginning gardeners are often inclined to worry about getting rid of insects and weeds, but it is much more enjoyable to think of insects and weeds as part of nature’s contribution to a diverse ecosystem. Weeds that compete with the plants we are trying to grow should obviously be taken out and added to the compost pile,

and insects that insist on helping themselves to our garden vegetables need to be related with gently yet firmly. Generally, a garden will benefit from the gardeners focus on health and life rather than on death and disease. A thriving diverse garden with healthy soil will attract beneficial insects that will make themselves useful pollinating, cleaning up rotting debris, and eating harmful insect larvae. In fact, in a balanced mini-ecosystem, for every seven or eight good bugs, there will be only one harmful one. If we get rid of all the bad bugs in our garden, the good bugs have less to eat and have no reason to stay around to help. Insects and disease are most likely to attack sick plants, those that are under stress for some reason.

Making sure the soil has all the nutrients, soil air, soil moisture and cured compost needed by plants we are growing is a much better way to use our energy than looking for ways to get rid of pests. Compost made from a variety of plant materials will encourage a variety of microorganisms in the soil, and they will provide the wide range of nutrients and microorganisms needed for healthy plants. Careful transplanting also helps to promote uninterrupted root growth and encourages vigorous, healthy plants. The right amount of water throughout the plants growing period will also reduce the likelihood of stress.

The basic kinds of insects and how to control them easily

TYPE	**CONTROL METHOD**
Chewing or biting; soft of hard bodied	Aromatic and distasteful sprays such as garlic, onion and pepper spray
Sucking soft bodied	Soap solution sprays (not detergents)
Sucking hard bodied	Hand picking

Garlic/Onion tea insect repellent
(Good against nematodes).
- Mash 10 cloves of garlic or a medium onion.
- Mix with 2 quarts/liters of water.
- Let it sit. Strain.
- Spray without diluting.

“The Bomb” insecticide
- Melt ½ bar of soap (not detergent) in 8 quarts/liters of water.
- Spray.
- For strong pests, add 2 teaspoons of slat and about 30 mashed cayenne peppers.

Chapter 5
Watering

Water is very important for both soil and crops. Water keeps plants turgid and erect. It is a cooling agent and also carries nutrients in solution in the soil. We all know that without water nothing can grow. The retention of soil moisture is affected by:

1. Soil type
2. Structure and texture of soil
3. Climate and air temperature
4. Humidity and wind characteristics
5. Pants themselves

The Biointensive method’s emphasis on building a healthy soil from the beginning should not be overlooked when examining the systems capacity to absorb and retain moisture to the benefit of the plants.

The deep soil preparation and the addition of good compost allow the soil to hold its moisture longer. Compost holds 6 times its weight in water. And the addition of compost to the soil can cut water consumption by as much as 75% per pound of food produced. Other aspects of the Biointensive method further increase water use efficiently. Due to the living mulch of Biointensive spacing, evaporation can be reduced by 13%-63%.

Since a high level of soil fertility is maintained. Transpiration by a plant can be reduced by 10%-75%. We should all know that plants lacking nutrients use more water to try to get the necessary elements. The Biointensive method calls for watering to be done approximately 2 hours before sunset. When water is less subject to evaporation and the water has over half a day to sink down to the root zone before the hot sun appears again. This saves considerable water.

When you water in the afternoon, you allow water to percolate into the soil for the whole night. The availability of moisture is critical, since plants do a significant amount of their growing at night. Immature plants and seedlings in flats may have to be watered in the morning and again in the afternoon if there will be sun the whole day. As the living mulch effect develops due to their leaves growing close together, less water will be required.

When watering a new bed. The shiny layer should stay for 2-3 seconds. On older bed, it will stay for 5-15 seconds. If the shiny layer disappears sooner, continue watering. If the water is not being absorbed well at all, it may be that the bed is so dry, that it is acting like a barrier to the water. Try to wet the soil under the surface to allow water to be absorbed.

It is wise to check the soil moisture before starting to water, to determine at what depth the soil is moist and how much water is needed. A soil can look very dry and be wet just under the surface, or appear damp when it is very dry. Also check how deeply water is going into the soil when you irrigate.

Climate considerations that indicate the amount of watering that will be needed are:

1. Rainfall
    - Amount in millimeters per day
    - Distribution in millimeters per day
    - Intensity in millimeters per day
2. Temperature
    - Monthly
    - Extremes
3. Evaporation in millimeters per day, month or day

POINTS TO REMEMBER WHEN WATERING

1. Watering practices depend largely on the gardens soil type.
2. The different stages of a plants growth require different amounts of moisture.
3. Small seeds-can be washed right off the bed when too much water or pressure is applied. Being near to the soil surface, they dry out easier.
4. Carelessness with watering can or hose can break stems, damage leaves, remove flowers, and bruise fruits. Be gentle.
5. Pay a little attention to a bed’s corners and edges because they tend to dry out easier.
6. Frequent, light watering encourages roots to grow near the soil surface making them prone to drying out and less capable of surviving drought conditions. It also reduces a plants ability to absorb minerals from deep in the soil.
7. Does a plant wilting mean its time to water? Midday wilting on a hot day is a normal process for most plants. They are simply losing water through transpiration quicker than their roots can pull it from the soil, and will usually recover every night. If they are wilting in the morning they should be given water quickly.
8. Salty conditions interfere with a plants ability to absorb water because the mineral competes for available moisture.
9. Be careful of using large amounts of poultry or feedlot manure. Both of these are mixed with urine which has a high salt content. Certain crops are more tolerant of salty conditions. These are **beets, spinach, lettuce, broccoli, and tomatoes.** The salt sensitive crops are **beans, carrots, onions,** and **radishes.**

10. Potassium affects the rate of a plant's water retention by regulating the opening and closing of its stomata. Thus the availability of this major nutrient determines how rapidly photosynthesis takes place.

Results of water stress

1. Slows down photosynthesis, thus reducing amount of food manufactured by a plant
2. Harmful wilting
3. Prevents adequate transport of nutrients

Results of over watering

1. Compaction of soil and possible suffocation of roots
2. Creates environment for damaging off
3. Also prevents proper transport of nutrients, thus interfering with plant growth
4. Leaches nutrients from soil

All of these weaken plants by making them more vulnerable to insect infestation, and less resistant to disease and harsh environmental conditions

DEFINITION OF TERMS

- **Pore Space-** The soil is that portion occupied by air and water. In sandy soil the pore spaces are large, and in clay soils they are numerous and smaller.
- **Texture-** The portion of different sized particles a soil has in it. There are stones, gravel, sand, and silt and clay particles. The water holding capacity of a soil depends largely on its texture. (The amount of sand, silt, and clay in the soil).
- **Structure-** The grouping together of the particles in a soil into larger pieces or granules. The structure has a large influence on the retention and release of water.
- **Organic Matter-** when added to your soil will significantly modify its water holding and drainage capacity, and compost is the best material for this.
- **Capillary Water-** is water held in between soil particles
- **Gravity Water-** percolates through soil under the force of gravity
- **Infiltration –**The rate that water moves into the soil, and is measured in millimeters per hour
- **Field Capacity-** The moisture holding capacity of the soil after gravity water has been removed. Water added beyond field capacity will not be held in the soil's pore spaces. The field capacity of light soils is les than that of heavy soils. Light soils need much light irrigation, and heavy soils can take fewer, heavier watering.
- **Permanent Wilting Point-** The level of moisture at which plants are not able to extract any more water and from which they do not recover but wilt and die. Structure, texture and organic material affect the permanent wilting point.
- **Root Zones-** Determine the frequency and the amount of watering required. Deep rooted plants need heavy, infrequent watering. Shallow rooted plants want light, shallow watering frequently. Plants make most use of water from the upper area of their root zones.
- **Evaporation-** As the plant matures and has larger leaves shading the soil. Transpiration is a larger factor of water loss than evaporation.
- **Hydrologic Cycle-** The movement of water from the earth's surface and back

Chapter 6
Crop Rotation

Changing the type of plant grown in an area each time you plant

ADVANTAGES

- Control of pests and diseases which could otherwise thrive due to continuous planting of the same crop
- Crops such as beans and other legumes add nutrients to the soil. This makes the soil stronger and more fertile. Some vegetables take certain nutrients from the soil while growing, this weakens the soil.

By growing the same crop repeatedly in the same area you cause the soil to be progressively less fertile.

Heavy feeders (weaken the soil)	**Givers** (strengthen the soil)
Maize Lettuce	- almost all types of beans
Cassava Beetroot	- groundnuts / peanuts
Onion Broccoli	- peas
Tomato Carrots	- almost all other legumes
Egg plant etc	

CROP FAMILIES

When you are practicing crop rotation also keep in mind the following crop families as they will help in pest and disease control. The crops in the same family should not be planted in the following season.
The crop families are as follows:

1. **SOLANUMS**
a. Tomatoes.
b. Egg plants.
c. Irish potatoes.
d. Peppers.
e. Solanum nigrum.

2. **LEGUMES.**
a. Common peas.
b. Peas.
c. Ground nuts.
d. Green and black grams.
e. Cowpeas.
f. Soya beans.
g. Lab beans.
h. Winged beans.
i. Other lesser beans.

NOTE: *forage legumes can be covered under animal production as pastures and fodder crops.*

3. **GRAMINACEA.**
a. Maize.
b. Sorghum.
c. Sugar cane.
d. Rice.
e. Oats.
f. Finger millet.
g. Bulrush millet.
h. Wheat.
i. Barley

NOTE: *other grasses can be covered under animal production as pastures and fodder crop section*

4. **CHENOPODIUM.**
a. Spinach (S. Oleracea)
b. Beets (Beta Vulgaris).
c. Swiss chard.

5. **ALLIUMS.**
a. Onion (spring, bunch, bulbs)
b. Leeks.
c. Garlic.
d. Chives.

6. **UMBELLIFERAE (UMBELS OR PARSELY FAMILY)**
a. Carrots.
b. Several herbs
- Coriander- coriandum sativum.
- Parsley- petroselinum srispum.
- Caraway- carum.
- Pimpinella- anise anisum.
- Foeniculum- fennel vulgare.
- Anetum graveoleus- dill

7. **CUCURBITS**
a. Cucurbita-Pumpkin, Squash, Gourds
b. Cucumis melo- Musk melon, Melous, Cantaloupe, Cucumbers and Watermelons
c. Chayote (Sechilim edule

Chapter 7
Insect and Pest Control

Not all insects are bad (weeds are good plants growing in the wrong place and pests are good insects feeding in the wrong place). Without butterflies and bees many flowers would not give seed or fruit. Earth worms help to break down soil, to let air and water through and help bacteria to break down natural rubbish to feed plants.

HOW TO CONTROL INSECTS AND PESTS

- Early every morning check for garden pests and insects like snails, slugs and grasshoppers. Kill them and drop them on the garden beds so the smell will frighten away other pests.
- Some plants, like garlic, marigold flowers and basil, produce a smell not liked by many insects. It is advisable to plant these around the vegetable plots to keep the insects away.
- Garlic spray: chop 2 or 3 whole bulbs of garlic. Add 2 tablespoons of paraffin. Soak for 24 hours. Add a tiny piece of soap and 2.5L of water. Mix thoroughly and strain into a labeled bottle. Keep it until needed. Spray or paint onto the plant with a small brush. It is not advisable to apply this spray a week before harvesting.
- Hot garlic spray: mash two bulbs of garlic and two teaspoons of chili peppers with a tiny piece of soap. Mix with 2 cups of hot water. Keep in a labeled bottle. To use, take ½ cup full and mix with 4 cups of hot water. Sprinkle this over caterpillars and other pests when the mixture is cool.

PROTECTING THE GARDEN

There are various ways to protect your garden from chickens and other animals. These include:

- Children around the house can chase animals away from the garden
- Construct a fence around the garden to keep the predators away. Materials to do this can include sticks, grass, old maize and fertilizer sacks, old fishing nets, etc.
- Plant thorny plants like sisal around the garden

Chapter 8
How to Make Liquid Manure

Liquid manure is good food for your vegetables if the plants look yellow, showing they are short of nitrogen. Use fresh or dry chicken, cattle or goat manure, but never put it directly on the garden as it is too strong and may kill your plants or bring pests to the area.

1. Put one liter of manure in a bucket. Cover with water and leave for 3 days for chicken manure and 6 days for cow or goat manure. Strain the liquid and put the solids on a new compost heap.

2. Dilute the liquid manure with 40 cups of water to one cup of liquid manure. Use this to water seedlings. Dilute with 20 cups of water to one cup of manure to water the soil around more mature growing plants once a week. Do NOT pour it directly on the leaves.

WHAT TO INCLUDE IN YOUR PLANT-BASED WASTE

Use any of these	**Do NOT use any of these**
Kitchen scraps; egg shells, maize, cobs, vegetables and fruit peels	Meat, fish, dairy products, cooked porridge or rice-things that go sour
Leaves, cut grass, thin sticks and twigs	Pine or blue gum leaves, sticks or sawdust
Tom paper or cardboard	Grass
Crushed old bones (no meat or feathers)	Plastic
Old manure (ensure it is OLD)	Aluminum cans
Fresh ash; preferably ash that has not been rained on. DO NOT USE COAL ASH	Manufactured waste
	Coal ash (poisonous)