NATIONAL OPEN UNIVERSITY OF NIGERIA

CRP 401

Crop Production Techniques I

CRP 401 CROP PRODUCTION TECHNIQUE I

Course Writer

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Crop Production Technique I

1.0 Introduction

As an agric student you should by now have covered most related courses in crop prodution. You will however agree with me that most of your experience in the last 2-3 years were either classroom based or resticted to classroom activities.

You need to appreciate the fact that agriculture in general and specifically crop production is not exclusively a book reading business. Effort in this study will increase your knowldge by engaging you in alot of farm activities to transform your knowldge from virtual to real activities.

You are requested to get attached to an environment where active farming activities are going on and be active in participating in all the activities for the period of on practical year**.**

2.0 Objectives

At the end of the practical year, you are expected to have upgraded your knowldge of crop production cultural practices beyong ordinary definations. Other objectives of this study encompasses affording you to physically enterpise with crop species and varieties. You will also have the opportunity of being competent in taking decision on where, to grow, when to grow, what to grow and how to grow crops. You will be prepared to be competent in managing the farm with a sand knowldge of crop production cultural pracices.

3.0 Main Content

3.1Procedure

Enteprice of importance:
Grain legumes (Cowpea, Ground nut and soybean) **leguminous**. adjective. of, relating to, or belonging to the Fabaceae (formerly Leguminosae), a family of flowering **plants** having pods (or legumes) as fruits and root nodules enabling storage of nitrogen-rich material: includes peas, beans, clover, gorse, acacia, and carob.

Cereal crops (Maize, Sorghum and Milet) **Cereal** is any grass cultivated for the edible components of its grain (botanically, a type of fruit **called** a caryopsis), composed of the endosperm, germ, and bran.**Cereal** grains are grown in greater quantities and provide more food energy worldwide than any other type of crop and are therefore staple crops.

Root and Tuber Crops (Yam, Cassava and Potetoes) Root and **Tuber Crops**. Root and **tuber crops** (**Crop**Groups 1 and 2) consist of root **crops**, such as beets and carrots, and **tuber crops**, such as potatoes and sweet potatoes, and the leaves of root **crops**, such as beet tops

Vegetable crops (Pepper, Tomatoes, Onions And Spinach) any plant whose fruit, seeds, roots, tubers, bulbs, stems, leaves, or flower parts are used as food, as the tomato, bean, beet, potato, onion, asparagus, spinach, or cauliflower. 2. the edible part of such a plant, as the tuber of the potato. 3. any member of the **vegetable** kingdom.

Site selection
Now let us look at the points to consider in site selection for farming purpose.

1. Climatic factors
By this, we are referring to rainfall, humidity, wind pressure and direction, temperature etc. These factors must be favourable to the farming enterprise you choose be it crops or animals. Different types of crops do well under a certain range of climatic conditions, likewise certain animals. It is, therefore, relevant to consider the factors that will promote your farming enterprise and avoid those that will not. (Rainfall characteristics, Photo period, Temperature regimes).

2. Socio-economic factors
These factors include infrastructure, population, settlements, market, labour and others. Infrastructure, includes access roads, electricity, water, telecommunication, health facilities, police station, etc. The presence of these makes it suitable to site a venture like a poultry farm. However, proximity to the urban settlement may make it unsuitable. Another example is security and health considerations which will require the presence of health facilities and police presence, respectively. You may need a market close to your farm and available labour. Careful thought and research must be carried to assess the suitability of a farm site in the presence or absence of all or a combination of the socio-economic factors.

3. Edaphic factors
These are related to soil conditions like structure, fertility, texture, porosity, consistency etc. These soil factors determine the suitable farming enterprise be it crops or animals. Lands with clayey soils may be suited for fish farming, with all other factors favourable. Some lands a prone to flooding and/or erosion. These lands, depending on your resources may be managed to set up a profitable farm eg. fish farming. However, with a crop farm like vegetables and tree crops in mind, avoid such areas as it will not favour the crops.

4. Environmental factors
Your farming operations should not have a negative impact on the environment. Some farming activities, when exposed to human or animals, can be harmful. This is usually the case when farms are site close to the urban area. On the other hand, the environment may also have a negative impact on your farm, reducing productivity. Some farms are forced to move or change operation and the urban developments catch up. It is therefore very important to consider this factor in the selection of your site for farming.

5. Government policies
Various government make policies that help them to achieve growth in agriculture. Take advantage of it and set up your farm in a location likely to benefit from the implementation of the policy. For example, the government may decide to cut taxes for farms in a particular area or zone of the country. Also, the government may increase the allocation of subsidised fertilizer and other agro-inputs for certain areas of the countries. You may build a farm in such areas to take advantage of it. You must consider Government policies in your site selection for farming purpose.

6. Biotic factors
This is relating to the presence or absence of some harmful or beneficial organisms. In site selection for farming purposes, you may consider the natural population of certain organisms like bees and other pollinators. and less pest and disease-causing organisms. Where the farming venture involves tree crops, farmlands in forest areas are preferred. However, places with a long history of pests and diseases may be avoided. Also, you should be careful in choosing a site with certain dominant weeds which are difficult to control.

7. Economic factors
If you want your agricultural business to thrive, then this factor is the most important to consider. It includes the cost, benefits and terms of lease or acquisition. You need to carry out a feasibility study of the site to make sure that it will yield enough returns to sustain your farm. This will give you an idea and better understanding, at the time of site selection, the site that will give you the highest returns, taking into consideration all the other factors.

4.0 Summary

The site may determine the suitable farming enterprise and vice versa. Before you reach a decision on the site for your farm or the right enterprise for your site, use all available expertise.

Land Clearing and Preparation Techniques

Removal or clearing the existing herbaceous and woody vegetation (grass, shrub, bush or trees). This can be either done with or without root extraction;
- Disposal of vegetative debris by windrowing, chopping and mixing with soil or burning;
- Soil cultivation either on strips or entire areas in conjunction, where necessary, with soil and water conservation techniques.

Mechanized removal of woody vegetation by felling operations. Felling single trees by bulldozer blade

1. Definition and description

This operation uses crawler bulldozers equipped with front-end sharp angle or straight blades to cut and fell single trees at or near ground level.

2. Objectives

- To eliminate or minimize the competition for nutrients, moisture and light between the existing woody vegetation and the new plantation.
- To quickly achieve medium-scale land clearing.

3. Locations and conditions for use

- For medium-scale clearing operations in upland wood or brush country with sparse standing trees. The bulldozer blade can be used for various purposes, and can be immediately turned to a new task after felling the trees.
- Where manual felling is expensive and the necessary machinery is available.
- Where the topography and soil conditions are suitable for a mechanized operation.

Clearing of bushy vegetation by mechanized choppers

1. Definition and description

This operation entails the extensive felling of brush or thicket growth using heavy rolling choppers which consist of a large drum with cutting blades towed by a tractor (Chapman and Allan, 1978).

2. Objectives

- To improve the nutrient balance and physico-chemical properties of the soil by chopping the woody vegetation into small pieces and mixing the debris into the soil.
- To destroy the competing vegetation and facilitate root penetration.
- To increase the organic content and infiltration capacity of top soil, and facilitate the penetration of rain-water into the deep rooting zone by subsoiling (Donmez, 1984). In many cases, the chopping operation leaves a mulch of chopped vegetation on the ground surface which protects the soil from the beating action of rain drops and splash erosion.

3. Locations and conditions for use

- On sites where a dense growth of shrubs is the dominant competing vegetation and needs to be cleared.
- On dry and poor sites with shallow sandy soils where a bushy, vegetation dominates.
- Where bushy vegetation, such as maquis in the Mediterranean region, or chaparral in north America, covers large areas.
- **Where manual labour is expensive**

Burning - This is done during dry, sunny days. Burning, despite various raised concerns, is a conveneient, fast, and inexpensive practice that marginal farmers are used to in land clearing. It is usually commenced starting from low elevation at a time of the day when there is wind. As the burning progresses, the farmer is always alert to contain the fire to prevent damage to standing crops and to prevent the fire creeping outside of the intended area to be burned.

d. **Spraying herbicide -** A day after burning, the area may be planted to corn. However, if the same area had thick growth of cogon and has not been cultivated before, the farmer applies herbicide to further reduce root mass and ensuing growth of weeds. A week or two are commonly allowed to pass until the grass weeds have regrown and then herbicide is sprayed.

Adopting the above into an approximately one-hectare portion of our farm, land preparation was completed in two weeks. The activities included blanket slashing, raking, burning, and herbicide spraying. Labor requirement was as follows: slashing- 8 man-days (MD), raking- 2 MD, burning- 1 MD, and herbicide spray- 1 MD for a total of 12 MD.

Crop Selection

Proper crop selection is a factor in successful crop farming.

In addition to the purpose of farming, the major factors to be considered in crop selection include the following**:**

1. Prevailing farm conditions

Know your farm first then select the right crop.The biotic factor refers to living organisms including ruminant animals, insect and other pests, disease pathogens and weeds, as well as organisms having beneficial effects like civet cat population for the production of *civet coffee* and the abundance of pollinators. Where there is prevalence of a disease in a locality, susceptible crops may be excluded or a resistant variety may be selected.The topographic features of the land like elevation, slope, and terrain as well as the physical and chemical properties of the soil such as texture, color, organic matter content, pH and fertility levels will determine the crops that are naturally suited. Also, the various climatic factors, such as prevailing climate type, temperature, rainfall, relative humidity, incidence of light, and frequency of typhoons will limit the choice of crops. A stable supply of water within the farm will allow wide possibilities in crop selection.

In addition, the accessibility of the farm to and from the market will influence the choice of crops. For example, cassava and oil palm should be preferably grown in farms with good roads and as close as possible to the market because the harvest is bulky and must be transported immediately due to rapid rate of degradation.

2. **Crop or varietal adaptability**

The crop(s) and the variety (ies) to be grown should be selected based on their adaptability to the prevailing conditions in the farm. A useful guide is to identify the crops growing in the farm and in the neighborhood. An interview of the neighboring farmers will also provide valuable information as to the probability of success, or failure, of growing certain preferred crops. Furthermore, it is an advantage to have access to lists of different crops under the various plant classification based on natural adaptation or habitat.

3. **Marketability and profitability**

For those who want to engage in cash crop farming or, at the least, ensure financial sustainability, crop selection must consider marketability and profitability. In general, this means that the crop to be selected must be high yielding. The product, be it the fruit, seed, modified root or stem, flower or foliage or any part, must have an accessible, stable and robust market. With efficient labor and use of inputs, the harvest will realize profit to finance the suceeding farm activities or generate substantial return on investment. However, market and price are dictated by many factors such as the number of competitors, supply and demand, development of new products, promotional campaign, and agribusiness cycle.

4. **Resistance to pests and diseases**

Regardless of the purpose of farming, it is important to be able to select a crop and variety with wide resistance to important pests and diseases. The use of susceptible varieties may result to high cost of production or, worst, total crop failure.

5. **Available technology**

The technology for the growing of the crop must have been well established or easy to learn and apply. Likewise, certain crops are preferred because technical assistance is available locally.

6. **Farming system**

Crop selection is affected by the system of farming employed, that is, whether purely crop farming or integrated with livestock animals. Likewise, the particular crop species to be grown will depend on the crop production practices such as monoculture, multiple cropping, hedge row-strip cropping, and planting patterns.

If there is a plan to integrate crop production with free-range livestock, or where entry of astray animals is unhampered, it would be wise to install tree guards or fences. However, additional cost can be eliminated or minimized by selecting crops that are less susceptible to nibbling. Some crops, likesoursop (or guyabano) and sugar apple (or atis) have anti-herbivory properties. In intercropping, it is desirable that the component crops have complementary or mutualistic relation.

7. **Security**

In the absence of security personnel or where there is no fence that will exclude intruders, crop security should be considered.

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Before selecting crops for the upcoming season, review records for last season. Did you have any persistent disease issues in a particular crop? Did one crop do exceptionally well or very poorly? Did some varieties of lettuce bolt a lot earlier than others, leaving you without enough volume? By assessing where you've been, it's easier to plan for where you want to go.

Soil basics

The first step is to test your soil. "Identify which crops you plan to grow, and the soil lab will give recommendations based on your soil and crop needs," advised Katie Campbell-Nelson of the University of Massachusetts Extension and Stockbridge School of Agriculture. "Each crop has specific fertility needs."

Matching crops to the existing limitations of your soils is a smart step. Soil texture, compaction, cation exchange capacity and organic matter content are just a few of the variables that can impact the crop. Planting crops that are well-suited to your soil characteristics gives you a better chance of success. Growers can have an impact on soil characteristics through cultivation practices, by adding amendments, using certain planting methods, or employing techniques to alter factors such as soil temperature, moisture retention or compaction. However, working with a soil that already meets most of a given crop's needs increases the chances of success.

Mineral nutrition issues can be difficult to remedy and can have a major impact on certain crops. "For example, boron is toxic to beans, but prevents hollow heart in brassicas. So if a soil is high in boron, grow brassicas," Campbell-Nelson said.

Local adaptability
Different varieties of the same species can have different nutrient requirements. Select varieties that are suited to your soil's fertility levels.

"What should be growing in your area? It may not be what you expect, and it certainly won't be what your customers expect," Ames said. Common cultivars are not always the best choice. Those that have been bred for local production may not be widely known, but will be most adaptable to the environmental stresses present in any given locale.

Disease resistance
Diseases arise due to the right combination of pathogen, host and environmental conditions. Choosing crops and varieties that are resistant to known disease issues, along with having a good crop rotation plan to break disease cycles, can help to minimize soilborne pathogens. "Selecting crops with disease resistance is really important," Campbell-Nelson emphasized. Properly identifying diseases will not only help with disease control for the current crop, but also with ongoing crop planning. Services such as the University of Massachusetts diagnostic lab can assist growers with this step.

Likewise, some species of plants are more tolerant of certain insect activity than others. Planting crops or varieties that have insect resistance is important if a pest issue is already known to exist. Planting different varieties in succession can be possible, using the most insect-resistant varieties when pressure is the highest and switching to a variety with better flavor or storage characteristics once the pressure abates.

Environmental factors
Daylight hours are another concern. Onions, for example, are influenced by day length and must be selected so that the plant's needs match the actual growing conditions. Proper timing of seeding is important, as bulbs need an increase in day length to develop. Similarly, the timing of seed sowing for overwintering carrots is important. If they aren't sown by November 1 in New England, you'll end up with woody carrots instead of sweet ones, Campbell-Nelson said.

Crops that need significant light and warm temperatures for growth and optimal flavor, such as melons, require special attention. Where the growing season is short, choosing a melon variety that matures a week or so earlier than other varieties can make a difference in the crop's success. Choosing crops with planting and sowing needs that make sense for your farm is important.

If a field is prone to wind damage, select wind-tolerant crops, or find a compatible field crop to serve as a windbreak. If your region experiences regular heavy rains in late spring, choosing a crop that is seeded after the rainy period can minimize headaches. If summer drought is an issue, a crop whose water needs are at their maximum during this time is going to require more irrigation and other inputs than crops with minimal water needs. The water needs of any individual crop vary depending on growth stage. Planning for this can minimize stress for both the plant and the grower.

Companion planting

Planting crops that are mutually beneficial is another method that can increase quality and yield while decreasing negative effects of insects and diseases. While beets and beans are compatible and do well together, beets and pole beans suppress one another's growth and shouldn't be planted in proximity to each other. Planting chives within, near or alongside carrots can improve the flavor of the carrots and increase their growth. Planting crops that can serve as a trap, diverting insects or wildlife from the cash crop, is another consideration.

Markets

Planting a crop to meet a market demand can mean altering conditions through cultivation practices, adding infrastructure such as irrigation or a hoophouse, or utilizing chemical inputs to control intense pest or disease concerns. Meeting the demands of the market might mean choosing particular traits, germination times or maturity dates. Desired traits may be different for wholesale distribution, farm markets, restaurants or other outlets. While ability to withstand packing and shipping is a must when selling to distributors, flavor and taste is going to win out for farm-to-table chefs, and easy-to-harvest, tasty varieties might be the best choice for pick-your-own locations. Pick-your-own turnips may not be a hit with customers, but a wholesale market might exist.

For winter markets in colder areas, planting crops that are less susceptible to freeze damage can extend the season. Kale, beets, Brussels sprouts, parsnips and rutabagas are able to withstand freezing and can still be harvested after cold weather arrives, making them good selections for season extension.

A nursery is a place where plants are propagated and grown to usable size.

Theyinclude retail nurseries which sell to the general public, wholesale nurseries which sell only to businesses such as other nurseries and to commercial gardeners, and private nurseries which supply the needs of institutions or private estates. Some retail and wholesale nurseries sell by mail.

Nurseries may supply plants for gardens, for agriculture, for forestry and for conservation biology.

Some of them specialize in one phase of the process: propagation, growing out, or retail sale; or in one type of plant: e.g., groundcovers, shade plants, or rock garden plants. Some produce bulk stock, whether seedlings or grafted, of particular varieties for purposes such as fruit trees for orchards, or timber trees for forestry. Some produce stock seasonally, ready in springtime for export to colder regions where propagation could not have been started so early, or to regions where seasonal pests prevent profitable growing early in the season.

nurseries can grow plants in open fields, on container fields , in tunnels or greenhouses. In open fields, nurseries grow ornamental trees, shrubs and herbaceous perennials, especially the plants meant for the wholesale trade or for amenity plantings. On a containerfield nurseries grow small trees, shrubs and herbaceous plants, usually destined for sales in garden centers. Nurseries also grow plants in greenhouses, a building of glass or in plastic tunnels, designed to protect young plants from harsh weather (especially frost.While allowing access to light and ventilation, modern greenhouses allow automated control of temperature, ventilation and light and semi-automated watering and feeding. Some also have fold-back roofs to allow "hardening-off" of plants without the need for manual transfer to outdoor beds.

Plants may be propagated by seeds, but often desirable cultivars are propagated asexually. The most common method is by cuttings. These can be taken from shoot tips or parts of stems with a node (softwood cuttings) or from older stems (hardwood cuttings). Herbaceous perennials are also often propagated by root cuttings or division. For plants on a rootstock grafting or budding is used. Older techniques like layering are sometimes used for crops which are difficult to propagate.

Crop establishment

Sowing Methods The method of sowing a crop depends on a number of factors including the crop to be sown, the condition of the soil and the system of production used. The methods for sowing seed fall into two categories: surface sowing, and drilling the seed into the soil. Surface sowing involves the broadcasting of seed on the surface of the soil by ground machine or from the air. Sowing by this method is generally inferior to placement of the seed in the soil, largely because the conditions are less conducive to good germination and establishment, with seedlings at greater risk of desiccation. Theft of seeds by ants and birds is also a problem. Aerial sowing, however, is a common method of establishing rice (Oryza sativa). The seed is pre-germinated before being dropped into water.

This method has the particular effect of advancing the growth of the crop by up to ten days and therefore is advantageous in situations where sowing is delayed or in areas with a shorter growing season such as the Murray Valley in southern New South Wales. However, crop damage by bloodworms and ducks is increased (Woodlands et al., 1984). The most common method of sowing is by drilling the seed into the soil at a prescribed depth. The winter cereals and many small grain crops are usually sown by a combine, a grain drill with a fertiliser box attached, thereby resulting in the seed being placed in the soil adjacent to a band of fertiliser. From the seedbox the seed passes through a metering device, commonly a fluted wheel or a double run, into droppers which extend to a prescribed depth in the soil behind furrow openers. The fertiliser follows a similar procedure although the metering system is different, usually being a 'star' feed. The furrow openers vary, there being single disc, double disc and tine types. Traditional tine drills have poor plant residue handling capabilities and blockages occur unless the residues have been fragmented, are dry and are in small amounts (Kamel, 1975; Brown et al., 1986).

This is important for stubble retention farming, necessitating a change in tine geometry to greater trash clearance both within the tine row and between rows of tines. Tines are also less useful under heavy wearing conditions such as sandy soils. Problems arise where disc openers are used under conditions where soil is likely to adhere to the discs (Kamel, 1975).

Many combines have a small seeds box attachment preferably in conjunction with a band seeder through which pasture seed or small seeded crops such as canola are sown by mixing them with the fertiliser, providing consideration is given to likely fertiliser germination damage. Combines sow the crops in rows approximately 18 cm apart although this can be varied in multiples by blocking the appropriate seed openings. The metering systems in conventional combines are not particularly precise and considerable variation in sowing rate and fertiliser rate both within and between rows is frequent. In many crops, however, this is relatively unimportant, but in the case of concentrated fertiliser, small differences represent considerable variation in actual nutrient supply.

Cultural practices

Cultural practices that are carried out during crop production:

- **Thinning**

Thinning is a term used in agricultural sciences to mean the removal of some plants, or parts of plants, to make room for the growth of others. In agriculture and gardening, thinning is the selective removal of flowers, fruits, shoots, and seedlings or young plants to allow adequate space for the remaining organs/plants to grow efficiently. In large-scale farming, techniques like precision seeding and transplanting can eliminate the need for thinning by starting plants at their optimum spacing. On a smaller scale, such as a home vegetable garden, thinning can be used as a way to make maximum use of space for certain crops. For example, beets, carrots, green onions and others can be planted densely, and then thinned to make room for continued growth of the plants left in the soil, and also as a harvest of baby vegetables (beet greens, baby carrots, baby onions). Also thinning is used in post harvesting

- **Staking**

In horticulture, staking refers to inserting a stake beside a plant in order to provide it with support while it grows. Tomato plants are perhaps the most commonly staked plant in household gardens, but there are others that benefit from support.Staking requires very little in the way of materials. A wooden stake and a mallet or hammer is really all that's needed. Some growers also use metal stakes or bamboo stakes, and many growers tend to use whatever is lying around the house in a pinch. For example, old broom handles, leftover PVC pipe from another project, and so on.

Throughout your gardening experience, especially when growing tomatoes it is important to stake them as they extend in length. Staking provides each plant the ability to grow without bending to the point where it breaks the plant and stops growth. It can also can also be used prevent the fruit from beginning to rot as it sits on the ground as the stalk grows overtime . Having the plant grow upward after it is staked allows the plant to get the necessary sunlight it needs to continue growth. It can be used as a method to keep the aisles of each row of plants clear and decent. And overall it allows the growth of the fruit to continue successfully.

Training

Defination

Training can therefore be defined as 'an operation done to a plant by which it is made to develop an frame work or structure land this is spreading on pergola with or without pruning of plant pears and training is usually done when the plant/shrubs vines are young.

It is necessary to pay sufficient attention for training of plants during the first few years of planting. During this period, the pre planned frame work as decided by the grower should be allowed to develop. The main points to be kept in view while training the fruit these are:

Objects of Training:

1. To admit adequate sun light and air to the center of the tree and to expose maximum leaf area to the sun.
2. To limit the growth and spread of the tree so that various cultural operation such as spaying and harvesting are performed at minimum cost.
3. To build the frame work and arrangement of scaffold branches.
4. To build the structure of the tree is such heights at which the tres are less exposed for sunscald and wind damage.

Before attachment to train of any tree, one should decide the height of the head or crown. Depending upon the height of the crown from ground level, the plants can be grouped in two:

a) High Head:

In this case, the main branches are encouraged about one meter or higher up from the ground level. In case of these plants, cultural operations with animal or mechanically drawn implements can be carried out easily. In the tropical climate, the high headed trees are unsuitable as they are prone to sunscalted and wind damage.

b) Low Head:

Main branches forming the foundation frame work of the tree are encouraged on the trunk at a height of 1 meter from the ground level. The low headed trees are now becoming common all over the world as they come into bearing comparatively earlier, are able to resist stormy winds more effectively and spraying and harvesting expense are reduced.

How to Train the Plats

The formation of the main frame work of the tree is most important part of training. Usually two to four main branches are encouraged at almost the same height. These should be allowed be rise from different direction, at some distance from one another as to from a balanced head. These branches are called scaffold branches. The frame work is greatly strengthen if the branches are spaced at 15 cm apart vertically on the main tarn. If two or more branches of equal size are allowed to arise from one place, they from a bad crotch ehicjh is after prone to spilt stem except a few like pomegranate custard apple, fig, etc. which are better trained to two of three stems.

- **Pruning**

Selective removal of parts of a plant such as branches, buds, or roots is typically known as pruning.

Pruning is a horticultural and silvicultural practice involving the selective removal of certain parts of a plant, such as branches, buds, or roots. Reasons to prune plants include deadwood removal, shaping (by controlling or redirecting growth), improving or sustaining health, reducing risk from falling branches, preparing nursery specimens for transplanting, and both harvesting and increasing the yield or quality of flowers and fruits.

The practice entails *targeted* removal of diseased, damaged, dead, non-productive, structurally unsound, or otherwise unwanted tissuefrom crop and landscape plants. In general, the smaller the branch that is cut, the easier it is for a woody plant to compartmentalize the wound and thus limit the potential for pathogen intrusion and decay. It is therefore preferable to make any necessary formative structural pruning cuts to young plants, rather than removing large, poorly placed branches from mature plants.

Specialized pruning practices may be applied to certain plants, such as roses, fruit trees, and grapevines. It is important when pruning that the tree's limbs are kept intact, as this is what helps the tree stay upright.[1] Different pruning techniques may be deployed on herbaceous plants than those used on perennial woody plants. Hedges, by design, are usually (but not exclusively) maintained by hedge trimming, rather than by pruning.

- **Shading**

This involves the provision of artifical canopy for crops. The main objective of the practice is to reduce the scorching effect of the sun on young tender crop. The practice will also facilitate the comtrol of temperature, excessive evaporation and evaptranspiration and as well regulate the light intensity for croms that a photosensitive. The practice also affortd eed control.

The practice can be achieved by affording a canopy of existing plant with big leaves jast as we have it in cocoa plantation where banana or plantain is been used to ptovide shade for young cocoa plants. It is also possible to errect artifical canopy using thatches from palm trees and bamboo poles. Other options include the use of synthetic material and plastic with fibre or metal poles.

- **Mulching**

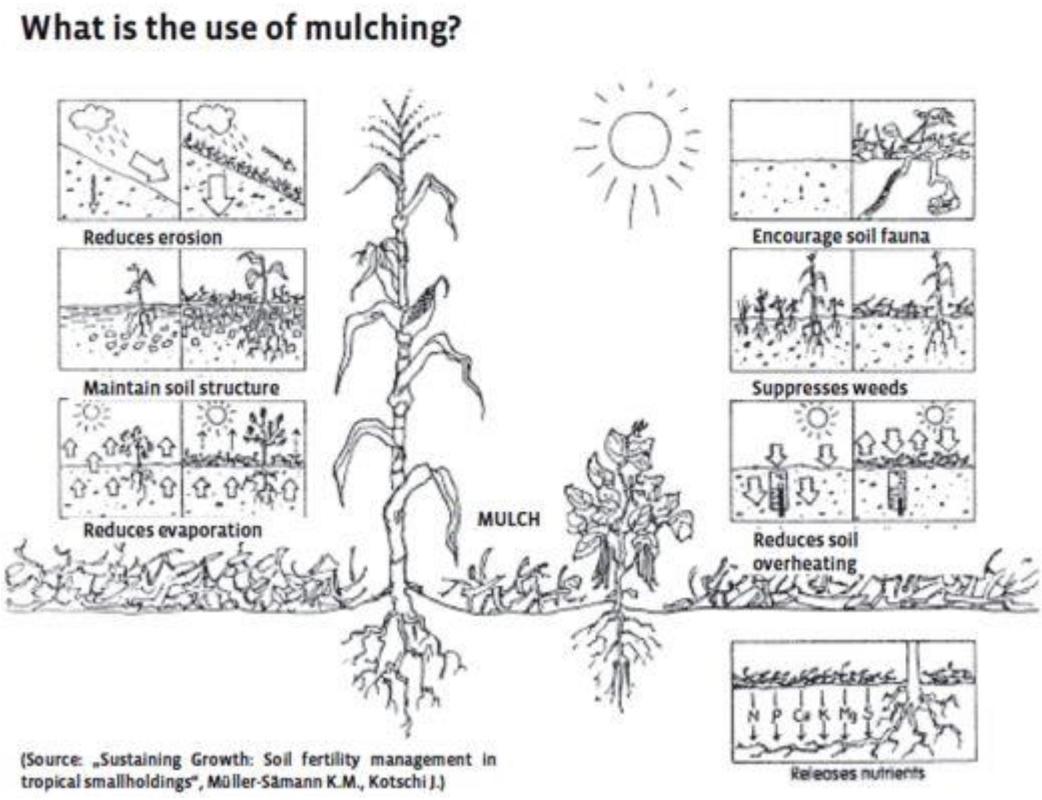
Mulching is the process of covering the topsoil with plant material such as leaves, grass, twigs, crop residues, straw etc. A mulch cover enhances the activity of soil organisms such as earthworms. They help to create a soil structure with plenty of smaller and larger pores through which rainwater can easily infiltrate into the soil, thus reducing surface runoff. As the mulch material decomposes, it increases the content of organic matter in the soil. Soil organic matter helps to create a good soil with stable crumb structure. Thus the soil particles will not be easily carried away by water. Therefore, mulching plays a crucial role in preventing soil erosion.

Description

In some places, materials such as plastic sheets or even stones are used for covering the soil. However, in organic agriculture the term 'mulching' refers only to the use of organic, degradable plant materials.

Why to use mulch?

- Protecting the soil from wind and water erosion: soil particles cannot be washed or blown away.
- Improving the infiltration of rain and irrigation water by maintaining a good soil structure: no crust is formed, the pores are kept open
- Keeping the soil moist by reducing evaporation: plants need less irrigation or can use the available rain more efficiently in dry areas or seasons
- Feeding and protecting soil organisms: organic mulch material is an excellent food for soil organisms and provides suitable conditions for their growth
- Suppressing weed growth: with a sufficient mulch layer, weeds will find it difficult to grow through it
- Preventing the soil from heating up too much: mulch provides shade to the soil and the retained moisture keeps it cool
- Providing nutrients to the crops: while decomposing, organic mulch material continuously releases its nutrients, thus fertilizing the soil
- Increasing the content of soil organic matter: part of the mulch material will be trans-formed to humus



Sketch on the effects of mulching

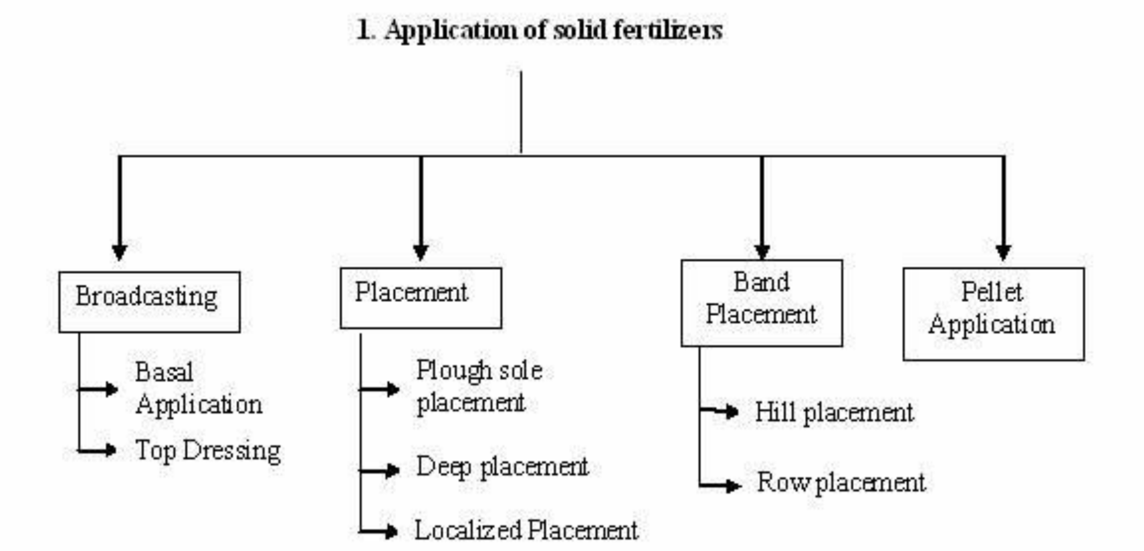
Selection of mulch materials

The kind of material used for mulching will greatly influence its effect. Material which easily decomposes will protect the soil only for a rather short time but will provide nutrients to the crops while decomposing. Hardy materials will decompose more slowly and therefore cover the soil for a longer time. If the decomposition of the mulch material should be accelerated, organic manures such as animal dung may be spread on top of the mulch, thus increasing the nitrogen content

Filling- in /supplying
This is the replanting of seeds and seedlings to replace dead crops or gemination failures
Earthing-up
Movement of soil to re-enforse the base of the crops or to cover up the exposed root or tubers.
Weeding., pest control, desease control and fertilizer application will be discussed in detail later
Fertiliser applicationa) Broadcasting.
b) Placement.
a) Starter solutions.b) Foliar application.
c) Application through irrigation water (Fertigation)
d) Injection into soil.
e) Aerial application

METHODS OF FERTILIZER APPLICATION

The different methods of fertilizer application are as follows:



a) Broadcasting
1. It refers to spreading fertilizers uniformly all over the field.
2. Suitable for crops with dense stand, the plant roots permeate the whole volume of the soil, large doses of fertilizers are applied and insoluble phosphatic fertilizers such as rock phosphate are used.

Broadcasting of fertilizers is of two types.
i) Broadcasting at sowing or planting (Basal application)
The main objectives of broadcasting the fertilizers at sowing time are to uniformly distribute the fertilizer over the entire field and to mix it with soil.

ii) Top dressing
It is the broadcasting of fertilizers particularly nitrogenous fertilizers in closely sown crops like paddy and wheat, with the objective of supplying nitrogen in readily available form to growing plants.

Disadvantages of broadcasting
The main disadvantages of application of fertilizers through broadcasting are:
i) Nutrients cannot be fully utilized by plant roots as they move laterally over long distances.
ii) The weed growth is stimulated all over the field.
iii) Nutrients are fixed in the soil as they come in contact with a large mass of soil.
b) Placement
1. It refers to the placement of fertilizers in soil at a specific place with or without reference to the position of the seed.
2. Placement of fertilizers is normally recommended when the quantity of fertilizers to apply is small, development of the root system is poor, soil have a low level of fertility and to apply phosphatic and potassic fertilizer.

The most common methods of placement are as follows:
i) Plough sole placement
1. In this method, fertilizer is placed at the bottom of the plough furrow in a continuous band during the process of ploughing.
2. Every band is covered as the next furrow is turned.
3. This method is suitable for areas where soil becomes quite dry upto few cm below the soil surface and soils having a heavy clay pan just below the plough sole layer.

ii) Deep placement
It is the placement of ammoniacal nitrogenous fertilizers in the reduction zone of soil particularly in paddy fields, where ammoniacal nitrogen remains available to the crop. This method ensures better distribution of fertilizer in the root zone soil and prevents loss of nutrients by run-off.
iii) Localized placement
It refers to the application of fertilizers into the soil close to the seed or plant in order to supply the nutrients in adequate amounts to the roots of growing plants. The common methods to place fertilizers close to the seed or plant are as follows:
a) Drilling
In this method, the fertilizer is applied at the time of sowing by means of a seed-cum-fertilizer drill. This places fertilizer and the seed in the same row but at different depths. Although this method has been found suitable for the application of phosphatic and potassic fertilizers in cereal crops, but sometimes germination of seeds and young plants may get damaged due to higher concentration of soluble salts.
b) Side dressing
It refers to the spread of fertilizer in between the rows and around the plants. The common methods of side-dressing are
1. Placement of nitrogenous fertilizers by hand in between the rows of crops like maize, sugarcane, cotton etc., to apply additional doses of nitrogen to the growing crops and
2. Placement of fertilizers around the trees like mango, apple, grapes, papaya etc.

c) Band placement
If refers to the placement of fertilizer in bands.

Band placement is of two types.

i) Hill placement

It is practiced for the application of fertilizers in orchards. In this method, fertilizers are placed close to the plant in bands on one or both sides of the plant. The length and depth of the band varies with the nature of the crop.

ii) Row placement

When the crops like sugarcane, potato, maize, cereals etc., are sown close together in rows, the fertilizer is applied in continuous bands on one or both sides of the row, which is known as row placement.

Following are the common methods of applying liquid fertilizers

a) Starter solutions

It refers to the application of solution of N, P_2O_5 *and* K_2O in the ratio of 1:2:1 and 1:1:2 to young plants at the time of transplanting, particularly for vegetables.

Starter solution helps in rapid establishment and quick growth of seedlings.

The disadvantages of starter solutions are

(i) Extra labour is required, and

(ii) the fixation of phosphate is higher.

b) Foliar application

1. It refers to the spraying of fertilizer solutions containing one or more nutrients on the foliage of growing plants.
2. Several nutrient elements are readily absorbed by leaves when they are dissolved in water and sprayed on them.
3. The concentration of the spray solution has to be controlled, otherwise serious damage may result due to scorching of the leaves.
4. Foliar application is effective for the application of minor nutrients like iron, copper, boron, zinc and manganese. Sometimes insecticides are also applied along with fertilizers.

c) Application through irrigation water (Fertigation)

1. It refers to the application of water soluble fertilizers through irrigation water.
2. The nutrients are thus carried into the soil in solution.
3. Generally nitrogenous fertilizers are applied through irrigation water.

d) Injection into soil

1. Liquid fertilizers for injection into the soil may be of either pressure or non-pressure types.
2. Non-pressure solutions may be applied either on the surface or in furrows without appreciable loss of plant nutrients under most conditions.
3. Anhydrous ammonia must be placed in narrow furrows at a depth of 12-15 cm and covered immediately to prevent loss of ammonia.

e) Aerial application

In areas where ground application is not practicable, the fertilizer solutions are applied by aircraft particularly in hilly areas, in forest lands, in grass lands. or in sugarcane fields etc.

Weed and Pest Management

Although herbicides can provide effective weed management, corn growers should not depend on herbicides alone. Growers should use good cultural practices so the corn is competitive with any weeds and should integrate chemical control programs with cultivation, especially with difficult-to-control weeds or when weather conditions reduce herbicide effectiveness.

The first step in cultural weed control is the selection of a corn hybrid that is adapted to local growing conditions. Timely planting along with proper fitting in tilled situations or proper adjustment of no-tillage planters ensures rapid germination and a competitive advantage for the corn. Another cultural practice that favors rapid establishment of corn is proper band application of fertilizer at planting.

All primary (plowing) and secondary (fitting) tillage operations help provide a weed-free seedbed. Cultivation of row crops is an effective way to control annual weeds between corn rows. Band application of herbicides over the row at planting, combined with one or two cultivations, provides good control of annual weeds such as common lambsquarters and foxtails. Although rotary hoes effectively destroy weed seedlings in small corn, a row cultivator adjusted to minimize pruning of corn roots should be used after corn is 5 or 6 inches tall. Creeping perennials such as common milkweed and quackgrass are not adequately controlled by one or two cultivations. These weeds regrow from rhizomes (underground stems) following cultivation and are controlled with tillage only if the operations are repeated over long periods. Biennial (wild carrot, etc.) and simple perennial (dandelion, etc.) weeds do not persist in fields that are plowed but can be a problem in reduced and zone/no-tillage fields.

A variety of herbicides are available for preplant, preemergence, and/or postemergence weed control in corn. These herbicides vary in their effectiveness in controlling different weeds (Table 3.7.1) and in the length of time they remain active in the soil. Some corn herbicides, such as *atrazine and Princep, can carry over to affect triazine-sensitive rotational crops such as small-seeded forage legumes, small grains, and soybeans. Knowledge of the weeds present, herbicide effectiveness, and rotational plans should be considered when selecting herbicides.

Cost of chemical weed control dictates that herbicides be applied when they will provide maximum return. Label guidelines for the timing of herbicide applications are based on research and are geared for maximum weed control and minimum crop injury. The labeled application timings for corn herbicides are shown as shaded cells in Table 3.7.2.

Preventative Weed Control

Preventative weed control refers to any control method that aims to prevent weeds from being established in a cultivated crop, a pasture, or a greenhouse. Examples of preventative weed control would be using certified weed free seed, only transporting hay that is weed free, making sure farm equipment is cleaned before moving from one location to another, and screening irrigation water to prevent weed seeds from traveling along irrigation ditches.

Cultural
Cultural weed control refers to any technique that involves maintaining field conditions such that weeds are less likely to become established and/or increase in number. Examples of cultural weed control would be crop rotation, avoiding overgrazing of pastures or rangeland, using well-adapted competitive forage species, and maintaining good soil fertility.

Mechanical
Mechanical weed control refers to any technique that involves the use of farm equipment to control weeds. The two mechanical control techniques most often used are tillage and mowing.

Biological
Biological weed control refers to any technique that involves the use of natural enemies of weed plants to control the germination of weed seeds or the spread of established plants. This is a rapidly expanding area of weed control with many examples. Examples of biological weed control include sheep to control tansy ragwort or leafy spurge, cinnabar moth and the tansy flea beetle to control tansy ragwort, the chrysolira beetle to control St. John's Wort, and the use of goats to control brush on rangeland.

Chemical
Chemical weed control refers to any technique that involves the application of a chemical (herbicide) to weeds or soil to control the germination or growth of the weed species. In economic terms, chemical control of weeds is a very large industry and there are scores of examples of chemical weed control products. Common examples of chemicals used to control weeds in forages are 2,4-DB; EPTC; bromoxynil; and paraquat.

Irrigation

Irrigation System Types for Every Crop Production
Irrigation systems are widely used in every crop production in order to apply the amount of water needed for the crop. Despite its broad application, irrigation should occur in a uniform and timely manner in order to minimize losses and damage to soil, water, air, plant, and animal resources.
Irrigation is the artificial application of water to the soil at rates, quantities, and times needed to meet farm irrigation requirements. Water can be artificially supplied to plants using five irrigation systems:
Flood irrigation; entire soil surface is covered with water; it moves over the field by gravity flow
Sprinkler irrigation; crops are irrigated with high-pressure sprinklers set in the field; it can be solid or hand-moved
Drip irrigation; water is placed directly into the crop root zone from the low flow emitters
Center Pivot irrigation; single central irrigation pipeline rotates around the pivot point. As it rotates, water sprinklers along the central pipe and irrigates crops
Furrow irrigation; surface irrigation method where water is applied in furrows
Prior to setting up an irrigation system, a farmer must consider the following limiting factors in order to adequately operate an irrigation:
Soil properties; soil type, drainage, water holding capacity

Water availability, quality, quantity, crop water requirements
Crop properties; yield potential, frost resistance, row space, harvest practices, rooting depth.
Climate requirements; humidity, temperature, precipitation
Farmer capabilities; farm labor, finance health, management skills, farm practices
Irrigation system properties; operating cost, and the ability to deliver and apply the amount of water needed to meet the crop's water requirement.

Some irrigation methods

Irrigation is the the controlled application of water for agricultural purposes through manmade systems to supply water requirements not satisfied by rainfall. Crop irrigation is vital throughout the world in order to provide the world's ever-growing populations with enough food. Many different irrigation methods are used worldwide, including:

Center-Pivot: Automated sprinkler irrigation achieved by automatically rotating the sprinkler pipe or boom, supplying water to the sprinkler heads or nozzles, as a radius from the center of the field to be irrigated. Water is delivered to the center or pivot point of the system. The pipe is supported above the crop by towers at fixed spacings and propelled by pneumatic, mechanical, hydraulic, or electric power on wheels or skids in fixed circular paths at uniform angular speeds. Water is applied at a uniform rate by progressive increase of nozzle size from the pivot to the end of the line. The depth of water applied is determined by the rate of travel of the system. Single units are ordinarily about 1,250 to 1,300 feet long and irrigate about a 130-acre circular area.
Drip: A planned irrigation system in which water is applied directly to the Root Zone of plants by means of applicators (orifices, emitters, porous tubing, perforated pipe, etc.) operated under low pressure with the applicators being placed either on or below the surface of the ground.
Flood: The application of irrigation water where the entire surface of the soil is covered by ponded water.
Furrow: A partial surface flooding method of irrigation normally used with clean-tilled crops where water is applied in furrows or rows of sufficient capacity to contain the designed irrigation system.
Gravity: Irrigation in which the water is not pumped but flows and is distributed by gravity.
Rotation: A system by which irrigators receive an allotted quantity of water, not a continuous rate, but at stated intervals.
Sprinkler: A planned irrigation system in which water is applied by means of perforated pipes or nozzles operated under pressure so as to form a spray pattern.
Subirrigation: Applying irrigation water below the ground surface either by raising the water table within or near the root zone or by using a buried perforated or porous pipe system that discharges directly into the root zone.
Traveling Gun: Sprinkler irrigation system consisting of a single large nozzle that rotates and is self-propelled. The name refers to the fact that the base is on wheels and can be moved by the irrigator or affixed to a guide wire.
Supplemental: Irrigation to ensure increased crop production in areas where rainfall normally supplies most of the moisture needed.
Surface: Irrigation where the soil surface is used as a conduit, as in furrow and border irrigation as opposed to sprinkler irrigation or subirrigation.

Calibration of sprayers

Six Simple Steps for Sprayer Calibration

The following step-by-step method of calibrating a backpack or hand-gun sprayer involves very little math or formulas. It is based on the following principal:
One gallon = 128 fluid ounces and your calibration area to be sprayed is 1/128 of an acre, thus fluid ounces collected = gallons per acre (GPA).

STEP 1. Clean sprayer and nozzle thoroughly. Then, fill the spray tank with clean water. Spray with water only to check to see that the nozzle forms a uniform spray pattern. If the pattern is uneven, check to make sure the nozzle is clean and replace it if needed. Adjustable nozzles should be set and marked to permit repeated use of the selected spray pattern. If necessary, add a marker dye to the water to more easily see your spray pattern.

STEP 2. Measure an area 18.5 feet by 18.5 feet, which is equal to 1/128th of an acre. ***If possible, this should be done in the field on which you will be spraying.***

STEP 3. Time the number of seconds it takes to spray the measured area uniformly with water using gentle side-to-side sweeping motion with the spray wand similar to spray painting a home or automobile. Record the number of seconds required to spray the area. During application be sure to maintain a constant sprayer pressure and cover the entire area uniformly one time. ***You should repeat step 3 at least twice and use the average of the two times.***

STEP 4. Spray into a container for the average time calculated in step 3. Be sure to maintain constant sprayer pressure while you spray into the container.

STEP 5. Measure the number of fluid ounces of water in the bucket. The number of fluid ounces collected from the bucket is equal to the number of gallons of water per acre the sprayer is delivering. ***Volume sprayed in fluid ounces = gallons of water per acre (GPA).***

STEP 6. Add the proper amount of herbicide to the tank.
For backpack or other small volume sprayers:
Use Table 1 to determine how much ***liquid herbicide*** to add to ***1 gallon*** of water.
Use Table 2 to determine how much ***dry herbicide***to add to ***2 gallons*** of water.
For larger hand-gun sprayer: Use Table 3 to determine the amount of liquid herbicide to add to your spray tank.

Harvesting

Crop Production – Harvesting & Storage
Ultimate stages of crop production are harvesting and storage. Harvesting requires art and practice because a large proportion of crop can be lost due to an improper method of harvesting. Another responsibility after harvesting is storage. Storage of grains is much more to be taken care. An improper way of storage can lead the whole hard work in vain. This necessitates the knowledge of.

Once the crop is mature, it is cut and gathered which is called harvesting. Harvesting depends on many factors like season, crop variety, maturity period etc. Over-irrigation, irregular sunlight can prolong ripening of crop which thus delays the harvesting time. Early harvesting causes loss of unripened grains while delayed harvesting leads to shedding off of grains, sometimes even birds eat the grains. Therefore regular examination of the crop is necessary as the harvesting period approaches. The Golden yellow color is the indication of ripened crops like rice and wheat. Manually harvesting is done by using sickles but it is a tedious job as well as time-consuming. In recent times, machines called harvesters are used for harvesting especially in large-scale farming.

Followed by harvesting, threshing of the crop has to do. Here grains are separated from the chaff by beating or by the threshing machine. In small-scale farming, chaff and grains are separated from each other by a process called winnowing.

Harvesting is considered as a festival. It is a time of joy where the fruits of the hard work of farmers come into reality. Some of the harvesting festivals are Pongal, Bihu etc.

Storage
In the case of small-scale cultivation, farmers use the harvested crop for themselves while large-scale production is mainly for marketing. Thus the cultivators have to store the grains. For this, a proper storage space has to be arranged. Inadequate storage space and improper storage methods can lead to a huge grain loss.

In addition to pest and rodents, microbes like bacteria, fungus, environmental conditions like moisture, temperature etc. may attack the stored grains. Therefore a proper treatment is required before storing of grains. Rodents and pests can be prevented by pesticides. Moist environment results in fungal growth on grains. This can be avoided by proper drying of grains in sunlight. Another method is fumigation where chemicals are used to prevent bacteria and other microorganisms. After proper treatments, grains have to be stored in gunny bags or granaries and deposited in godowns.

Cleaning
After harvest, excess field dirt and plant debris can often be removed from many types of produce by gentle scrubbing with a dry brush. Be sure to clean the brushes frequently, and use a tarp or container to catch the dirt so it does not contaminate the processing area. It is recommended to use this method of dry brushing when possible, rather than washing, before packing or marketing fresh fruits and

vegetables. However, very muddy produce or produce that cannot withstand brushing may require washing with water.

Understanding Contamination from Water

Washing with water must be done carefully, as it has the potential to lower the quality of the produce and cause contamination. Although washing with water is typically a good food safety practice by the consumer just prior to consumption, when preparing produce for sale it can increase the risk of contamination. Water can infiltrate to the inside of the fruit or vegetable through the following process. When produce is placed in a container of water that is at a different temperature than the produce, this situation is called a temperature differential. If the water is colder than the produce, it causes the air in the cells of the fruit to contract. This contraction draws water into the fruit or vegetable through pores, channels, or bruises. The water drawn into the produce may be contaminated, thus causing the produce to become internally contaminated.

In some instances, washing produce may be required. Growers often look to various methods of washing fresh produces before selling it to customers.

References/Further Reading

Hegerfeld-Baker, J. "Unit 4, Lesson 1." Local Foods: Food Safety and Marketing Strategies. South Dakota Cooperative Extension Service, 2009. CD.

Commodity Specific Food Safety Guidelines for the Fresh Tomato Supply Chain. 2nd ed. North American Tomato Trade Work Group, July 2008. We b. 22 Jan. 2014.

Commodity Specific Food Safety Guidelines for the Melon Supply Chain. Produce Marketing Association, Nov. 2005. Web. 22 Jan. 2014.

Hodges, L. Growing Scallions (Green Onions) for Market Gardeners. Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln, Aug. 2004. Web. 16 Jan. 2014.

Defroster J.N. et al (1971) – technology of food preservation, AVI publishing Company Eden T. (1999). The Art of preserving: How cooks in colonia Virginia imitated Nature to control it. Govern,

P.M (2002). The origins and Ancient History of Wine. The University of Pennsylvania Museum of Archeology. Ihekeronje, A.I.J Ngoddy, P.O. Integrated food science and technology for the tropics, Macmillian publishers Ltd, London, England, 198 Mack L. (2001) Food preservation in the Roman.

Empire. Chapel Hill, Nc University of North Carolina. Sanni A.I. (1993) the need for process optimization of African fermented foods and beverages Int. J. food microbial. 18, 85-95 Vol. 2.

Shepherd, S., Simon and Schuster (2001). Pickled, potted and canned; how the Art and Science of food preservation changed the world Taiwo, K.A., Oladepo, O.W., Ilori, M.O., Akanbi, C.T.A. study on the Nigerian food industry and the impact of technological changes on the small Scale food enterprise.

Food reviews International, 2002, 18(4) 243-261 Vol. 4. The Annual conference of the Nigerian Institute of food Science and technology, Ilorin, Dec 6-10, 1993, Akingbola, J.O., Ed, NIFST. Lagos,Nigeria, 1993, 20-37 Vol. 3. Wilson C.A. (1991). Food preservation from Early Times to the present.Edinburgh University.

Primary Processing

Agriculture, horticulture, commercial fishing and aquaculture are all primary industries in Australia. They each produce food for the human population. All of these industries undertake some primary processing activities to make the food available to the consumer. Primary processing is all of the activities involved in the alteration of raw food into food products or to make the food ready to be consumed. Primary processing is carried out after foods are harvested or animals slaughtered, to prepare them for consumption or to turn them into other products. It includes transportation, sorting, cleaning, blending and milling.

Reasons for primary processing

- Prepare raw food so that is ready for human consumption. Raw food is prepared by cleaning and sorting so that the produce is available to the consumer in an appealing and useable form. Removing insects, soil, stones, and other debris from the edible parts of the food extends the shelf life of the food and improves its immediate sensory appeal to the consumer at the marketplace.

- Make raw food available to the consumer despite their geographical location and the season of the year. Cherries grown in New South Wales and Victoria can be transported to various locations in Australia and exported to other countries around the world. Strawberries are made available for sale in the winter months in the southern states of Australia because they can be grown in Queensland at that time.

- Extends the shelf life of the raw food by placing it in suitable conditions so that it is still in peak condition when transported to a food manufacturer or consumer marketplace. Tomatoes are refrigerated in bulk after harvesting so that they will not spoil prior to transportation to a food manufacturer or marketplace.

- Test raw food for quality assurance. Manufacturers seek to have a product that has a consistent and reliable quality. Harvested wheat grain is stored in silos and tested for moisture content so that the grain can't spoil during storage. Moisture content is also an important factor when selling the grain to food manufacturers. Hanging meat carcasses is essential to allow maximum tenderness of the meat for the food manufacturer or consumer. The nutrient content of milk is tested for quality assurance and to monitor the yield and health of the herd.

- Protect food from contamination. The temperature in a wheat silo is constant and the air is replaced with a non-toxic gas that kills rodents and insects.
- Prepare raw food for delivery to food manufacturers for conversion into other food products. Wheat is milled and converted into flour. The flour can be transported to a food manufacturer for blending with other ingredients in the manufacture of bread, pasta, noodles, soups and sauces.

Test your understanding

1. Identify the origins of the food supply.
2. Outline the advantages of a diverse food supply for the human population.

3. Provide examples of primary processing of raw foods before they are supplied to the consumer.
4. Explain how primary processing improves food quality.
5. Outline the reasons for the primary processing of raw foods.
6. Differentiate between primary and secondary processing of foods.
7. Describe the purpose of the secondary processing of foods.
8. Outline the advantages of secondary processing for food producers and consumers.
9. Differentiate between the physical, chemical, and sensory properties of food. Suggest an example of each property.
10. Explain how an understanding of food properties affects food preparation and processing.

Harvesting and Threshing

Nearly all small farmers in the developing countries harvest their cereal crops and beans by hand and thresh them later. In the case of peanuts, harvesting involves lifting the plants and attached pods from the ground, then allowing them to cure (dry) in the field for a period of from several days to four to six weeks before threshing.

Threshing consists of separating the seeds from the seedheads, cobs or pods by beating, trampling or other means. With peanuts, threshing separates the pods from the pegs that hold them to the plant and does not include actual shelling. (With maize, the term "shelling" is usually used in place of "threshing".)

With cereal crops and beans, the small farmer has several options as to when to thresh the crop. If the matured crop has stood in the field for some time during dry weather, the seeds may be low enough in moisture content to be threshed without damage right after harvest. However, the farmer may still prefer to delay threshing for two reasons:

• The grain may still be too high in moisture content to escape spoilage if stored as loose seed. Grain stored in unthreshed form on the cob, on the seedhead or in the pod can be safely stored at a much higher moisture content since there is much more air space for ventilation and further drying.

• Maize stored as unhusked ears and pulses stored in their pods are more resistant to storage insects.

Winnowing follows threshing and consists of separating chaff and other light trash from the grain using wind, fan-driven air or screens Winnowing may need to be repeated several times before consumption or marketing and is usually supplemented by manual removal of stones, clods, and other heavy trash.

Guidelines for Harvesting and Shelling Maize

Determining Maturity

In the 0-1000 m zone in the tropics, most maize varieties reach physiologic maturity within 90-130 days after seeding emergence or 50-58 days after 75 percent of the plants have produced silks. As maturity nears, the lower leaves begin to yellow and die off. In healthy, wellnourished plants, this should not occur until the ears are nearly mature. Ideally, most of the leaves should still be green when the husks begin to turn brown. Unfortunately, such high-yielding plants are not often seen in small farmer fields because of stress factors like low fertility, insects, diseases, and inadequate weeding. More typically, most of the leaves are dead by the time the plant matures.

The "black layer" method: When a maize kernel reaches physiologic maturity (maximum dry weight), the outside layer of cells at its base where it connects with the cob will die and turn black, thus preventing any further cob-to-kernel nutrient transfer. This "black layer" provides an indication of maturity. The layer can be seen by detaching kernels from the cob and examining their bases. Newly-matured kernels may have to be slit lengthwise with a pocketknife to expose the black layer. However, with older kernels, the layer can be readily seen by scraping the base with the fingernail.

Keep in mind that physiologic maturity is not reached until all the kernel's milky starch has solidified. This process begins at the tip of the kernel and moves downward toward the base. The kernels at the ear tip are the first to mature, followed by those in the middle and finally the ones at the lower end (the difference is no more than a few days).

With healthy plants, kernel moisture at physiologic maturity will vary from about 28-36 percent. This is usually too high for damagefree threshing or for mold-free storage except in the form of husked ears placed in very narrow cribs. The black layer may form much earlier in the maize plant's growth cycle if growing conditions are adverse. Such kernels will be small and shrunken and have much higher moisture contents when the black layer forms. The drydown rate of maize: When maize plants are left standing in the field after maturity, the kernels lose about 0.25 0.5 percent moisture per day, but this can range from 0.1 - 1.0 percent depending on weather conditions and whether the ears are pointing downwards to prevent water entry.

Methods of Harvesting Maize:

• **By Hand**: The ears are removed by hand from the plants with or without husking. Husked ears require a smaller storage area and are more resistant to insects, but may rot more easily if stored at a high moisture content.

• **Mechanical**: Tractor-drawn pickers and picker-shellers can handle one to two rows at once, but self-propelled combines are available which can harvest up to six to eight rows. By changing the front attachment (the "head"), combines can also harvest other cereal crops (if not overly tall) and bush beans, but cannot be used on peanuts. Well-adjusted pickers and combines should have losses of less than 2 percent and 4 percent respectively unless lodging is severe.

When to Begin Harvesting

Harvest should begin as soon as is practical after maturity, but this depends on the farmer's harvest method and storage and drying facilities.

Hand harvesting: Since husked ears can be safely stored in narrow cribs (see storage section) at up to 30-32 percent kernel moisture, harvest can be started at or soon after maturity if desired. Most small farmers prefer to let the maize dry down further in the field first.

Mechanical harvesting.

• Pickers If narrow cribs (see storage section) are used for storage, mechanical picking can be started once kernel moisture is down to 30-32 percent.

• **Picker-shellers and combines**: In this case, adequate drying facilities and kernel damage from shelling are the main concerns. In the tropics, shelled maize above 14 percent moisture will not store more than a week to a few months without spoilage. Rapid drying is essential and usually requires forced air and heated dryers when large volumes are involved. Kernel damage from mechanical shelling may become serious above 28-30 percent or below 15-18 percent moisture.

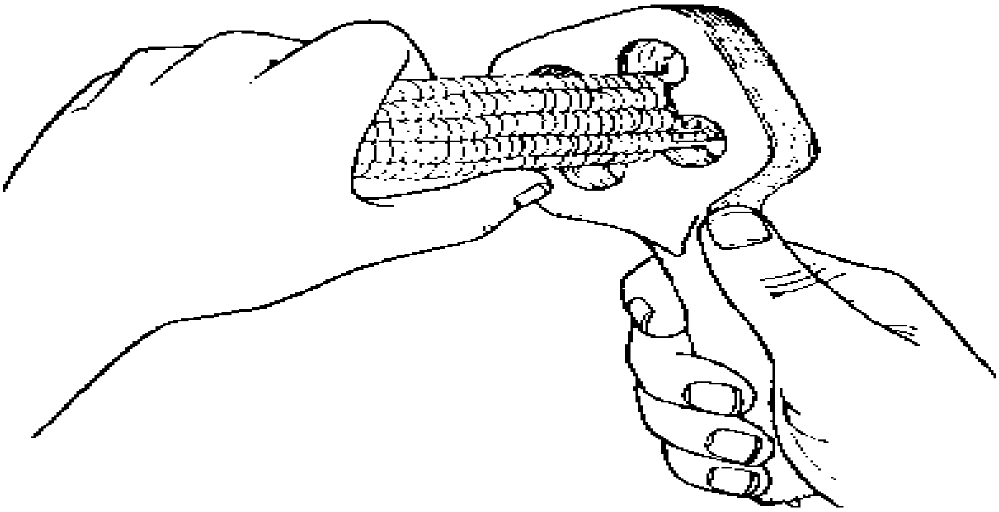
Methods of Shelling Maize

If done too roughly or at too high a moisture content, shelling can cause kernel damage such as tip loss, cracking, stress cracks, and pulverization. Studies have shown that damaged kernels spoil two to five times more rapidly during storage than undamaged ones. Hilysine varieties and other floury types are more susceptible to damage. Shelling methods and guidelines for small farmers include these:

Traditional methods

• **By hand**: This method is very tedious and labor-intensive, but causes little damage to the kernels. It is more thorough than other methods and also allows for separation of damaged and insect-infested grain. This method is best suited to small amounts.

• Beating: Dry ears are placed in bags and beaten with sticks. This is quicker but less thorough than hand shelling and may cause damage.



Wooden, hand-held maize sheller

Improved methods

• **Wooden hand-held maize sheller**: The model shown in the drawing was developed by the Tropical Products Institute and has an output of roughly 80 kg/hour. (Plans are available from ICE.) Other types of hand-held shellers are available commercially. Cobs must be husked first.

• **Hand-cranked or pedaloperated shellers Small**, hand cranked models have outputs of about 50-130 kg/hour. The Ransomes Cobmaster twin-feed pedal-operated sheller has an hourly output of 750-900 kg. For details write Ransomes Ltd., Ipswich 1P3 9QG, England. Maize at too high or too low a moisture content is likely to be damaged, but this can be checked visually. Ears must be husked first.

• Motor-driven shellers have outputs of about 1000-5000 kg/hour. The comments above also apply to this type.

Winnowing Methods

Reliance on wind is the traditional method, but hand-cranked or pedal-driven fans can be constructed easily. The larger models of the hand-cranked or pedaloperated shellers usually are equipped with blowers.

Guidelines for Harvesting and Threshing Sorghum And Millet

Determining Maturity

When grown under favorable conditions and good management, grain sorghum reaches physiologic maturity while the stalks and most of the leaves are still green. Like maize, sorghum kernels also develop a "black layer" at their base when physiologic maturity is reached. The layer can be checked by pinching off some kernels from the bracts that hold them to the head and examining their bases. If present, the black layer can be seen without splitting the kernel. Sorghum flowers and pollinates from the tip of the seedhead downward, a progression which takes from four to seven days. The kernels mature in the same direction, with those at the bottom lagging about a week behind those at the top. Kernel moisture content is about 30 percent at physiologic maturity.

Methods to Harvest Sorghum

• By Hand: The seedheads are cut off using a knife or sickle.

• Mechanical: Tractor driven or self-propelled combine harvesters can harvest and thresh short (dwarf) and medium varieties.

When to Harvest Sorghum

In most sorghum-growing regions in developing countries, maturity often coincides with the start of the dry season, and the crop may be left standing in the field to dry for a number of weeks before harvest. Crop losses during this period can be heavy. If dry conditions prevail, the crop can be harvested at or shortly after maturity and stored on the head with little danger of spoilage. Sorghum can be harvested and threshed with a combine once kernel moisture reaches 25 percent. However, loose grain that is this "wet" must be dried down to around 14 percent within a few days to avoid spoilage. If large amounts of grain are involved, some form of forced air or heated drying would probably be needed.

Methods of Threshing Sorghum

• Traditional methods: These include pounding, beating, and animal trampling and are very tedious except for small quantities. Kernel damage is possible unless care is taken.

• Mechanical methods: Tractoror motor-driven stationary threshers come in many models with outputs of 600-3000 kg/ hour. All but the simplest models will also clean the threshed grain by the use of shaking screens and/or blower fans.

Plans for a four-person pedalpowered grain thresher/mill for sorghum, millet, and wheat designed by VITA can be obtained from ICE. As of 1979, however, this thresher/mill had not been adequately field tested and is not suited to local village construction.

NOTE: Millet is harvested and threshed much like sorghum.

Guidelines for Harvesting and Threshing Peanuts

Peanuts reach maturity when the veins on the inside of the pods turn dark. However, since the plants produce flowers over a period of from 30-45 days, the nuts do not mature simultaneously. Unfortunately, harvesting cannot be delayed until all the nuts have ripened, because heavy losses may occur for two reasons:

• By the time the last pods ripen, many of those which matured earlier will have become detached from the plants due to peg rotting. This pod "shedding" can be especially serious when Cercospora leaf spot causes premature leaf loss or when lifting occurs in dry, hard soils.

• In Spanish-Valencia varieties, the early-maturing kernels may sprout if kept too long in the ground. The Virginia types have a lengthy seed dormancy period which prevents this.

Likewise, if harvesting occurs too early, an undesirably high proportion of the kernels will be immature, shrunken, low in weight, and inferior in flavor. The choice of harvesting date can easily make a 400-500 kg/ha difference on a high yielding crop. How to determine "peak maturity": The farmer should aim for a harvest date that will recover the largest number of mature kernels before excessive pod shedding or sprouting has occured. This is often referred to as "peak maturity", and there are no easy rules for determining it. The pattern of flowering, pod setting, and kernel maturation varies from year to year due to differences in weather and leaf spot incidence. The first 40-60 flowers to bloom are generally the ones that end up as mature kernels at peak maturity. Flowering starts about 30-45 days after plant emergence in warm areas and begins very slowly. In fact, most of these 40-60 flowers usually bloom near the end of the flowering period, although there maybe several "bursts" of flowering.

Peak maturity cannot be determined by looking at the aboveground portion of the plants. The best method is to carefully dig up a few plants every several days beginning near the end of the growing period and examine the pods. With experience, the farmer can learn to estimate quite accurately how many young pods will ripen before the matured pods begin to shed or sprout.

Minimizing crop losses: Pod shedding can be reduced by keeping the plants green and healthy until maturity. This often requires controlling Cercospora leaf spot with fungicide sprays or dusts. This also increases yields by prolonging the growing season by as much as two to three weeks. Some farmers, however, may object to having leafy green foliage at harvest time, since it may slow down the rate of field curing when the harvested bushes are placed in stacks. In this case, farmers may purposely stop their fungicide applications late in the season to promote defoliations. This also has the effect of making maturity more uniform, although yields are reduced. Such a practice may be justified in some regions, especially where field curing weather is not always dry. On the other hand, farmers can use leafy plants for lifestock feed after harvest.

(NOTE: Extension service advise against feeding peanut hay to dairy or beef animals if it has received fungicide applications, except in the case of copper or copper-sulfur products.)

Peanut Harvesting

Whether traditional or modern methods are used, the harvesting process basically consists of four steps:

• The taproots are cut and the plants are pulled (lifted) from the ground with the attached pods.
• Under traditional methods, the plants are cured (dried) in the field for up to 4-6 weeks before threshing. With modern methods, the plants are cured in the field for 214 days, depending on whether artificial drying is available afterwards.
• The pods are threshed from the plants.
• The threshed pods are placed in bags for storage and possible further drying. In dry areas, the pods are often stored in outdoor piles.

Note that shelling the nuts from the pods is not normally a part of the harvesting process, since the kernels dry and store better in the pod. Shelling damage can be high unless kernel moisture is at or below 10 percent.

Methods of "Lifting" the Crop:

• By hand: The plants are pulled from the ground manually after loosening the soil with hand tools. It takes about 30 hours to pull and stack a hectare with this method.

• Animal-drawn methods: Special animal-drawn lifters are available and consist of a sharpened, horizontal blade that is run under the plants right below the nuts to cut the taproots, loosen the soil, and partially lift the plants. One hectare can be lifted and stacked in about 15 hours. A carefully operated weeding sweep (see Chapter 5) about 30-40 cm wide can be used, but the blade should be adjusted to slice rather than push through the soil to minimize pod losses. Some farmers use moldboard or lister plows on ridge-planted peanuts.

• Tractor-drawn methods: Tractors can be equipped with front mounted cutter bars and rear-mounted pullers that lift the plants. Two to four row setups are common, and some of the pullers will combine two or more rows into one windrow for curing. Peanut inverters are available that flip the bushes over to expose the nuts to the sun.

Some General Guidelines for Lifting

• Lifting the crop when the soil is too wet can weaken the pegs. It may cause excessive amounts of soil to adhere to the pods which can also slow down curing.

• Lifting losses can be high in very hard, dry soils.

• If cutter blades are used, they should be kept sharp and be set at a slight forward pitch to aid in lifting the plants and loosening the soil.

Methods for Curing and Threshing Peanuts

The method and length of curing prior to threshing varies considerably with weather conditions and the availability of equipment and artificial methods of drying. The most common methods are:

• The "stackpole" method: This is often used by mechanized and unmechanized farmers alike where curing weather can be wet and no means of artificial drying are available.

Poles are placed firmly in the ground, and two slats are nailed at right angles to each other about 50 cm above ground on each pole. After being allowed to wilt, the plants are stacked around the pole with the pods facing inward. The slats hold the bottom layer off the ground and also improve air curculation. The stack is built in a cone shape and the top covered with a few vines to help shed water. In some cases, the plants are kept in the stacks until kernel moisture is down to 8-10 percent. This may take up to four to six weeks in cool, wet weather.

If harvest takes place at the start of the dry season, the plants may be stacked right on the ground.

• Row or windrow curing: If artificial methods of drying are available or effective sun drying is possible, the plants may be cured in the field in rows or windrows for two to five days before threshing. Where post-threshing drying is less efficient, the curing period lasts about 7-14 days so the pods will be drier at threshing time.

Windrows can be made by hand or through careful operation of a side-delivery rake (tractordrawn). The main advantage of windrows is that they save time when self-propelled modern threshers are used.

The plants can be placed upside down to expose the nuts to the sun. This will reduce damage in wet weather, hut can lower quality under hot, sunny conditions.

Windrows that are overly compact and dense increase curing time and spoilage under wet conditions. After a heavy rain, it may be necessary to gently turn the windrow to prevent mold. This should be done before it dries out to minimize pod shedding. Avoid placing windrows over depressions in the field.

Methods of Threshing

•Traditional: Peanuts can be manually threshed by stripping the pods by hand or by striking the base of the plants (above the pods) against the edge of a barrel or wooden box.

• Improved: A hand-cranked thresher with an output of 200 kg/hr is being marketed in Senegal.

Stationary motor-driven threshers are available. Tractor-drawn or self-propelLed threshers are used in modern farming and pick up the plants right from the windrows.

Threshing Guidelines

• Peanuts can be threshed any time after the plants are lifted as long as adequate natural or artificial drying methods are available (in the case of high-moisture nuts). Further drying will be needed after threshing for peanuts above 10 percent moisture intended for bulk storage and for peanuts above 16 percent intended for storage in loosely stacked bags under good ventilation. Peanut moisture content at lifting may be over 35 percent.

• Tips on mechanized threshing: llull damage and splitting is lowest for peanuts threshed at 25-35 percent moisture. Letting the lifted plants dry down longer in the field reduces post-threshing drying requirements but increases the weather risk. Unless the vines are dry enough to be easily torn apart, rough threshing action may be needed which will increase kernel damage.

Shelling Peanuts

Peanuts are not usually shelled until shortly before consumption or oil extraction. The shelling percentage is about 68 percent (1000 kg of unshelled peanuts yields about 680 kg of shelled kernels), and the process is most easily accomplished when kernel moisture is below 10 percent. Hand shelling is very tedious and the output is only about 10-20 kg/day Various models of hand-cranked or pedal-operated shellers are commercially available with outputs about 15-90 kg/hour.

Plans developed by VITA for a beltdriven peanut huller made from scrap motor vehicle parts are available from ICE; some simple welding and cement work is needed. Power can be supplied by a water wheel, small motor or animal.

Guidelines for Harvesting and Threshing Beans And Cowpeas

Determining Maturity

The pods begin to turn yellow during the final stages of growth and become brown and rather brittle once maturity is reached. Determinate bush varieties and some indeterminate types have fairly even pod maturity, and the plants have usually lost most of their leave< by the time the pods have ripened. Most indeterminate vining types mature much less uniformly, and a good number of pods may ripen while most of the leaves are still green. Seed moisture content is around 30-40 paecent at physiologic maturity.

When to Harvest

Indeterminate varieties with an uneven maturity are usually harvested in several pickings, while determinate bush types are harvested all at once when most of the pods are dry.

Method of Harvesting

The following methods apply to bush or semi-vine varieties with uniform maturity:

• By hand: The mature plants are pulled from the ground and placed in piles for drying. Pulling is best done in the early morning when the pods are moist to prevent shattering.

• Mechanized: Two basic methods are used. The plants are cut or "glided" out of the ground using a tractor with frontmounted horizontal blades with blunt cutting edges or rotating disks operated slightly below the soil surface. Several rows are combined into one windrow using a side-delivery rake which can be rear-mounted behind the cutters. The windrows are dried for 5-10 days before threshing with tractor-drawn or selfpropelled threshers.

Direct harvesting is popular in the U. S. and Canada using grain combines with modifications.

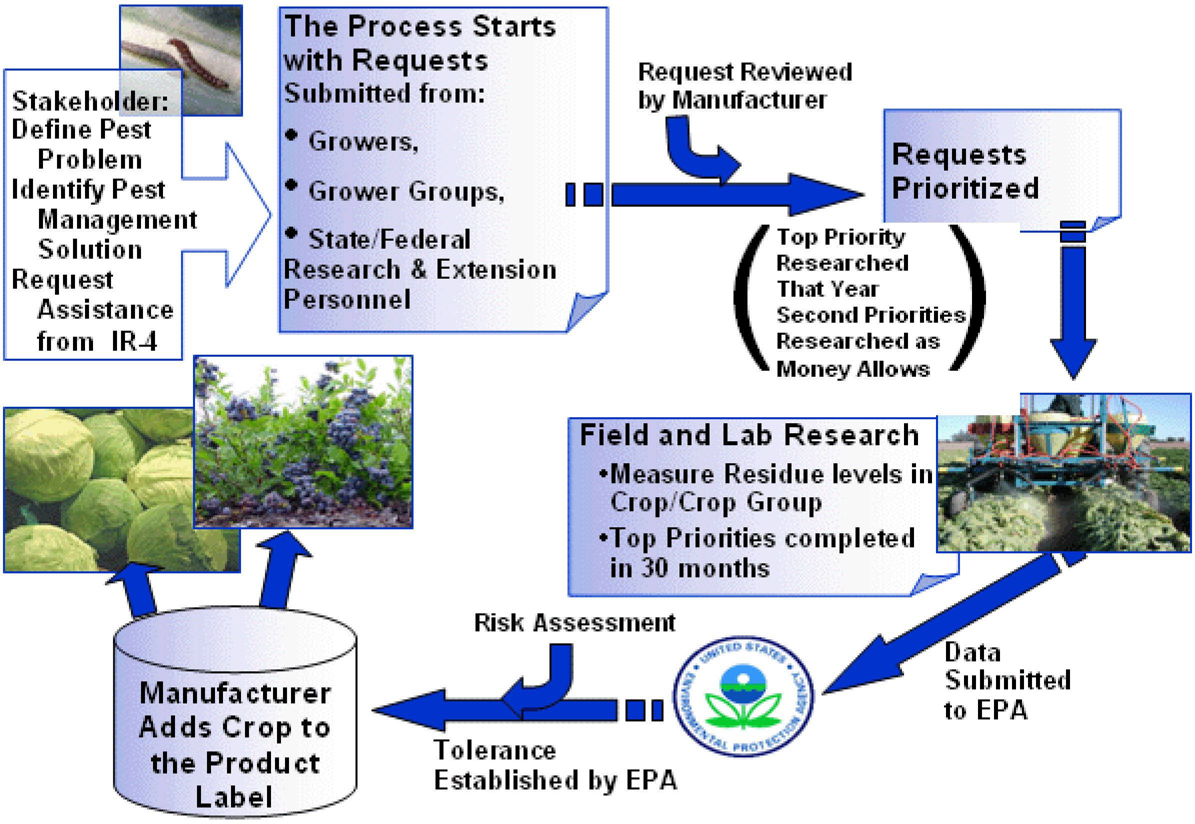
Threshing Methods for Beans

Beans can be threshed manually by beating the plants or bagged pods with sticks once they are dry enough. Whatever the method used, bean seed can be easily injured if threshed too roughly or when too dry. Injured seed, when planted, will produce weak, stunted plants and other abnormalities.

Winnowing beans: Refer to maize.

Biopesticides

Production of Bacillus thuringiensis (Bt) based biopesticide was studied using hydrolysed or raw wastewater sludge as a raw material. The sludge hydrolysis was carried out at different pH (2, 4 and 6). The sludge after hydrolysis was sterilised at 121 degrees C for 30 minutes. The effect of temperature, pH and agitation speed on growth and toxin production was also investigated. The pH in the shake flask was controlled by adding 0.1 M TRIS buffer. The progress of the biopesticide production process was monitored by measuring viable cell count (VC), spore count (SC) and entomotoxicity (Tx). The entomotoxicity was measured against spruce budworm. Control of pH substantially increased the entomotoxicity of the final product. Increased agitation speed resulted in higher VC, SC and Tx values.



STEP I; Production of Mass/Stock Culture of Bioagents
Various agricultural and waste materials viz., seed husk-soil-molasses, saw dust-soil-molasses, baggasse-soil-molasses, leaflitter-molasses, sorghum meal-molasses and sorghum seeds were tested for mass production of biocontrol fungi and bacteria. Based on relative performance of the material tested, sawdust-soil-molases (5%) mixture in the ratio of 15:5:1 was selected to grow mass (stock) culture of bioagents viz., Trichoderma harzianum, Pochonia chlamydosporia and Pseudomonas fluorescens. One kg of the mixture was filled in heat resistant polybags. The bags were sealed and steam sterilized at 15 kg/cm2 pressure at 121° C. for 15 minutes. For trichoderma harzianum and pochonia chlamydosporia, chloramphenicol 10 mg/kg material and for P. fluorescens 45 mg novoboicin, 44.9 mg penicillin and 75 mg cycloheximide was added to the 1 kg material. There after the bags containing 1 kg autoclaved sawdust-soil-molasses mixture were inoculated with homogenized pure culture of the bioagent (5 ml/bag) by sterilized needle and syringe. A puncture made

in the polybag to insert the needle was released by cellotape. Pure culture of Trichoderma harzianum and Pochonia chlamydosporia were prepared in potato dextrose broth supplemented with chloramphenicol 10 mg/litre and pseudomonas fluorescens in Kings B broth supplemented with 45 mg novobiocin, 44.9 mg penicillin and 75 mg cycloheximide per litre. The bag was resealed and incubated at room temperature (30-35° C.) or at 25±2° C. in an incubator for 10-15 days (fungi) and 35±2° C. for 5 days (bacteria) in an incubator. During incubation the bag were shaken daily for a few minutes to achieve uniform colonization by the bioagents on the material. Luxurient and uniform colonization by the bioagents occurred with in the incubation duration of 5-15 days.

STEP II: Immobilization of Bioagents

After preliminary screening of molasses-lignite-stillage granules, alginate-bran-fermenter biomass pellets, alginate-clay pellets, diatomacious molasses-soil pellets, sawdust-soil-molasses fermenter biomass, seek husk-sand-molasses fermenter biomass.

charcoal powder/pyrex (talc) fermentor biomass powder, fly ash fermenter biomass powder, sodium alignate pellets of liquid fermenter biomass etc., to support survival and multiplication of biocontrol fungi and bacteria four carriers viz., talc, charcoal, fine clay and flyash were selected for further study (FIG. 1 of the accompanying drawings). The stock culture of biocontrol fungi viz., Trichoderma harzianum and Pochonia chlamydosporia was mixed in the above mentioned four carriers and 5% molasses in the ratio of 1:0:1, 1:5:1, 1:10:1, 1:15:1 and 1:20:1 and supplemented with 10 mg chloramphenicol/kg formulation and was incubated at 25±2° C. in an incubator for 10 days. For pseudomonas fluorescens the carrier was supplemented with novobicoin (45 mg), penicillin (44.9 mg) and cycloheximide (75 mg/kg carrier) and then mixed with the stock culture and incubated at 35±2° C. for 15 days. After incubation CFU load/g formulation was determined using the dilution plate method which has been presented in FIG. 1. The fly ash based formulation revealed highest CFU count in comparison to the other materials used. The CFU load of T. harzianum, P. chlamydosporia and P. fluorescens on fly ash was increased by 31-117%, 19-40% and 23-71% in fly ash compared to the stock culture or other carriers, respectively (FIG. 1).

Final Composition of the Biopesticides

A mixture of flyash, soil (loam) and 5% molasses in the ratio of 15:3:1 plus chloramphenicol formulation for biocontrol fungi or 45 mg novobiocin, 44.9 mg penicillin and 75 mg cycloheximide formulation for biocontrol bacteria was used as a carrier to immobilize Trichoderma harzianum, Pochonia chlamydosporia and Pseudomonas fluorescens. The fly ash was collected from a coal fired thermal power station, Kasimpur, Aligarh, where bituminous coal is burnt. Some of the important physico-chemical characteristics of the ash were: pH 8.9, conductivity 7.6 m mhos/cm, cation exchange capacity 9.3 m mhos/cm, sulphate 9.72%, carbonate 1.07%, bicarbonate 2.60%, chloride 1.85%, nitrogen 0.00%, phosphorus 0.093%, potassium 0.82%, calcium 1.06%, magnesium 0.90%, manganese 64.5 mg/g, copper 117.8 mg/g, zinc 85.1 mg/g and boron 198.5 mg/g. The ash soil mixture was solarized under thin and transparent polythene sheet for five days (+38° C. ambient temperature) or filled in heat resistant polybags and autoclaved at 15 kg/m2 pressure at 121° C. for 15 minutes. Thereafter, 1 part stock culture was added to the bags containing 20 parts carriers (ash-soil mixture) and shaken for uniform distribution. The bags were sealed and incubated for 10-15 days at room temperature (25-35° C.) or inside an incubator at 25±2° C. for T. harzianum and P. chlamydosporia and 35±2° C. for P. fluorescens. After incubation number of colony forming units (CFUs)/g formulation was determined using dilution plate method. The ratio of 20 parts carrier and one part stock culture was found to be the best in comparison to 5:1, 10:1 and 15:1. The formulations were packed in airtight polypacks of 200, 500 and 1000 g.

Fumigation

Fumigation is the treatment of a structure to kill pests such as wood-boring beetles by sealing it or surrounding it with an airtight cover such as a tent, and fogging with liquid insecticide for an extended period, typically of 24–72 hours. This is costly and inconvenient as the structure cannot be used during the treatment, but it targets all life stages of pests.[32]

An alternative, space treatment, is fogging or misting to disperse a liquid insecticide in the atmosphere within a building without evacuation or airtight sealing, allowing most work within the building to continue, at the cost of reduced penetration. Contact insecticides are generally used to minimise long lasting residual effects umigation is a method of pest control that completely fills an area with gaseous pesticides—or fumigants—to suffocate or poison the pests within. It is used to control pests in buildings (structural fumigation), soil, grain, and produce, and is also used during processing of goods to be imported or exported to prevent transfer of exotic organisms. This method also affects the structure itself, affecting pests that inhabit the physical structure, such as woodborers and drywood termites.[1]
Process[edit]

Fumigation generally involves the following phases: First the Homeowner will have to put all their food in fume bags to prevent the loss of good food. Second the area intended to be fumigated is usually covered to create a sealed environment; next the fumigant is released into the space to be fumigated; then, the space is held for a set period while the fumigant gas percolates through the space and acts on and kills any infestation in the product, next the space is ventilated so that the poisonous gases are allowed to escape from the space, and render it safe for humans to enter. If successful, the fumigated area is now safe and pest free.

Baur, Fred. Insect Management for Food Storage and Processing. American Ass. of Cereal Chemists. pp. 162–165. ISBN 0-913250-38-4.
Jump up^ Messenger, Belinda; Braun, Adolf (2000). "Alternatives to Methyl Bromide for the Control of Soil-Borne Diseases and Pests in California" (PDF). Pest Management Analysis and Planning Program. California Department of Pesticide Regulation. Retrieved March 1, 2016.
Jump up^ Decanio, Stephen J.; Norman, Catherine S. (2008). "Economics of the "Critical Use" of Methyl bromide under the Montreal Protocol". Contemporary Economic Policy. 23 (3): 376–393. doi:10.1093/cep/byi028.

Seed Dressing Technique

Seed treatment describes both products and processes. Using specific products and specific techniques can improve the growth environment for the seed, seedling, and young plant. Seed dressing is the most common method of seed treatment. The seed is dressed with either a dry formulation or wet treated with a slurry or liquid formulation of the seed treatment chemicals. Dressings are applied both industrially and on-farm. Seed treatment comprises priming, coating, pelleting, phytosanitary treatment, and microbial inoculation. The seed treatment techniques continue to evolve.

Pesicide Dosage Calculation

Calculation based on pesticides

Being highly toxic, pesticides are not sold in its pure form. They are subjected to dilute with any carrier to avoid the hazards of poisoning to applicator or human being. The pure forms or technical grades are only used in analytical and toxicological studies. Pesticides are commercially manufactured in various formulations (by adding various additives) like emulsifiable concentrates, water-dispersible powders, dusts, granules, solutions etc. The strength or active ingredient is mentioned on the label.

What is active ingredient?

It is the chemical in commercial products which is directly responsible for its toxic effect.

What is acid equivalent?

It refers to the formulation that theoretically can be converted to the parent acid. Some herbicides are active organic acids like phenoxy acetic acid, picloram & chloramben and some are generally supplied in the form of their salts and esters as in 2, 4-D.

Let us see some commercially available pesticides

Insecticides: Endosulfan 35EC, Malathion 50EC, Metasystox 25EC, Dimethoate 30EC, Phorate 10G, Carbafuron 3G,

Herbicides: Atrazine 50 WP, Simazine 60 WP, Paraquat 24WSC, Fluchloralin 45EC, Alachlor 50EC or 100G, Butachlor 50EC or 5G, Glyphosate 41WSC, Propanil 35EC, 2, 4-D Ethyle ester 18 & 35%, 2, 4-D Amine salt 58 & 72%, 2, 4-D Sodium salt 80 & 85P etc.

Fungicides: Carbendazim 50 SC, Carbendazim 50 WP, Copper Oxychloride 50WP, Difenconazole 24.9EC, Dithianon 5, 10EC, Dithianon 5SC, Hexaconazole 5, 10EC, Hexaconazole 5 SC, Mancozeb 80, 75 WP, Miclobutanil 10 WP, Propiconazole 10, 25 EC, Tebuconazole 24.9 EW, Tricyclozole 75 WP etc.

Pesticides are recommended in three ways for its field application such as amount of pesticides per hectare (kg/ha), amount of active ingredient or acid equivalent per hectare (kg a.i./ha) and concentration of solution to be applied (eq 0.07 % of endosulfan).

Before application or purchase of pesticides it is always strike in the mind of farmers that how much amount of insecticides or herbicides or fungicides etc would be required for application on their farm of definite size so that he could parches only the required amount . Let us see the methods for calculating the pesticide dose with some example.

If recommended as kg a.i./ha:

Rate of herbicides is given mainly in terms of a.i. or a.e. /ha

Rate of application

Quantity of material required per hectare = -------------------------------- X 100
Active ingredient in %

Example: Find out the quantity of simazine 80WP to be sprayed in one hectare area if rate of application is 3 kg a.i. /ha

Quantity of simazin/ha =3/80 x 100 = 3.75 kg WP/ha

For the calculation of this type we must know the a. i. present in the commercial product.

If recommended as kg/ha:

Experience has shown that to spray one hectare with a hydraulic nozzle sprayer in good working condition and a 15 liter sprayer, one will need 300 liters of solution, i.e. 20 sprayer loads.

Example: To control grasses, 5 liter of propanil should be applied per hectare. Its mean

1 liter = 1000 ml

20 sprayers (15 L each) per ha

5000 ml/ 20 = 250

i.e. 250 ml per 1 small Kap-sac sprayer and 20 loads will be required.

If recommended as per cent concentration:

By Formulae

$$\text{Amount of pesticide} = \frac{\text{Volume of spray solution (liter)} \times \text{Per cent strength of pesticide solution to be sprayed}}{\text{per cent strength of pesticide given (a.i./l or kg)}}$$

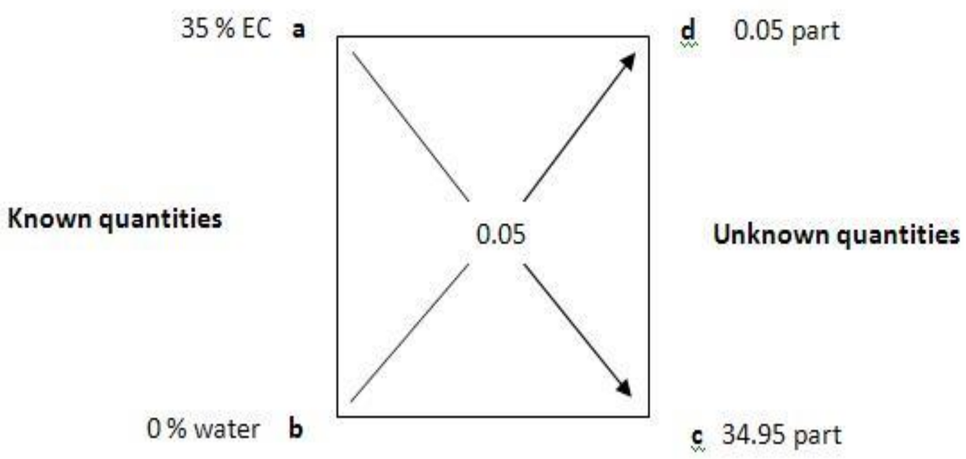
Example: Amount of malathian 25 EC when applied as 0.025 per cent solution

$$= \frac{300 \times 0.025}{25}$$

$$= 0.3 \text{ liter or } 300 \text{ ml/ ha}$$

By Pearson's square method:

Example: To prepare 0.05 per cent mixture from endosulfan 35EC.



To get the required amount of insecticide and water, substract the smaller figure from the higher ones (i.e., 0.05-0=0.05 and 35-0.05=34.95), diagonally.
Put 0.05 opposite EC at **d** and 34.95 opposite water at **c** point.
This mean that to make 0.05 % solution out of the endosulfan 35 EC, we have to require 0.05 part of endosulfan + 34.95 part of water.

Safety in the Use of Pesticides

- Make sure kids, pets, and anyone non-essential to the application is out of the area before mixing and applying pesticides.
- Be sure to wear clothing that will protect you when using pesticides. Consider wearing a long sleeve shirt, long pants, and closed-toe shoes in addition to any other protective clothing or equipment required by the label.
- Mix pesticides outdoors or in well-ventilated areas.
- Mix only what you need to use in the short term to avoid **storing or disposing** of excess pesticide.
- Be prepared for a **pesticide spill**. Have paper towels, sawdust or kitty litter, garbage bags, and non-absorbent gloves on hand to contain the spill. Avoid using excessive amounts of water, as this may only spread the pesticide and could be harmful to the environment.
- Read the first aid instructions on the label before using the product. Have the telephone number for the Poison Control Center (1-800-222-1222) available in case you have additional questions.
- Remove personal items, such as toys, clothing, or tools from the spray area to avoid contamination.
- When spraying pesticides indoors, make sure the area is well ventilated.
- When applying pesticides as a spray or dust outside, avoid windy conditions and close the doors and windows to your home.
- After using pesticides, wash your hands before smoking or eating.
- Evaluation of disease severity and/or disease incidence is crucial to many phytopathological studies. Disease severity is defined as the 'area of a sampling unit affected by disease, expressed as a percentage or proportion of the total area', while disease incidence is defined as the 'number of plant units sampled that are diseased expressed as a percentage or proportion of the total number of units assessed' (10). The amount of disease, either expressed as severity or incidence, is referred to as disease intensity (10) . Incidence is used in pathosystems in which a single lesion per plant is critical, as well as for many wilt and systemic virus diseases (4). On the other hand, severity is more difficult to estimate, but it is used in many pathosystems, such as potato late blight (LB), to conduct research related to disease management (4).
- Severity can be estimated with special equipment or with the naked eye. The use of equipment (e.g. 11) is normally too expensive or too labor-intensive for large-scale disease evaluations (5). For this reason, severity of foliar diseases is generally estimated visually.
- Scales have been developed to improve visual estimation of severity for many diseases (see Campbell and Madden 4). Different scales can be compared based on the accuracy and precision of their estimates. Accuracy is defined as the 'measure of the closeness of an estimate (disease assessment) to the true value', and precision is defined as a 'measure of reliability and/or repeatability of disease assessments' (10). Hau (cited in Campbell and Madden 4) proposed the following method to determine

the accuracy and precision of disease severity estimates: plant units with known severity are assessed by an evaluator with no previous knowledge of the actual severity. The estimates are then regressed on the actual values with a no-intercept model (regression through origin). The slope of the regression represents the accuracy: the closer to 1.0, the more accurate the estimation made by the evaluator. Precision is directly related to the coefficient of determination (r2).

- Severity of LB is routinely evaluated using two types of scales: Horsfall-Barratt scales (Table 1) and direct percentage. Horsfall and Barratt (7), through application of the Weber-Fechner law to visual assessment of disease severity, proposed that the human eye would estimate high and low disease severities with greater precision than mid range severities (5). To correct this problem, they suggested that scale increments should be logarithmic rather than linear (5). On the other hand, the percentage scale estimates disease severity directly. Forbes and Korva(5) compared a Horsfall-Barratt scale formerly used in the International Potato Center (CIP) and direct percentage on LB under field conditions. They found that evaluators tended to linearize the Horsfall-Barratt scale and, therefore, direct percentage estimation was more accurate. The Horsfall-Barratt scale used at CIP has intervals that double in size until 50% infection and then reduce in size symmetrically (Figure 1) (5). Intervals on the scale are roughly similar to unit intervals of the linearizing transformation for the logistic model (or logit = ln [x /(100 ? x)], where x = percentage severity 5).

- ***Table 1. Horsfall-Barratt scale formerly used at the International Potato Center to estimate severity of potato late blight (5).***

Class	Disease severity (%)	Value to convert back to % (midpoint)
1	0	0
2	> 0 to 2.5	1.25
3	> 2.5 to 10	6.25
4	> 10 to 25	17.5
5	> 25 to 50	37.5
6	> 50 to 75	62.5
7	> 75 to 90	82.5
8	> 90 to 97.5	93.75
9	> 97.5 to 100	98.75

- An example of a percentage scale used to evaluate LB severity is the 'modified blight rating system' developed by W. E. Fry and co-workers (unpublished data) (Table 2). This scale was based on data reported by Fry (6), James (8), and the British Mycological Society (3). The methodology to estimate LB severity consists in dividing the plot (experimental unit) in small quadrants, each containing 20 to 25 plants. The percentage of infected tissue is then estimated in each quadrant according to Table 2, and averaged to obtain the estimated severity in the plot. The number of quadrants to be evaluated varies according to plot size: in 4.5 x 4.5 m plots containing 100 plants, the number of quadrants is 4 (6), i.e., 80 to 100 plants are evaluated. In bigger plots, the number of quadrants to be evaluated depends on the variability in disease distribution: more variability, more quadrants. This scale was developed for epidemics in which the first symptoms appeared when plants had about 200 leaves (6) (approximately two-month old plants), but it has been used successfully with younger plants (1,2). The modified blight rating system may be used just as a reference, because there is evidence suggesting that it is better to simply estimate the percentage of foliage (everything green: stems, leaves, etc.) which is affected by disease rather than using some kind of scale (5).

Table 2. Modified blight rating system used to estimate severity of potato late blight (W. E. Fry and co-workers, unpublished data). See text for references

Severity (%)	Description
0.01	Two to five leaflets per 10 plants affected. About five large lesions per quadrant (20 to 25 plants).
0.1	About five to 10 infected leaflets per plant, or about two affected leaves per plant.
1.0	General light infection. About 20 lesions per plant, or 10 leaves affected per plant, or 1 in 20 leaves affected severely.
5	About 100 lesions per plant. One in 10 leaflets affected, up to 50 leaves affected.
25	Nearly every leaflet infected but plants retain normal form. Plants may smell of blight. Field looks green although every plant is affected.
50	Every plant is affected and about 50% of the leaf area is destroyed. Field appears green flecked with brown.
75	About 75% of the leaf area destroyed. Field appears neither predominantly green nor brown.
95	Only a few leaves on plants, but stems are green.
100	All leaves dead, stems dead or dying.

- Visual estimation of disease severity is subject to an important source of error. The portion of the disease that is really evaluated is the one that has produced visible symptoms and that is still on the plant. Symptomless tissue and infected leaves that had fallen off are not evaluated. This is an important consideration when severity is used as a criterion to decide an intervention (e.g., fungicide application), because the estimated severity may be much lower than the actual severity.

Cractical Considerations for Estimating LB Severity
Practical considerations for estimating foliage late blight severity in the field
Estimation of severity is crucial to study epidemics of potato late blight (LB) (see Estimation of Disease Severity). Severity is used to graph disease progress curves and to calculate epidemic descriptors, such as the area under the disease progress curve (AUDPC) and the apparent infection rate (*r*) (see Summarizing the

Epidemic). Several questions may be raised when estimating foliage LB severity in the field.

What method to use? The International Potato Center (CIP) recommends simply estimating the percentage of foliage affected by LB. Illustrated keys for whole plants (Figure 1, 4) or leaves (Figure 2, 8) can be used as reference. The modified blight rating system (see Estimation of Disease Severity can be used if greater precision is required. Readings across the season in a certain experiment should be done by the same person to avoid inter-assessor variability.

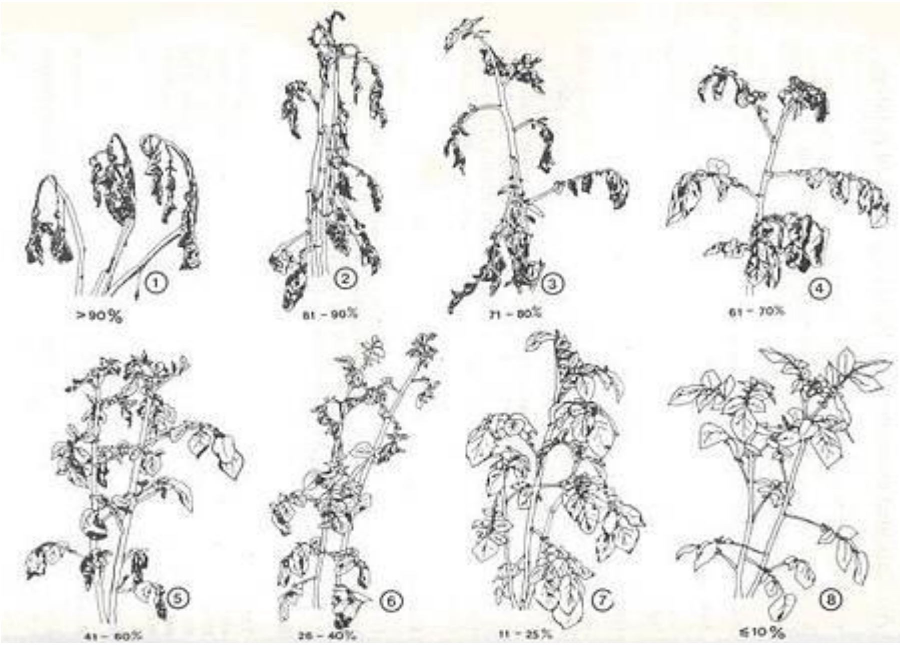


Figure 1. Key to evaluate percent infection of late blight in potato plants. Reproduced from Cruickshank et al. (4).

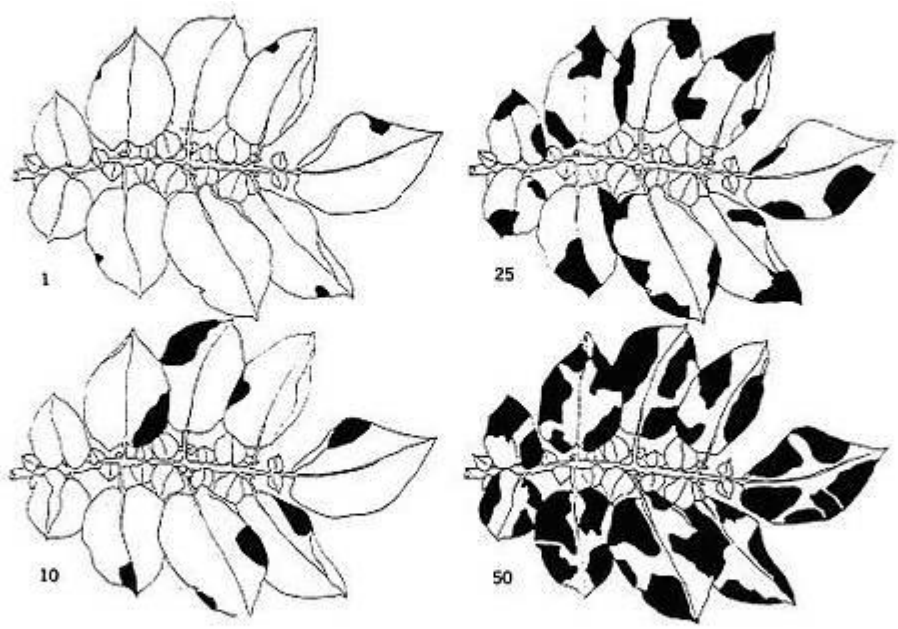


Figure 2. Key to evaluate percent infection of late blight in potato leaves. Reproduced from James (8).

Severity is estimated in each experimental unit several times across the growing season. The results are written in a datasheet (Table 1) preferably printed in dark tone paper to avoid reflection of sunlight. If possible, the evaluations should be made early in the morning or in overcast days, because excessive sunlight may difficult the readings (7). Depending on the size of the experimental unit and the variability within it, it may be possible to take more than one reading per unit and use the average for the calculation of descriptors. In that case, the experimental unit could be divided into quadrants (Table 2) as described by Fry (5) (seeEstimation of Disease Severity). Also, it is best to record readings independently (i.e., without knowing the value given at the previous reading) at each date, such as having someone else write in the field book or by using a cassette recorder (7).

Table 1: Datasheet for evaluation of potato late blight severity (%) in an experiment with 2 treatments, 3 repetitions, and 3 evaluation dates

Treatment	Repetition	15-aug	30-aug	15-jul
A	1	0	1	5
A	2	0	3	5
A	3	0	1	5
B	1	0	0	1
B	2	0	0	3
B	3	0	0	1

Table 2: Datasheet for evaluation of potato late blight severity (%) in an experiment with 2 treatments, 3 repetitions, 4 quadrants per repetition, and 3 evaluation dates

Treatment	Repetition	Quadrant	15-aug	30-aug	15-jul
A	1	1	0	3	10
A	1	2	0	1	5
A	1	3	0	0	5
A	1	4	0	0	0
A	2	1	0	5	10
A	2	2	0	1	3
A	2	3	0	1	3
A	2	4	0	5	5
...	...	...	...	...	...
B	3	1	0	1	1
B	3	2	0	0	1
B	3	3	0	0	1
B	3	4	0	0	1

It is recommended to confirm that what it is being evaluated is indeed LB. Other diseases (e.g., early blight), frost, and herbicides cause necrosis that may be misinterpreted as LB (7). Inexperienced evaluators may use field microscopes to verify the presence of sporangia and sporangiophores. In closed canopies, it is advisable to take a closer look within them, because there is usually more disease in the lower than in the upper leaves.

When to start? The time to start the severity readings depends on the objective of the experiment and on weather conduciveness for LB. Depending on the objective of the experiment, severity readings should start before the initiation of disease or as soon as the symptoms appear. In experiments for validation of LATEBLIGHT, a LB simulator (1), it is critical to have an accurate estimation of the time when disease starts and initial severity (2). Therefore, severity readings should start before the initiation of disease. In experiments for evaluation of treatments to control LB (e.g., potato genotypes, fungicides, etc.), severity readings should start as soon as the symptoms appear. Otherwise, part of the disease progress curve of the less effective treatments would not be considered and epidemic descriptors, such as AUDPC, would be biased.

Weather conduciveness for LB also determines the time to start the severity readings. In locations/seasons with very conducive weather (and inoculum available), LB can appear a few days after plant emergence (2). Thus, it is advisable to start the readings as soon as the plants emerge. In locations/seasons with less favorable weather, there is no a defined moment to start the severity readings and frequent scouting is required.

How many readings? The number of severity readings depends on the objective of the experiment and on the expected speed of the epidemic. If the objective of the experiment is to evaluate resistance of many potato genotypes against *P. infestans* and AUDPC is used as epidemic descriptor, then the number of readings could be as low as 2 (6,9). The first severity reading must be made shortly after the epidemic has started, and the second when the epidemic has reached its peak (100% severity) in the most susceptible genotypes (6). Using 2 severity readings is recommended when time and economic resources are tight, but there are two conditions that must be met: (i) the period of time that disease is present must be the same for all the genotypes, and (ii) the disease must progress as a sigmoid curve (6).

In experiments in which non-sigmoid progress curves are expected (e.g., in experiments to test fungicides), or in those in which an accurate estimation of disease progress curves is needed (e.g., in the validation of a disease model), the number of severity readings depends on the expected speed of the epidemic. In locations/seasons with very conducive weather for LB and susceptible potato genotypes, a high level of disease (e.g. 50% blight severity) may be reached in a few days (3) and, therefore, severity should be evaluated frequently (5 to 7 days). In locations/seasons with less favorable weather and/or resistant genotypes, 50% blight severity may be reached in a longer period (3), and the interval between evaluations can be longer (10 to 14 days).

The intervals between evaluations are flexible, especially if AUDPC is being used as epidemic descriptor. If an accurate estimation of disease progress curves is needed, then the intervals are still flexible, though it is advisable to try to keep them constant.

When to finish? It depends on the objective of the experiment and the variables to evaluate the treatments. In experiments to evaluate the resistance of potato genotypes against *P. infestans* by using AUDPC and/or *r*, the severity readings should be finished when the most susceptible genotypes reach 100% severity. If readings are taken too long after susceptible genotypes reach 100%, the differences in AUDPC between resistant and susceptible genotypes may be underestimated. In the case of *r*, the logistic transformation is undefined at severity values of 100%.

In experiments in which the efficacy of a certain treatment (e.g., potato genotype, fungicide, etc.) is evaluated by measuring yield, or in those to validate a disease model, it is advisable to continue the severity readings until plants in LB-free treatments start to senesce. These treatments are obtained usually with continuous applications of fungicides against *P. infestans*.

References/Further Reading

Andrade-Piedra, J. L., Hijmans, R. J., Forbes, G. A., Fry, W. E., and Nelson, R. J. 2005. Simulation of potato late blight in the Andes I: Modification and parameterization of the LATEBLIGHT model. Phytopathology (in press).

Andrade-Piedra, J. L., Hijmans, R. J., Juárez, H. S., Forbes, G. A., Shtienberg, D., and Fry, W. E. 2005. Simulation of potato late blight in the Andes II: Validation of the LATEBLIGHT model. Phytopathology (in press).

Andrade-Piedra, J. L., Forbes, G. A., Shtienberg, D., Grünwald, N. J., Chacón, M. G., Taipe, M. V., Hijmans, R. J., and Fry, W. E. 2006. Qualification of a plant disease simulation model: Performance of the LATEBLIGHT model across a broad range of environments. Phytopathology (in press).

Cruickshank, G., Stewart, H. E., and Wastie, R. L. 1982. An Illustrated Assessment Key for Foliage Blight of Potatoes. Potato Res. 25:213-214.

Fry, W. E. 1977. Integrated control of potato late blight: Effects of poligenic resistance and techniques of timing fungicide applications. Phytopathology 67:415-420.

Haynes, K. G., and Weingartner, D. P. 2004. The use of area under the disease progress curve to assess resistance to late blight in potato germplasm. Am. J. Potato Res. 81:137-141.

Henfling, J. W. 1987. Late blight of potato, *Phytophthora infestans* Technical Information Bulletin 4. International Potato Center, Lima.

James, C. 1971. An illustrated series of assessment keys for plant diseases, their preparation and usage. Canadian Plant Disease Survey 51:39-65.

IJeger, M. J., and Viljanen-Rollinson, S. L. H. 2001. The use of the area under the disease-progress curve (AUDPC) to assess quantitative disease resistance in crop cultivars. Theor. Appl. Genet. 102:32-40.

Sample SOP: Cleaning and Sanitizing Surfaces, Tools, and Equipment

1—Purpose
Describes how food contact surfaces, tools, and equipment are to be cleaned and sanitized.
2—Scope
Applies to farm and packinghouse personnel including farm owners and workers.
3—Responsibility
Workers are responsible for following the SOPs to properly clean and sanitize food contact surfaces.
Farm owners and food safety managers are responsible for training the workers on proper technique, providing necessary resources such as tools, detergents and sanitizers, and making sure the cleaning and sanitizing steps are followed correctly.
4—Materials
- Detergent name, brand, and concentration (labeled for use on food contact surfaces) ***[Provide name here]***
- Sanitizer name, brand, and concentration ***[Provide name here]***
- Container(s) as needed for mixing and using detergent(s) and sanitizer(s) or for washing tools
- Brushes, sponges, or towels for scrubbing tools and equipment
- Clean water (microbial equivalent to drinking water)

5— Procedure
1. The surface should be brushed or rinsed to remove visible dirt and debris.
2. Prepare the detergent ***[Add detergent mixing or preparation instructions here]***.
3. Apply the prepared detergent solution and scrub the surfaces moving in the direction top to bottom for large pieces of equipment. Detergent should be mixed according to the product instructions.
4. Rinse the surface with clean water until all soap suds are rinsed away moving in the direction top to bottom for large pieces of equipment.
5. Prepare the sanitizer. ***[Add sanitizer mixing or preparation instructions here]***.
6. Apply the prepared sanitizer solution. Allow it to sit for ***[Enter number of minutes according to product instructions]*** minutes.
7. Rinse with clean water.
8. Let the surface air dry.