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ABSTRACT

This reference manual for training Peace Corps agricultural development workers deals with crops. The document begins with common units of area, length, weight, volume, and conversions between them. A practice problem is worked and other conversion problems are given. The second section is intended to show agricultural field workers how to survey and interpret the important features of a local agricultural environment and the individual farm units that are part of the environment. Section 3 is a guide to troubleshooting common crop problems. Section 4 offers guidelines for vegetable growing. Section 5 is an introduction to insects and insect control. Section 6 discusses nonchemical pest controls. Using chemical insecticides is the subject of section 7. Section 8 covers disease control. Section 9 discusses nematodes. Section 10 deals with weed control. An annotated bibliography suggests four vegetable-related references to be ordered for each trainee and references on vegetables and field crops to be placed in a training center library. Included among those library references are 7 on vegetables, 20 on insects, diseases, weeds, and nematodes; 3 on soil management and fertilizer use; 2 on irrigation; 13 on field crop production; 3 on root and tuber crops; 1 on tropical agriculture; and 2 on agriculture extension. (CML)

T-38D

TECHNICAL GUIDELINES AND REFERENCES:

CROPS TRAINING COMPONENT

From:

Agricultural Development Workers

Training Manual

Volume III: Crops

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CHAPTER III: TECHNICAL GUIDELINES AND REFERENCES FOR THE CROPS TRAINING COMPONENT

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COMMON UNITS OF MEASURE AND CONVERSIONS

Area

1 HECTARE = 10,000 sq. meters = 2.47 acres = 1.43 manzanas (Central America)

1 ACRE = 4000 sq. meters = 4840 sq. yards = 43,500 sq. ft. = 0.4 hectares = 0.58 manzanas (Central America)

1 MANZANA (Central America) = 10,000 sq. varas = 7000 sq. meters = 8370 sq. yards = 1.73 acres = 0.7 hectares

Length

1 METER = 100 cm = 1000 mm = 39.37" = 3.28 ft.
1 CENTIMETER = 10 mm = 0.4"
1 INCH = 2.54 cm = 25.4 mm
1 VARA (Latin America) = 32.8" = 83.7 cm
1 KILOMETER = 1000 m = 0.625 miles
1 MILE = 1.6 km = 1600 m = 5280 ft.

Weight

1 KILOGRAM = 1000 g = 2.2 lbs. = 35.2 oz.
1 POUND = 16 oz. = 454 g = 0.454 kg
1 OUNCE = 28.4 g
1 METRIC TON = 1000 kg = 2202 lbs.
1 LONG TON = 2240 lbs; 1 SHORT TON = 2000 lbs.
1 QUINTAL = 100 lbs. (Latin America); 112 lbs. (British); 100 kg (metric)

Volume

1 LITER = 1000 cc = 1000 ml = 1.06 U.S. quarts
1 GALLON (U.S.) - 3.78 liters = 3780 cc (ml)
1 FLUID OUNCE = 30 cc (ml) = 2 level tablespoons (measuring type)[1]
= 6 level teaspoons (measuring type)[2]

Miscellaneous Conversions

Lbs./acre x 1.12 = kg/hectare; lbs./acre x 1.73 = lbs./manzana
Kg/hectare x 0.89 = lbs./acre; kg/hectare x 1.54 = lbs./manzana
Lbs./manzana x 0.58 = lbs./acre; lbs./manzana x 0.65 = kg/hectare
Temperature: C° = (F° - 32) X 0.55
F° = (C° x 1.8) + 32

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1. With liquids, 1 level tablespoon equals 18 cc (ml) due to surface tension.

2. 1 level teaspoon (measuring type) = 5 cc with solids; 6 cc with liquids.

HOW TO CONVERT YIELDS FROM A SMALL PLOT BASIS TO A KG/HECTARE OR LBS./ACRE BASIS

Sample problem: Poro tells you that she harvested 130 kg of tomatoes off a plot measuring 8 x 10 meters, but her friend Suheyla says her own plot yielded 75 kg and measures 5 x 6 meters. What are the relative yields in terms of kg/ha?

Solution: The easiest way is to set up a proportion like so:

$$\frac{\text{plot area in } M^2}{10{,}000\ M^2} = \frac{\text{yield of plot in kg}}{\text{kg/ha yield}}$$

In Pora's case:

$$\frac{80\ M^2}{10{,}000\ M^2} = \frac{130\ \text{kg}}{\text{kg/ha yield}}$$

Cross multiply: 80 x kg/ha yield = 10,000 x 130

$$\text{kg/ha yield} = \frac{10{,}000 \times 130}{80}$$

kg/ha yield = 16,250 for Pora

In Suheyla's case:

$$\frac{30\ M^2}{10{,}000\ M^2} = \frac{75\ \text{kg}}{\text{kg/ha yield}}$$

$$\text{kg/ha yield} - \frac{75 \times 10{,}000}{30}$$

kg/ha yield = 25,000 for Suheyla

Alternate Method: Use this formula:

$$\text{Yield in kg/ha} = \frac{10{,}000 \times \text{plot yield in kg}}{\text{plot area in } M^2}$$

What about lbs/acre?: The English system is more cumbersome since an acre equals 43,560 sq. ft. or 4840 sq. yards. However, you can use 4000 sq. meters which is close enough (1 acre actually equals 4050 sq. meters). Work the lbs/acre problems in the same way as above.

UNITS OF MEASURE PRACTICE PROBLEMS

1. 15 acres = _____ HECTARES
2. 5 Hectares = _____ ACRES
3. 8000 M^2 = _____ HECTARES
4. 60 cm = _____ INCHES
5. 1500 mm = _____ INCHES
6. 6 inches = _____ cm
7. 100 km = _____ MILES
8. 40 miles = _____ km
9. 10 meters = _____ FEET
10. 20 feet = _____ METERS
11. 50 kg = _____ LBS.
12. 1000 lbs. = _____ kg
13. 12 ounces = _____ GRAMS
14. 800 g = _____ LBS.
15. 5 gallons = _____ LITERS
16. 10 liters = _____ gallons
17. 10 fl. oz. = _____ cc (ml)
18. 120 cc (ml) = _____ fl. oz.
19. 30°C = _____ °F
20. 100°F = _____ °C

ANSWERS: 1) 6 ha 2) 12.5 acres 3) 0.8 ha 4) 23.6" 5) 60" (59")
6) 15" (15.2) 7) 62.5 miles 8) 64 km 9) 32.8 ft. 10) 6.1 meters
11) 110 lbs. 12) 454 kg 13) 341 g 14) 1.76 lbs (1 lb. 12 oz.)
15) 18.9 liters 16) 2.65 gals. 17) 300 cc. 18) 4 fl. oz.
19) 86°F 20) 37.7°C

SURVEYING AND INTERPRETING THE AGRICULTURAL ENVIRONMENT

The purpose of this chapter is to show you, the agricultural field worker (AFW), how to survey and interpret the important features of the local agricultural environment and the individual farm units which are a part of it. This is vital to your effectiveness as an extensionist, since it will enable you to fully comprehend your work area's farming systems and practices, as well as its individual farm units.

A. THE AGRICULTURAL ENVIRONMENT

The local ag environment is made up of those factors which influence an area's agriculture. The most important of these are listed below and are the ones on which we'll concentrate:

The Main Features of the Local Ag Environment

THE NATURAL (PHYSICAL) ENVIRONMENT	THE INFRASTRUCTURE[1]
Climate and Weather	Transport (road, rail)
Land and Soils	Communications
Ecology (the interaction among crops, weeds, insects, animals, diseases, people)	Storage and Market Facilities
	Improvements to Land
	Local Farming Practices, Systems
	Available New Technology
	Availability of Ag Supplies, Equipment
	Ag Credit
	Advisory Services
	Agricultural Labor Force
	Land Distribution and Tenure
	Incentives for Farmers (prices, markets, etc.)

Rainfall

In dryland (non-irrigated) areas of the tropics with year-round growing temperatures, rainfall is the major environmental factor that determines which crops can be grown, when they're planted, and what they yield. Rainfall varies greatly from place to place, often within surprisingly short distances, especially under mountainous or hilly terrain. The dryland farmer is keenly aware of his area's seasonal rainfall distribution and the frequent deviations from the "normal" cycle such as "early" or "late" rains or unseasonal drought. Too much rain which can drown out the crop, delay harvest, and accelerate soil erosion can be just as serious as too little. It may be too wet for plowing one day, yet too dry the following week for good seed germination; rare is the rainy season that receives no complaints from farmers.

When gathering rainfall data for your work area, you should keep several points in mind:

1. Annual rainfall averages have little meaning: seasonal distribution and reliability are far more important in terms of crop production. For example, Ibadan, Nigeria is located in the transition zone between the humid and sub-humid tropics and receives about the same annual rainfall (1140mm or 45") as Samaru, Nigeria which is located to the north in the savanna zone. Ibadan's rainfall is spread out over 9 months from March to November in a bi-modal pattern (i.e. 2 rainy

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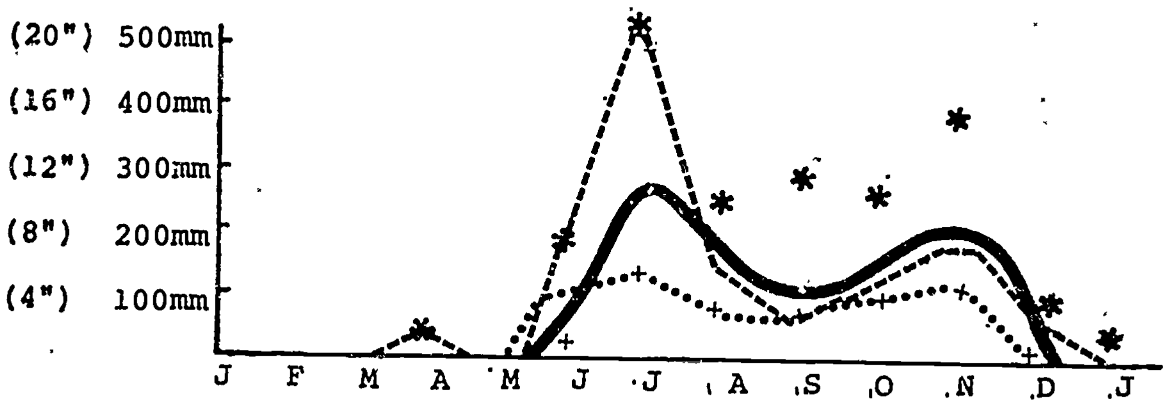
1. The infrastructure refers to those installations, facilities, goods, services, and inputs that encourage ag production.

seasons with a drier period in-between). The first season is long enough for a 120 day maize crop, although there is some periodic moisture stress; however, the second season is shorter, and soil moisture is usually adequate for only 80-90 days, so a 120 day crop suffers seriously. On the other hand, Samaru's equal rainfall is spread out over 5 months in a uni-modal pattern so that the maize crop is much less prone to moisture stress.

2. Seasonal rainfall distribution gives a good general indication of the amount of moisture available for crop production, but it doesn't give the full story. The amount of rainfall that actually ends up stored in the soil of a farmer's field for crop use depends on other factors too such as water run-off and evaporation from the soil surface, and the soil's texture (i.e. sandy vs. clayey) and depth.

3. When interpreting the rainfall pattern of your work area, don't get bogged down in what is "average" or "normal". Annual and especially monthly totals can deviate widely from the averages. Variations are the rule not the exception, even though the general seasonal distribution curve usually maintains a consistent shape. The chart below gives an excellent illustration of this.

Monthly Rainfall Pattern, Managua, Nicaragua, 1958-67[1]



Wettest year, 1958 ------ Annual total: 1437 mm (56")
Driest year, 1965 .... Annual total: 757 mm (30")
Average, 1958-67 ▬▬▬ Annual average: 1090 mm (43")

Highest monthly rainfall between 1958-1967 *********
Lowest monthly rainfall between 1958-1967 + + + + +

How cropping cycles are related to rainfall pattern: In the tropics, cropping cycles are closely tied to seasonal rainfall distribution; you can see this by comparing the cropping calendar on the next page with the rainfall chart above.

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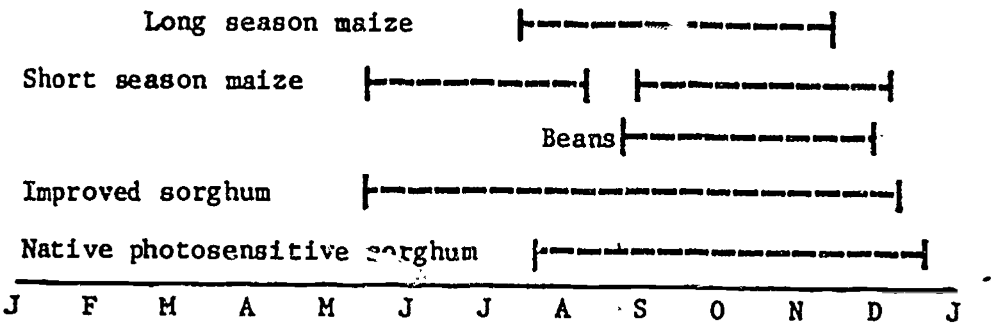
1. This chart is from the PC/Latin America Agric. Program Manual, Part III, Unit I: The Agricultural Environment, p. 4; prepared under John Guy Smith and published by Peace Corps in 1970.

Crop Calendar, Managua Area of Nicaragua[1]



4. The farmer as a weather "expert": Official weather station rainfall data is handy to have if it's representative of your work area and is reliable, but it isn't essential. You can find out nearly all you need to know about rainfall distribution by talking with experienced local farmers; they are the local weather "experts".

The following chart and graph[2] were developed from the comments of a small Nicaraguan farmer who lived only a mile away from the national weather station but had no access to its data. Notice how closely the curve derived from his remarks matches the station's average curve based on 10 years of data.

Month	Farmer's Observations	Observer's Rationalization
Dec. Jan. Feb. Mar. Apr.	"We always have a dry period from December through April--always. This is our "summertime". This is a bad time for cattle."	No significant rainfall for these five months. NO RAIN.
May	"We can plow in May and we like get the early crops in as soon as there is enough moisture."	Rainfall in May; enough to for germination. (A steep curve). RAINS START AND INCREASE.
July	"We always have our "little dry season" between July and Aug.--almost always--but last year it was so wet we lost our sesame harvest. We can plant our early crop so we can harvest it in the "little dry season". We should have 2 weeks when the sky is bright."	Dry months compared to June and Sept. There is a very short dry period between July and Aug. when rainfall is reduced. A RELATIVE DIP IN RAINFALL BETWEEN JULY AND AUGUST.

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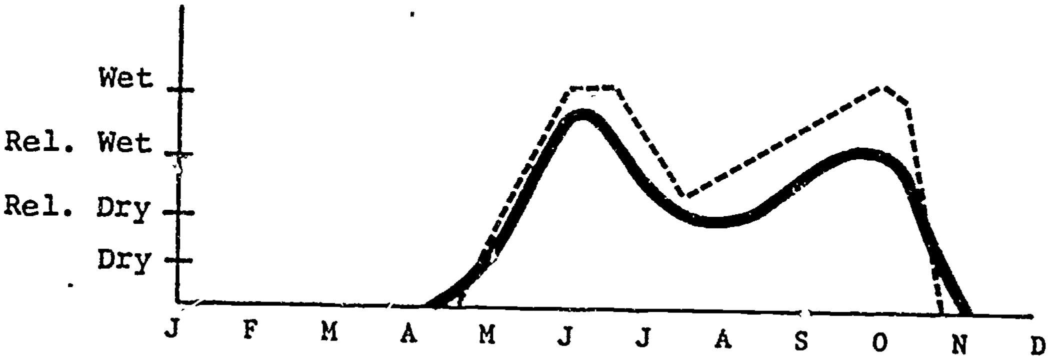
1. This cropping calendar is from the PC/Latin America Agric. Program Manual, Part III, Unit I: The Agricultural Environment, p. 4; prepared under John Guy Smith and published by Peace Corps in 1970. Note that 2 grain harvests are taken from the improved sorghum because of its ratooning ability.

2. Ibid, p. 14.

Sept.	"We get plenty of rain in Sept. but not so much in October.	A RELATIVELY WET MONTH
Oct.	"It rains as much as June, maybe a little more. October rainfall is what makes the cotton crop."	A WET MONTH
Nov.	"You can count on the rains stopping about the middle of November."	Rainfall tapers off rapidly in Nov. (A steep curve). A RELATIVELY DRY MONTH.



From farmer's observations ------------ From weather station ▬▬▬▬

B. GUIDELINES FOR THE ORIENTATION OF THE AGRICULTURAL FIELD WORKER[1]

These guidelines are designed to help you as a newly assigned agricultural field worker (AFW) to orient yourself to the local ag environment and its individual farm units within 1-2 months after your arrival. When using the guidelines, keep in mind the following:

1. Don't undertake a highly detailed survey of local resources at the start of your assignment unless your host agency specifically requests it. Otherwise, you're likely to arouse local suspicions, especially if you're overzealous or overbearing in your initial contacts.

2. Your host agency may give you a basic orientation to your work area, but it may be very limited.

3. If you discover discrepancies between the information gathered from local sources (farmers, etc.) and that from outside or official sources, trust your local "grass roots" information until proven otherwise. Local farmers are the ultimate authorities on the local ag environment.

4. The guidelines that follow are organized mainly by subject area but don't have to be followed in a set order. You'll be picking up bits and pieces of information from a single informant that may deal with a number of areas and will have to put them into their proper context.

FIRST PHASE (INTRODUCTORY) ORIENTATION

This initial phase focuses on the local ag environment in general and is designed to help you orient yourself to it and to adjust your work schedule and activities to the seasonal rhythm of your area's agriculture. Unless severely limited by your local language ability, you should be able to complete this phase in 2-4 weeks if you're energetic about covering your work area and spend several hours a day talking with local farmers and other sources of ag information.

A. GET ORIENTED TO FARMERS AND TO OTHER LOCAL RESIDENTS WHO HAVE A VESTED INTEREST IN AGRICULTURE

You're urged to spend a major part of your time talking with and LISTENING TO farmers and other knowledgeable sources who have a vested interest in agriculture.

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1. These guidelines are a condensation of "Guidelines for the Orientation of the Agric. Field Worker" from Part III, Unit I of the PC/Latin America Agric. Program Manual prepared under John Guy Smith and published by the Peace Corps in 1970. Their use is gratefully acknowledged.

1. Local Farmers

a. Get a general idea of how farmers are distributed geographically.

b. Get a specific idea of where your likely client farmers are located (i.e. those with whom your job description deals).

2. Locate other knowledgeable individuals

Such as ag technicians stationed or working in the area, local buyers of farm produce, local ag supply dealers, and local truckers.

3. The Sample: Selecting reliable local informants

Don't let your earliest contacts bias you overall impressions. Likely initial contacts are: your landlord's relatives, the local mayor or other local official, the more easily accessable talkative farmers, or the "pet" farmers of the agency. At the early stage, your contacts don't have to be completely representative as long as they're knowledgeable.

The value of your agency counterparts or supervisor as informants should be judged in terms of their actual experience (both in terms of time and among different classes of farmers).

The best farmer-informants are usually among the more progressive farmers. However, a good informant for orientation purposes is one who represents his own class of farmers. For example, a progressive small farmer will provide more information and insight into small farming operations than a larger scale commercial farmer.

Keep a careful record (diary entries) of all initial contacts.

4. How to Interview

a. Introducing yourself: Ideally, you should have a third party make the initial contact and introduction; if this isn't possible, be prepared with a practiced explanation of your presence. It's important that you emphasize that you are the learner at this stage.

b. Suggested techniques: Allow the farmer to talk as spontaneously as possible; any leading questions on your part almost always get "yes" responses. Use a memorized interview schedule rather than a written one which is likely to inhibit responses. Avoid overformality.

c. Recording your results: It's generally not a good idea to take written notes in front of a farmer, although in some cases he may expect you (as a "technician") to do so. Some farmers may view written notes as having some possible connection with future tax collections, etc. It's best to wait until an unobtrusive moment such as the mid-day break to summarize your information in written form.

B. GET ORIENTED IN SPACE AND TO THE PRINCIPAL PHYSICAL AND DEMOGRAPHIC FEATURES OF THE ENVIRONMENT

In order to locate farms, farmers, ag suppliers, etc., you should pinpoint their locations with reference to the road and trail network and the dominant topographic features. You'll also want to locate or understand the principal physical and demographic features of your work area.

1. Using maps

a. Sources of maps

(1) Geographic or geodetic service of the government; in a number of LDC's, the military geographic service may be the only source of relief (topographic) maps.

(2) National resource inventory maps: They're useful for understanding the regional dispersal of resources but not much help in making a local inventory of resources.

(3) Road maps: those secured from public works agencies will show more detail than the usual service station maps.

(4) Special sources: National and regional soil survey maps or land use maps; regional development authorities; regional studies done by international agencies.

(5) Homemade maps: Most official maps may not have a large enough scale to accurately pinpoint the location of farms, secondary irrigation systems, unimproved roads, etc. You can enlarge official maps yourself by hand.

b. Using plastic overlays

Use a separate plastic overlay for each class of information to avoid marking up the base reference map.

c. Using xerox or carbon copies

You'll save time by xeroxing or making carbon copies of your base map.

2. Check List: xerox or carbon copies

a. Topographical features: altitude, streams, principal features (landmarks) recognized locally as reference points, valleys, farm and non-farm lands.

b. Communications (roads and trails): seasonal access, distances, travel times and modes of travel between points.

c. Demographic: Locations of communities (and their local names), farmers.

d. Infrastructure: Irrigation systems, drainage systems, ag supply stores, schools, extension offices, etc.

C. GET ORIENTED TO CLIMATE AND WEATHER PATTERNS

1. Sources of Information

a. Weather station records

Obtain all available meteorological data from the official weather station nearest to your area of assignment. Its orientation value will depend on the station's proximity and how well it represents your area's conditions.

b. Relief maps

Altitude is the main temperature determinant in the tropics; remember that for every 1000 ft. rise in altitude, average (mean) temperature will drop about 3.5°F (0.65°C per 100 meters).

c. Local farmers

Official weather data is nice to have if its relevant to your work area and is reliable, but it's not essential. You can learn all you need to know about local climate and weather conditions from experienced local farmers. After all, they have every reason to be the local weather "experts".

You can draw a rainfall chart which is accurate enough for the initial orientation simply by systematically recording farmers' comments about the seasonal distribution of a rainfall; the same can be done as far as seasonal temperature variation. (See rainfall chart on p. 8).

When recording farmer's observations about climate and weather, you'll need a common reference point. In the example on p. 8, the observer understood that the word "dry" meant no rain, and this was the reference point.

2. Climate and weather checklist

a. Rainfall

(1) Monthly distribution of rainfall

Make tables and/or charts showing the month to month distribution using the following criteria:

(a) Dry to wet scale (see rainfall section, p..8)

(b) Rainfall frequency: the number of times it normally rains in a week or month.

(2) Variations from seasonal norms and risk factors

If reliable long run climate dat isn't available (10 years or more), talk with local farmers who have lengthy local experience.

Risk factors associated with climate and weather (i.e. droughts, hail, high winds, flooding) can be established by having farmers recall bad crop years over a span of years. Be sure to distinguish weather factors from other causes such as insects and diseases.

b. Temperature

(1) Monthly temperature averages.
(2) Periods of significantly high or low temperatures.
(3) Occurence of first and last killing frosts.

D. GET ORIENTED TO PREVAILING FARMING SYTSEMS AND PRACTICES

1. Identify the major crop and livestock enterprises in your work area.

2. For each of the crop enterprises which predominates in the area, indicate the following and note any local variations:

a. Indicate the growing season

(1) Normal growing season and its variations (early-late)

(2) Make a cropping calendar using line bar graphs (see p. 16)

b. Describe production practices

Don't confuse the practices recommended by extension with those generally accepted by farmers. Your interest is in the prevailing practices used by most of the farmers in your area. Make note of any significant differences among different groups of farmers.

(1) Describe the principal land preparation practices along with their earliest and latest dates of application.

(2) Indicate the following for every practice

(a) What the practice is called locally. For example, in many areas of Central America, the practice of hilling up maize (throwing soil into the row) is called the "aporque".

(b) The kind and amount of input or inputs associated with the practice and the amount applied as well as the method and timing of application. This includes man days of labor.[1]

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1. The use of the term "man days" is not meant to imply that all farmers are men!

c. Estimate yields and returns

At this stage of your orientation, you're advised not to make a detailed account of the costs and returns; seeking such data can arouse local suspicions or fears of future tax levies. You should be after rough estimates of production costs, and gross and net returns.

(1) Reported yields per unit of land.

(2) Recent prices at normal time of sale.

(3) Multiply recent prices by approximate average yield to get approximate gross returns.

(4) Subtract approximate production costs from gross returns to obtain approximate net returns.

There are 2 ways to do this: net return to capital, land, and family labor where the only labor costs you account for are hired labor; or net return to land and capital in which case an opportunity cost (exchange value) must be assigned to family labor and subtracted from the gross return. The first way is the easiest.

4. Indicate the relative disposition of production

a. Estimate the percentage that is marketed.

b. Identify the principal local market outlets (buyers).

c. Seasonality of marketing and prices

(1) Seasonal movement of the production off the farms: is it sold at harvest, some sold at harvest, some held for higher prices, etc.?

(2) Seasonal price fluctuations (average over several years).

5. List the outside production inputs which are available locally. ("Available" means when needed)

a. Crop production supplies (give brands, grades, and unit prices): fertilizers, insecticides, fungicides, herbicides, hand tools, hand operated equipment, seeds, etc.

b. Agricultural machinery and equipment (if used): tractors (horsepower and make), implements, irrigation pumps, etc.

c. Services

(1) Custom machinery services and rates charged.

(2) Professional services (indicate whether public or private): technical assistance, soil testing, etc.

E. SUMMARIZE YOUR INFORMATION, GET ORIENTED IN TIME

Every area's agriculture is tuned to a time schedule or seasonal rhythm to which you must adjust your work schedule and activities. That's why getting oriented in time (or better put, ahead of time) is so vital to your job effectiveness. Unless you have a clear picture of the local ag calendar, you could easily waste the first growing season.

We strongly recommend that you summarize this initial phase of your orientation by making graphs and calendar charts that show your area's seasonal rhythm of climate, agriculture, and social or religious activities.

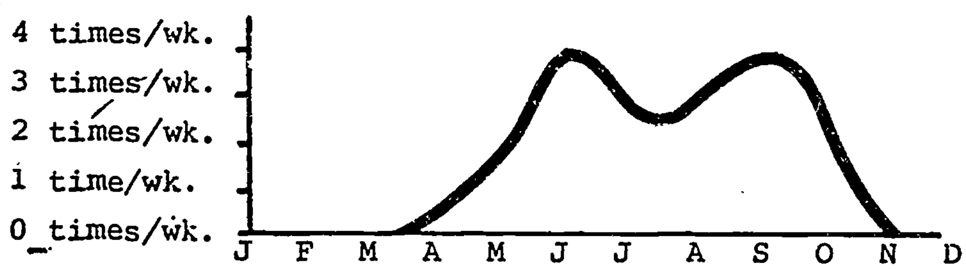
The following graphs, charts, and observations were obtained by a group of Peace Corps Volunteers assigned as rural credit agents in the Pacific region of Nicaragua during an orientation training exercise. The principles involved apply worldwide.

1. Make a generalized climate and weather calendar

   a. Normal monthly distribution of rainfall

      (1) As related by farmers using terms such as dry, wet, some rain, wettest time, rainfall drops off, etc. There are 2 ways to do this:

Using the Frequency of Rainfall to measure seasonal distribution



Using a Dry to Wet Scale: See graph on page 8.

      (2) Measured in millimeters or inches if you have access to reliable meteorological data.

   b. Indicate the range and frequency of possible deviations from normal rainfall patterns:

      (1) As related by farmers
      (2) As recorded by weather station (see graph on p. 6).

2. Making a calendar of agricultural activity

   a. For each of the major crop enterprises, display the following:

      (1) Length and possible range of growing season including likely variations in planting and harvest times.

3. i.e., Malaria in humans and cocci in chickens.

Rickettsiae

1. Smaller than bacteria but larger than viruses.

2. They can cause intracellular infection.

3. Like viruses, they can live and multiply inside the tissue cell of the host.

4. Unlike viruses, they are sensitive to antibiotics and have a carbohydrate shell.

5. i.e., Q fever and Rocky Mountain spotted fever are both caused by them (zoonoses).

Mycoplasma

1. A virus-like organism.

2. They can be grown in a medium free of mammalian tissue cells.

3. They are sensitive to certain antibiotics.

4. i.e., CRD in chickens.

Fungus

1. Molds (multicellular), yeast (unicellular).

2. They can invade animal tissue to produce disease and produce potent toxins.

3. They can grow outside the animal in feed, producing toxins which are harmful to animal after being consumed. i.e., mycotoxicosis and aspergilosis.

Parasitism (General)

1. They vary from a single cell coccidia to worms and insects.

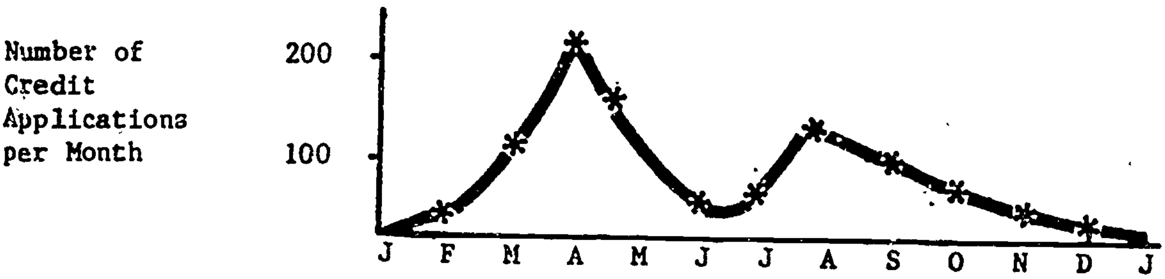
2. They can be either totally dependent on the host animal for survival or independent part of the time.

3. The relationship of many parasites is commensalistic. That is, the parasite lives off the host without really harming it, because if it did the parasite will be homeless.

4. Some immune response is developed.

5. Knowledge of the life cycle can provide the opportunity for control without depending on drugs.

Example: Demand for Production Credit, Branch Office of the National Bank of Nicaragua



b. Indicate seasonal marketing patterns (the area at which the crop is marketed).

c. Indicate seasonal range of prices: Draw graphs.

4. Make a calendar of social activity that includes religious holidays and other holidays or seasonally determined social obligations.

THIS CONCLUDES THE INITIAL PHASE OF YOUR ORIENTATION, and you should now be able to schedule your work activities intelligently and have a good understanding of the local ag environment and farming practices.

C. UNDERSTANDING THE INDIVIDUAL FARM UNIT

Classifying Farm Units

Each farm has its own unique characteristics, but those located in the same environment usually share enough similarities to allow grouping them into several general types of farm unit such as subsistence, market oriented field crop, plantation, etc. If your work area's environment is fairly uniform with equitable land distribution, only one type of farm unit may predominate. If it is characterized by irregular topography and lopsided land distribution, it may have several or more different types of farm units.

There are 8 basic criteria that can be used to differentiate types of farm units:

1. Location
2. Type of occupancy; owner occupant vs. tenant vs. squatter
3. Size of farm, parcelization, and land use potential
4. Size of the farm business
5. Type of farm enterprise
6. Production practices
7. Farm improvements
8. Farm labor supply

1. Location

The principal factors here are:

a. Natural characteristics such as soil type, slope, soil depth, drainage, access to water, etc.

b. Proximity to the transportation network and other infrastructural factors such as public irrigation and drainage systems.

c. Location in relation to other farm units.

d. Local name of the farm's location.

2. Type of Occupancy

The principal considerations are:

a. Who owns the land?

b. If not owner-operated, what is the tenancy arrangement (i.e. cash rent, crop share, or work share) and on what specific terms? How secure is the arrangement?

c. If no one has legal title to the land, is it occupied under squatters' rights that are protected by law?

d. Who manages the farm unit and makes the basic decisions?

3. Size of Farm, Parcelization, and Land Use

   a. Total farm size in terms of local units of measure.

   b. Location of farm parcels: If they're dispersed, how far are they from the farmer's house?

   c. Actual land use: tillable vs. pasture vs. forest; irrigated vs. non-irrigated.

   d. Characteristics of its soils: local name, color, texture, depth, drainage, slope, plus farmer's opinion of them.

4. Size of the Farm Business

   a. Land value of the farm unit

   b. Value of other fixed assets

   c. Amount of operating capital employed per land or livestock unit

   d. The value of production per land or livestock unit.

The value of the farm unit compared to its number of workers indicates whether it is capital intensive or labor intensive. The value of production per land unit indicates the intensity of land use.

5. Type of Farm Enterprise

Some farms are engaged in only one enterprise such as sugarcane, coffee, rice, etc., but this type of monoculture is unusual among small farms. More likely, some form of mixed agriculture will exist. The main considerations are:

   a. Relative importance of each enterprise.

   b. The yields obtained from each enterprise

   c. The disposal of the products from each enterprise (subsistence or cash sale) and where sold.

   d. Crop rotations and associations.

   e. Relationship between crop and livestock production, if any.

6. Production Practices

   a. The specific inputs.

   b. Rate, method, and time of application.

7. Farm Improvements

a. Condition of the farm family home (or the farm manager's and farm workers' homes).

b. Presence and condition of fences, wells, irrigation works, field access roads, storage facilities, livestock shelters, corrals, etc.

8. The Farm Labor Supply

a. Degree of reliance on the family's own labor force and the composition of that force.

b. Degree of dependence on hired labor.

c. The seasonal nature of work requirements.

d. Use of animal or tractor drawn eq .pment.

D. DESIGNING A QUESTIONNAIRE

The quality of the information which you are able to gather from local farmers depends heavily on the quality of your questionnaire. Even the most elaborate survey will fail to elicit accurate information if you have not taken care to design clear, unbiased questions. The following "Sample Survey" outlines one procedure for designing effective questionnaires.

Sample Survey

One of the most useful and economical means of gathering information about a population is the sample survey. The instrument used to collect data is known as a questionnaire. Before starting to construct a questionnaire, you should be able to answer the following questions:

a. In what areas do you need information?

b. Why do you need this information?

c. How will you analyze the data collected?

A questionnaire may appear to be easy to construct and use but in fact it requires a great deal of care and expertise. The following guideline should be sufficient for your work in the community. It is not meant to train you in the methods necessary for scientific research. If you are interested in collecting more detailed information, seek assistance from a social scientist in your area.

Steps in Designing a Sample Survey

I. Constructing the Questionnaire

A. Before writing the questions, several decisions should be made:

1. How to relate the content of the questions to the objectives of the survey. In certain studies such as population census, the relationship between the goals of the survey and the questions is usually obvious. But when the aim is to obtain information on motivation, intentions, feelings, etc., the wording of questions is more difficult.

When choosing issues to be raised, how to ask the questions and what vocabulary to use, try to be sensitive to people's backgrounds. A common problem found with inexperienced personnel in the field of survey research is the tendency to assume that the respondent has the same level of knowledge in the area studies as they do. Following are some reasons that may explain the respondent's inability to answer a given questions:

a. The respondent may not have enough knowledge in a given field.

b. The respondent does not have access to the information. This is true in studies which ask respondents to report about the characteristics of other family members or neighbors.

c. The respondent has forgotten facts that happened in the past.

d. The respondent may not understand the question.

2. Wording of questions

Having decided about the content of the questions, you should then give attention to the actual wording of these questions. Precise, clearly-worded questions will give you clear answers. Following are some suggestions you can use in writing them:

a. The language should be simple, direct and at a level which can be understood by all respondents. You should avoid two extremes: don't use technical terms and jargon which are familiar only to those with a certain level of education and avoid "talking down" to the respondent by using ungrammatical constructions and colloquial phrases.

b. The question should be specific and should deal with only one idea. For example, if a respondent were asked "Do you think that the community needs more family privies and are you planning to build one for your family?" The answer could be "No."--which might mean that he/she does not think that the community needs more privies or it might mean that the community does need more privies, but that she/he is not going to build one for the family. In any case, there is always a risk that the respondent is answering "yes" or "no" to only one part of the question.

To avoid these difficulties, it is better to limit the question to a single issue and then combine the responses later if this is necessary.

c. The question should not make unnecessary assumptions about the respondent. For example, the question "What is your present occupation?" assumes that the respondent actually has an occupation and would not be applicable to those who are unemployed. To avoid those dangers, it is best to use what is known as a "filter" or the "skip pattern" device. These questions have at leat two parts: the first determines whether or not the respondent qualifies for further investigations, while the second part will give more detailed information on those who qualify. For example:

(1) "Have you ever worked?"

(a) yes (b) no (skip to question 2)

If yes,

"What was your occupation?"

d. Avoid using indefinite words. One type consists of words that are indefinite in time, such as "frequently," "often," "rarely," etc. "Frequently" may mean "once a day" or "once a week," etc.

There are, of course, many other ways in which questions can be unclear, but these examples serve to illustrate some of the more common mistakes.

3. Types of questions

There are basically two types of questions used in a questionnaire: the "closed" and "open-ended" questions. The first one is illustrated by items such as:

"Do you think that the drinking water supply of the community is:

a. quite good?"
b. only fair?"
c. not good?"

where the respondent is asked to choose one out of a list of possible answers.

With "open-ended" questions, the respondent is free to use his/her own words to reply. For example: "How satisfied are you with the community's drinking water supply? Whay do you feel this way?" The majority of questionnaires contain both "open-ended" and "closed" questions.

4. Ordering the questions

There is no correct format for a questionnaire but certain principles are found to aid efficiency. These principles are:

a. The first impressions should be that the questionnaire is relevant, clear and easy to complete.

b. The first questions should ordinarily be terms that are emotionally neutral and easily answered.

c. The questionnaire should be as short as possible. Do not include questions on the basis that information might be useful for some purpose at some time in the future.

d. The questions should follow each other in a logical order and should not be repetitive, except when you are attempting to be sure that you are getting accurate information.

5. Culturally sensitive questions

In every culture there are some questions that cannot be asked, or must be asked very carefully in a survey. Sensitive questions should be carefully written during the initial drafting of the questionnaire and carefully analyzed for possible revision after the pretest (discussed below).

B. Types of Questionnaires

There are two types of questionnaires:

1. The self-administered questionnaire in which the respondent completes the answers to the questions.

2. The interview-questionnaire in which the questions are asked and recorded by an interviewer.

Advantages and disadvantages are found in both methods. However, for your work in the community, you might consider using the interview-questionnaire which will give you an opportunity to get to know the people on a personal basis. The interview-questionnaire has the following advantages:

1. It reduces the problem of non-response. The presence of the interviewer can sometimes serve as an incentive to respond.

2. It can be used with persons of almost all educational levels.

3. It allows probing for more detailed information and the interviewer can clarify misinterpretations. It is also possible to combine the two methods. The interviewer can visit the respondent, explain the purpose of the study and leave the questionnaire to be completed with the respondent.

II. The Pre-test

Once the questionnaire has been assembled, it should be tried out with people similar to those to whom it is to be administered. That is, it should be administered to households not included in the sample (See Section III).

It is only by doing this that errors and confusing questions can be corrected before time and effort are wasted on the actual survey. Five or 10 interviews are enough to know if the questionnaire works well or not. After the pre-test interviews are taken, you should review the questionnaire, any inadequacies should be corrected, and ideally, the modified questionnaire tested again. Following are some points you should consider in the pre-test.

A. Does the question ask for information that is needed for the purposes of the survey? Are you sure you need to ask this question?

B. Are the questions and words interpreted in the same way by people of different social groups, ethnic groups, educational level, sex, and locations?

C. Are there certain questions which seem to create irritation or embarrassment?

D. Are any questions confusing to the respondent? What would make these questions more clear?

E. Is the questionnaire too long?

F. Is there enough space to record the answer? Nothing is more annoying to the respondent or to the interviewer than having to write a lot of information into too small a space.

G. Are there repetitive questions?

Pre-test is an essential part of questionnaire design and should not be omitted on the grounds that the questionnaire can be properly evaluated by you and your team of local people.

III. Selection of the Sample

It is nearly impossible for you to ask everybody in the community a set of questions. What you can do is to select a small group of people (the sample) to whom you will administer your questionnaire. The aim of this process is to obtain information from the sample which will apply to the total population of the community when the information gathered is analyzed.

There are several sampling techniques, but for the purpose of your study, you need not get into complicated statistical calculations. Following is one simple method:

> Make a list of all the households street by street or block by block, then select one household out of every five, 10 or 15 households, depending on the size of your sample.

For your study, 20 to 30 interviews are sufficient. Select equal numbers of male and female respondents. Very often, the community may have several different ethnic or social groups. In this case, be sure to include in your sample representatives of each major group, in numbers proportional to its size.

Remember that the population of your sample must represent and have as much as possible the characteristics of the population of the whole community.

IV. Interviewing

You must keep in mind that the questionnaire is a tool that helps you to collect information for a better understanding of the community. Accept answers without showing any doubt; do not change replies that do not sound correct to you.

First, set up a friendly relationship with the respondent. Explain the purpose of the study in such a way that the respondent's curiosity and interest are stimulated. He/she must see that the study is worthwhile and that his/her cooperation is needed. Another important aspect of interviewing is probing. This is the technique used by the interviewer to encourage and stimulate the respondent to give further details. You can use a neutral question or comment such as "What do you mean?" or "I see" or remain silent, suggesting to your respondent you understand the answer given but you know that she/he has more to say.

The important point to keep in mind is that you should not impose your ideas upon your respondent to a point that she/he feels obligated to give the answer that you want--an answer that does not reflect his/her own feelings.

V. Analysis of the Data Collected

In conducting the community survey, your goal is not to gather statistical information such as the number of persons in different age groups or the number of persons having a certain illness, but rather to gain a better understanding of the people's traditions, knowledge, and beliefs of the community's felt needs, of what could and should be done for the well-being of the people.

For example, if you want to know what the community thinks about the services given at the health clinic, your analysis may present itself under this form:

"Reasons for not using the health center by ...."

a. sex (male/female)

b. marital status (single, married, divorced, widow(er))

c. education (know how to read and write, primary education, secondary education, etc ...)

d. income

e. location

f. and others

Examining the responses to this question for each of these categories will help you to understand why the health center is not used. For example, the location may not be too convenient for some people because of the lack of public transportation, or women say that the midwife-nurse's manners are rude, or the villagers, especially those with little education, consider the health center as the place for dying patients. This kind of information will help you to plan your educational activities accordingly.

INTRODUCTION TO CROP PRODUCTION MANAGEMENT

Good crop production management involves attention to two major areas:

1. Standard managerial skills like timeliness and recordkeeping that are essential to the success of any enterprise.

2. The farmer's ability to manipulate the ag environment by selecting and implementing an appropriate system of cropping practices from land preparation through marketing.

STANDARD MANAGERIAL SKILLS

Most of these skills apply as much to extension workers as to farmers:

A systemic approach: This means treating crop production as a system composed of interrelated management practices. Another term for this is integrated crop production management.

Organizing and planning: From land preparation through marketing.

Recordkeeping: For example, maintaining an accurate account of costs and returns; keeping a field notebook to record planting dates, dates and dosages of ag chemicals, rainfall, and general observations on the crop's progress. This is a much neglected management skill.

Observing-scouting to spot problems like insects and diseases so that timely action can be taken.

Timeliness and thoroughness: Delays in planting, fertilizing, weeding, watering, spraying, and harvesting can markedly lower yields. Carelessness and haste have a similar effect.

Equipment maintenance and repair: Sloppy maintenance not only raises equipment costs but the resulting delays can also lower yields.

Communication with other farmers, researchers, and extensionists to provide feedback and to keep abreast of new developments in cropping practices. In addition, farmers need to keep informed of market trends concerning their crops.

MANIPULATING THE AG ENVIRONMENT

No other endeavr is subject to more variables than outdoor crop production. The countless variations in soils, climate, pests and diseases, farmer management ability, available capital, and available inputs (improved varieties, fertilizers, etc.) make such agriculture a very location-specific enterprise with few "cookbook" recipes for success.

Despite the vagaries of Nature, a farmer still has a good deal of control over his/her specific cropping situation by choosing those management practices which can overcome or moderate limiting factors and often make the ference between profit and loss (or hunger and subsistence). Whether consciously or not, most successful managers and extensionists view crop production of an integrated system made up of the following management areas which each contain numerous options:

I. CROPPING SYSTEMS: How much of what to grow; type of rotation.

II. SOIL MANAGEMENT & LAND PREPARATION

III. PLANTING/TRANSPLANTING

IV. FERTILIZER USE

V. LIMING

VI. USING WATER EFFICIENTLY

VII. WEEK CONTROL

VIII. PEST & DISEAST CONTROL

IX. OTHER PRE-HARVEST GROWING PRACTICES

X. HARVESTING

XI. DRYING AND STORAGE

XII. MARKETING

NOTE: These management areas are presented in detail at the end of this section.

The "Package of Practices" Approach to Crop Management

In most cases, low crop yields are caused by several major limiting factors present simultaneously, rather than by one single obstacle. When farmers implement a locally adapted "package" of practices designed to overcome these mutliple yield barriers, the results are usually much more impressive than those obtained by concentrating on only one barrier. Some examples:

1. In a trial in India, a hybrid maize variety yielded only slightly more than a native variety when both were grown under traditional methods (2000 kg/ha vs. 1800 kg/ha). However, the same hybrid yielded 8000 kg/ha compared to 2000 kg/ha for the native variety when both were grown under improved practices (fertilizer use, insect control, proper plant spacing and population).

2. Results from a trial conducted with wheat in Mexico:

Treatment	Yield Increase
Irrigation	135%
Fertilizer	5%
Irrigation + Fertilizer	700%

A typical crop "package" consists of a combination of several locally proven new practices which are also tested in their combined form. Few packages are readily transferable without local testing and modification to suit conditions. Most packages consist of several of the following practices: an improved variety, fertilizer use, changes in plant population and spacing, improved control of weeds-pests-diseases, and improvements in land preparation, water management, harvest, and storage.

It's important to realize that a package doesn't always have to involve considerable use of purchased inputs. In fact, extension efforts can often effectively focus initially on improving basic management practices and skills that require little or no investment (i.e. timeliness, weeding, land preparation, seed selection, changes in plant population and spacing, etc.). This helps assure that small farmers benefit at least as much as larger ones, especially in regions where ag credit is deficient.

A GUIDE TO CROP PRODUCTION MANAGEMENT FACTORS

I. CROPPING SYSTEMS

A. How much of what to grow.

B. intercropping (several crops at once) vs. monocropping; monoculture (same crop year after year) vs. crop rotation

II. SOIL MANAGEMENT AND LAND PREPARATION

A. Soil conservation practices to lessen soil erosion losses on sloping fields.

B. Improving soil physical limitations: texture, tilth, depth, drainage.

C. Choice of seedbed type: raised, flat, sunken.

D. Seedbed fineness required for the particular crop.

E. Handling of previous crop's residues.

F. Tillage vs. no-tillage

G. Depth of tillage

H. Choice of equipment or implements.

III. PLANTING/TRANSPLANTING

A. Direct seeding vs. transplanting.

B. Direct seeding (field crops, some vegies)

1. Date of planting and its correlation with rainfall and temperature cycles.

2. Choice of crop variety: native vs. improved vs. hybrid plus choices within each of these groups.

3. Seed quality, purity, and germination.

4. Depth of planting: small vs. large seeds, soil texture, moisture.

5. Plant spacing: in the row, between rows; broadcasting vs. row planting; "hill" vs. "drill" planting.

6. Plant population (density).

7. Planting method: hand vs. mechanical.

C. Transplanting

1. Size and age of transplant.

2. Container-grown vs. bare-rooting vs. blocking.

3. "Hardening".

4. Depth of setting.

5. Shading.

IV. FERTILIZER USE

A. Organic vs. chemical fertilizer; use of green manure crops.

B. Determining fertilizer needs: soil sampling for soil lab tests, diagnosing hunger signs, field trials, "guesstimates".

C. Kind and amount of fertilizer: chemical, compost, manure.

D. Timing of applications: pre-plant, at planting, sidedressing.

E. Placement

1. Broadcast vs. localized placement (band, hole, half-circle).

2. Distance from the seeds or plants.

3. Special placement considerations for furrow irrigated soils, foliar applications.

V. LIMING

A. Deciding if liming is needed.

B. Kind, amount, application method and placement, timing.

VI. USING WATER EFFICIENTLY

A. Rainfed Crops

1. Choice of variety (drought resistance, length of growing period).

2. Plant population (especially important with cereal grains in marginal rainfall areas).

3. Timing of planting.

4. Mulching.

5. Weed control.

6. Fertilizer use.

7. Soil conservation to lower runoff losses.

B. Irrigated Crops

1. Irrigation method: hand watering, surface (furrow or flooding), sprinkler, etc.

2. Timing, amount, and frequency.

VII. WEED CONTROL

A. Method: Burning, mulching, hand implements, mechanical, herbicides.

B. Thoroughness.

C. Timeliness.

D. Avoiding crop injury: root pruning, herbicide toxicity, herbicide residues.

VIII. PEST AND DISEASE CONTROL

A. Birds (seed eating, seedling injury, grain eating): seed treatment, scaring (people, string-flagging, etc.).

B. Rodents (field): traps, baits, seed treatment.

C. Insects, slugs, snails

1. Non-chemical controls

a. Crop rotation.

b. Resistant varieties.

c. Intercropping.

d. Biological controls: bacillus thuringiensis, predator insects, etc.

e. "Organic" controls: collars, "organic" sprays, stale beer for slugs, etc.

f. Trap (barrier) crops.

2. Chemical controls

a. Deciding when to use insecticides.

b. Choice of insecticide: toxicity to humans and the environment, systemic vs. non-systemic.

c. Type of formulation: spray, dust, granules, baits.

d. Application dosage, frequency, and timing.

e. Coverage required, use of sticker-spreader.

D. Diseases

1. Non-chemical controls: resistant varieties, crop rotation, sanitation, roguing, improving drainage, intercropping, weed control, control of insect vectors, use of disease-free seed, timing and frequency of watering, sterilizing nursery seedbed soil with heat or boiling water.

2. Chemical controls: seed treatment with a fungicide, fungicide drench, chemical nursery seedbed sterilization, foliar fungicides, systemic vs. non-systemic fungicides.

E. Nematodes

1. Non-chemical controls: Resistant varieties, crop rotation, flooding, sugar, plowing up crop roots, antagonistic plants.

2. Chemical controls: Nematocides.

IX. OTHER PRE-HARVEST GROWING PRACTICES, etc.

A. Thinning of direct seeded vegies.

B. Pruning, staking, trellising.

C. Hilling-up of certain field crops like maize, beans, etc.

D. Equipment management; maintenance, adjustment.

X. HARVESTING

A. Determining maturity: especially important with vegies and peanuts.

B. Interval between maturity and actual harvest: farmers may allow field crops to dry down in the field before harvest, but losses to weevils, birds, rodents, and rots may be serious in some cases.

C. Harvest method.

XI. DRYING AND STORAGE

A. Drying (cereal and pulse crops): in the field vs. patio vs. crib vs. artificial methods.

B. Storage (cereal and pulse crops).

1. Form: threshed vs. unthreshed (or ear vs. shelled maize).

2. Type of container: sacks, gourds, clay pots, baskets, silos & bins, cribs, airtight containers.

3. Moisture requirements for safe storage and their measurement.

4. Controlling storage insects

   a. Pre-storage mgt: drying and cleaning of grain, cleaning & repair of facility, spraying or dusting of facility, disinfection of sacks.

   b. In-storage mgt: sunning, smoking, mixing materials with the grain (veg. oil, ashes, etc.), airtight storage; use of insecticide sprays, dusts, fumigants.

5. Controlling rodent losses: rodent proofing, baits, traps.

XII. MARKETING

1. Market analysis and price monitoring.

2. Crop quality control.

3. Cooperative marketing.

4. Contracts.

A GUIDE TO TROUBLESHOOTING COMMON CROP PROBLEMS

It takes a lot of practice and detective work to accurately troubleshoot crop problems. Some abnormalities like wilting or leaf yellowing can have numerous causes.

How to Troubleshoot: First, learn to distinguish normal from abnormal growth when you walk through a farmer's field. Keep a close watch for telltale trouble signs such as abnormal color, stunting, wilting, leafspots, and signs of insect feeding. Make a thorough examination of affected plants, including the root system and the inside of the stem, unless the problem is obvious. Obtain detailed information from the farmer concerning all management practices that might have a bearing on the problem (i.e., fertilizer and pesticide applications, name of crop variety, etc.). Note whether the problem occurs uniformly over the field or in patches; this can provide valuable clues; since some problems like nematodes and poor drainage seldom affect the entire field.

Troubleshooting tools, etc.

1. A pocketknife for digging up seeds or slicing plant stems to check for root and stem rots or insect borers.

2. A shovel or trowel for examining plant roots or checking for soil insects or adequate moisture.

3. A pocket magnifying glass to facilitate identification of insects and diseases.

4. A reliable soil pH test kit for checking both topsoil and subsoil pH; especially useful in areas of high soil acidity. Beware of cheap kits, especially those using litmus paper. The Hellige Truog kit is one of the best and costs about $15 (U.S.).

5. Disease, insect, and hunger signs guides: Refer to the Bibliography an the end of the Crops Guidelines.

TROUBLESHOOTING GUIDE

CROP APPEARANCE	PROBABLE CAUSES
POOR SEEDLING EMERGENCE (Carefully dig up a section of row and look for the seeds)	Low germination seed Planting too deep or too shallow Soil crusting or overly cloddy soil Lack of moisture Clogged planter Seeds washed out by heavy rain Fertilizer "burn" Pre-emergence damping off disease Birds, rodents Seed eating insects (wireworms, seed corn maggots, seed corn beetle)
WILTING (Pull up a few plants carefully using a shovel or trowel and examine the root; check stem for borers or rotted or discolored tissue.)	Actual lack of moisture due to drought or poor irrigation management (watering too lightly or too infrequently). Diseases (bacterial or fungal wilts; certain types of root and stem rots). Very high temperatures, especially if combined with dry, windy conditions. Root feeding insects Stem borers Weed competition Root pruning by hoe or cultivator Nematodes (especially if confined to patches and when plants wilt despite having sufficient water). Stem breakage or kinking
LEAF ROLLING OR CURLING	Lack of moisture (maize, sorghum, millet) Virus Sucking insects feeding on stem or leaves Boron, calcium deficiency (beans only) Verticillium wilt (peanuts)
LEAF CRINKLING, PUCKERING	Aphids, leafhoppers feeding on leaves or stems Virus
LEAF "BURNING" OR BROWNING	Drought Excessive heat Fertilizer burn Insecticide burn Dipterex, Azodrin (Nuvacron), or methyl parathion injury on sorghum Herbicide damage Nutrient deficiency Aluminum, iron, or manganese toxicity

CROP APPEARANCE	PROBABLE CAUSES
	due to excessive acidity (below pH 5.5). Salinity or sodium problems (confined largely to low rainfall areas, especially if irrigated.) Boron toxicity from irrigation water (low rainfall areas) or improper placement of fertilizer boron.
LEGGY, SPINDLY PLANTS	Lack of sunlight caused by overcrowding or long periods of heavy cloudiness.
HOLES IN LEAVES	Caterpillars Beetles Earwigs Crickets Snails, slugs, especially on beans (check for slime trails) Breakdown of dead tissue due to fungal or bacterial leafspots
SPOTS ON LEAVES	Fungal or bacterial leafspots Virus Sucking insects Spilling of fertilizer on leaves Herbicide spray drift, especially paraquat (Gramoxone) Sunscald (beans)
LEAF MALFORMATION WITH STEM CURVING & TWISTING (Broadleaf plants only)	2, 4-D type herbicide damage due to spray drift or a contaminated sprayer (broadleaf crops only).
LEAF MOTTLING, LEAF MALFORMATI , PLANT MALFORMATION	Virus
LEAF STRIPING	Nutrient deficiency Virus Genetic

Troubleshooting Guide (cont'd)

CROP APPEARANCE	PROBABLE CAUSES
YELLOWING, STUNTING	Nutrient deficiency Poor drainage Nematodes Low pH (excessive acidity) Root rot, stem rot, Misc. diseases
OVERNIGHT DEFOLIATION OF PLANTS	Leaf cutter ants, grazing animals
PLANTS CUT OFF AT OR NEAR GROUND LEVEL	Cutworms Mole Crickets
TWISTING TUNNELS IN LEAVES	Leaf miners
YOUNG SEEDLINGS COLLAPSE NEAR GROUND LEVEL AND DIE	Fungal seeding blights, damping off, Heat girdling of stem (beans)
POOR GROWTH, LACK OR VIGOR	Too dry or too wet Too hot or too cold Insects, diseases Weeds Unadapted variety Low pH Salinity-alkalinity problems Ovrcrowding Shallow soil Soil compaction, hardpan Poor drainage Nutrient deficiency Faulty fertilizer practices Nematodes Excessive cloudiness Herbicide carryover Overall poor management Damaged seed (beans)
LODGING OR STALK BREAKAGE (Maize, Sorghum, Millet)	Overcrowding Stalk rots Rootworms High wind K deficiency

CROP APPEARANCE	PROBABLE CAUSES
POOR NODULATION ON PEANUTS, COWPEAS, SOY-BEANS, OTHER LEGUMES THAT ARE EFFICIENT FIXERS (Carefully dig up the root system and check for nodulation; clusters of fleshy nodules, especially on the taproot, and with reddish interiors are signs of good nodulation. Don't confuse nodules with nematode galls!)	Soil lacks the correct type of Rhizobia; seed innoculation is needed. Improper innoculation: wrong strain, innoculant too old or improperly stored. Exposure of innoculated seed to excessive sunlight or contact with fertilizer or certain seed treatment fungicides. Excessive acidity (soybeans are especially susceptible to Molybdenum deficiency). Plants are too young (it takes 2-4 weeks after plant emergence for the nodules to become visible).

GUIDELINES FOR VEGETABLE GROWING

CONTENTS:

Rooting Depth of Vegetables When There's No Barrier to Their Penetration[1,2]

Shallow (45-60 cm)	Moderately Deep (90-120 cm)	Deep (More than 120cm)
Broccoli	Beans	Asparagus
Brussels sprouts	Beet	Beans, lima
Cabbage	Carrot	Corn, field
Collards	Chard, Swiss	Parsnip
Cauliflower	Cucumber	Pumpkin
Celery	Eggplant	Squash, winter
Chinese Cabbage	Muskmelon	Sweetpotato
Corn, sweet	Mustard	Tomato
Garlic	Pea (English)	Watermelon
Lettuce	Peppers	
Onion	Squash, summer	
Parsley	Turnip	
Potato		
Radish		
Spinach		

1. Adapted from Handbook for Vegetable Growers, J. Knott, John Wiley & Sons, NY, 1962.

2. Soil compaction, hardpans, subsoil dryness, poor drainage, and excessive subsoil acidity can all reduce usable soil depth.

VEGETABLE PRODUCTION PLANNING CHART

CROPS	PLANT SPACING[1] In Row	PLANT SPACING[1] Betw. Rows	SEED DEPTH	SEED[9] SPACING	DAYS TIL[4] HARVEST	YIELD PER[8] SQ. METER
BEANS, BUSH GREEN	5-10cm	40-60-cm	2-5cm	5-6cm	42-56	0.4-2kg
BEET	5-8cm	30-60cm	0.5-1cm	1-3cm	55-70	3-6kg
BROCCOLI	30-45cm	45-75cm	" "	T[2]	65-85T	1-2kg
CHINESE CABBAGE	25-30cm	30-60cm	" "	1-3 cm	75-85	2-6kg
CABBAGE	30-45cm	40-75cm	" "	T	65-95T	2-6kg
CARROT	5-8 cm	15-60cm	0.5	0.5cm	65-85	1.5-5kg
CHARD, SWISS	12-25cm	30-60cm	1cm	1-3cm	55-65	1-2kg
COLLARDS	35-45cm	45-75cm	0.5-1cm	T	50-85T	2-6kg
CORN, SWEET	25-30cm	75-90cm	2.5-5cm	12-15cm	70-90	3-4ears
CUCUMBER[5]	30cm	90-120cm	1-1.5cm	2/hole	50-65	0.8-3.2kg
EGGPLANT	45-60cm	60-90cm	0.5-1cm	T	75-95T	2-4kg
LETTUCE, HEAD	25-30cm	30-60cm	" "	T	45-70T	5-9heads
LETTUCE, LEAF	10-15cm	20-45cm	0.5cm	0.5cm	30-50	2-4kg
MUSTARD	10-20cm	30-60cm	0.5-1cm	1-3cm	40-50	2-6kg
OKRA[3]	45-60cm	70-90cm	1.5-2.5cm	10-15cm	50-70	1-3kg
ONION, BULB[6]	5-8cm	15-60cm	0.5-1cm	0.5cm	90-120	1.5-6kg
ONION, GREEN	3-5cm	15-60cm	" "	"	75-90	-----
PEPPERS	40-60cm	60-75cm	" "	T	60-90T	0.5-4kg
RADISH	5cm	15-30cm	1cm	1.5-2cm	23-30	1.5-4kg
SPINACH	5-8cm	15-30cm	0.5-1cm	1-3cm	40-65	0.6-2.8kg
N.Z. SPINACH[3]	30-40cm	45-60cm	1cm	5-10cm	65-75	-----
SQUASH, SUMMER (BUSH)	80-90cm betw. hills	90-120cm	2-3cm	6/hill (thin to 3)	50-70	2-8kg
SQUASH, WINTER (VINING)	90-120cm	150-180cm	2-3cm	" "	70-100+	2-8kg
TOMATO[7]	30-60cm	75-100cm	0.5-1cm	T	55-90T	0.8-6kg
TURNIP	6-12cm	30-60cm	" "	1-3cm	45-65	-----
WATERMELON	90-120cm(hills)	150cm	1.5-2.5cm	6/hill	80-100	0.6-3kg
COWPEAS	6-10cm	50-60cm	2-4cm	5cm	65-80	-----

1. In-the-row spacings are final spacings after thinning. Between row spacings vary greatly depending on seedbed style, variety size, and need for foot or equipment passage.
2. T = commonly transplanted.
3. Soak these needs overnite to improve germination speed and rate.
4. Time til harvest varies with variety and weather conditions.
5. Refers to "drill" planting. Space "hills" 75-90 cm apart in the row, plant 6 seeds/hill, and thin to 3 plants.
6. Bulb onions are usually grown from transplants or sets rather than direct seeding (except under very good management).
7. Staked tomato plants can be spaced much closer together than unstaked ones.
8. A vegetable's yield can vary greatly with growing conditions and management. A good yield in one area might be considered average or mediocre in another area.
9. Some direct planted vegies like chinese cabbage, okra, lettuce, swiss chard, and mustard can be cluster planted at 3 seeds/hole using the after-thinning spacing in Column 1.

HEAT TOLERANCE OF VEGETABLES

Heat tolerance varies greatly among vegetables and also among varieties of a vegetable. It's an important consideration in garden planning. It's impossible to give hard and fast maximum temperature tolerances, since high daytime temperatures can be somewhat offset by low night temperatures. Here's a rough table:

Monthly Average of Daytime Highs	Vegetables Whose Yields Won't be Seriously Affected
up to 95°F, 39°C	Eggplant, Hot Pepper, Okra, Watermelon, Sweetpotato, Corn, Cowpeas
up to 90°F, 36°C	Squash, Cucumber, Muskmelon, Pumpkin, Beans, Collards, Sweet Pepper, Lima Beans (vining types), N.Z. Spinach
up to 85°F, 33°C	Tomatoes, Radish, Bush Lima Beans, Cabbage (heat tolerant varieties), Chinese cabbage, Onion, Garlic, Leek
up to 80°F, 30°C	Mustard, Irish Potatoes, Carrots, Beets, Cabbage, Leaf Lettuce, Kale, Swiss chard
up to 75°F, 27°C	Broccoli, Spinach, Turnip, Brussels sprouts, Cauliflower, Celery

Practices like mulching and partial shading may help offset the effects of high heat.

COLD TOLERANCE OF VEGETABLES

Some vegetables (mainly the heat tolerant ones) are very susceptible to frost and also have their growth checked by cool temperatures. Young plants are more susceptible to frost than older ones; a few days of gradually cooling temperatures helps plants prepare for frost.

Very hardy (survive down to 20°F [-7.5°C]): Broccoli, Brussels sprouts, cabbage, chives, collards, garlic, kale, kohlrabi, leek, mustard, onion, parsley, peas, radish, rhubard, rutabaga, spinach, turnip. (Based on young plants)

Half-hardy (young plants survive light frosts): Beet, carrot, cauliflower, celery, chard, chinese cabbage, endive, lettuce, potato.

VEGETABLE FAMILIES

Why It's Important

1. Vegies of the same family share many of the same insects and diseases. You'll encourage a buildup by growing family relatives continually in the same section of the garden or field-especially true for the Crucifer and Solanaceous families.

2. Family members also share many similar traits re characteristics and growing practices. The Crucifer family (cabbage, broccoli, etc.) prefer cool to semi-warm temperatures, and most are shallow rooted.

CHENOPODIACEAE - Goosefoot Family

Beet   Swiss chard   Spinach

COMPOSITAE - Sunflower Family

Lettuce   Endive   Artichoke

CRUCIFERAE - Crucifer or Mustard Family

Cabbage	Broccoli	Radish	Rutabaga
Collards	Brussels sprouts	Mustard	Watercress
Cauliflower	Kale	Turnip	Horseradish
	Kohlrabi		

CUCURBITACEAE - Cucurbit or Gourd Family

Squash	Watermelon	Chayote
Pumpkin	Cucumber	Melons

LEGUMINOSAE - Legume or Pulse Family

Peas	Lima beans	Soybeans
Beans	Cowpeas	Peanuts

LILIACEAE - Lily Family

Asparagus	Onion	Leek
Garlic	Shallot	Chive

SOLANACEAE - Nightshade or Solanaceous Family

Potato	Pepper
Eggplant	Tomato

UMBELLIFERAE - Parsley Family

Carrot   Parsley   Celery   Parsnip

MALVACEAE - Mallow Family

Okra   Cotton

NUTRITIONAL VALUE OF VEGETABLES

Vegetables make several important contributions to tropical diets:

a) They enrich the diet with nutrients, particularly vitamins and minerals.

b) They render the staple food more palatable and hence improve the intake.

c) They improve digestion because of their high fiber content.

The addition of vitamins, minerals, and other nutrients to the diet is the most important factor. In fact, in many countries, vegetables (and fruits) may be the only significant sources of vitamins A, C, folacin (a B vitamin), and of the mineral iron.

Of the vitamins, carotene (vitamin A) and vitamin C are the most important. Carotene is deficient nearly everywhere in the tropics, with the exception of West Africa where red palm oil is used in food preparation. The low intake of fat hampers the absorption of carotene in the body. Vitamin C is less abundant in cereal than in tuber-consuming regions.

Vegies whose edible parts are deep green, deep yellow, or deep orange are good sources of vitamin A, but there's little correlation between color and vitamin C content. In leafy vegies, a deep green leaf color (and therefore high vitamin A) is highly correlated with leaf exposure to sunlight. That's why cabbage and head lettuce are much lower in vitamin A than their open leaved relatives collards and leaf lettuce.

One feature of vitamin A is that it is fat-soluble and can be stored for up to a year in the body's fat tissues. This is especially significant in light of the seasonality of vegetable availability in many countries. A person in good health can consume all of his/her yearly vitamin A requirement in one season, and draw on the stored reserves during seasons when vitamin A- carrying produce is in short supply.

In contrast, vitamin C is water soluble (stored in body fluids); the latest research indicates that vitamin C intakes above 100 mg/day are probably excreted from the body.[1] This suggests that regular, daily intakes of vitamin C are important in maintaining good nutrition. Vitamin C availability in vegetables is further complicated by the fact that it is found only in growing plants (not seeds or grains) and that it is destroyed by high temperatures and exposure to oxygen. Therefore, cooking vegetables in water for long periods of time effectively robs that food of its vitamin C.

In general, the protein content of vegetables is considered to be relatively unimportant. Some greens like spinach and cassava leaves contain

1. E. Whitney and E. Hamilton, Understanding Nutrition, 2nd edition; West Publishing; Minnesota 1981, p. 368.

over 25 percent protein on a dry weight basis, but because they are usually consumed fresh (containing up to 90% water), the bulk of greens which would have to be consumed in order to meet one's daily protein requirement is a major limiting factor. However, it's likely that many of the local varieties of greens commonly eaten in the tropics are more important sources of protein in those areas than they are given credit for by nutritionists in the developed countries.

The fibre content of vegetables is less important in the tropics than it is in developed countries, due to the generally coarser nature of prepared food in the tropics. In this context, it should be noted that a high intake of fibre effectively prevents constipation and digestive problems.

The important minerals, calcium and iron, are often lacking in diets in the tr pics. Calcium deficiency may occur more frequently if the basic food consists mainly of cereals. A high iron intake is important since anemia caused by malaria, bilharzia, and intestinary parasites occurs very frequently. Pulses such as cowpea are rich in calcium and iron.

The nutrient content of some vegetables compared with that of cereals, tubers, and pulses is presented in the following tables, "Nutrient Composition of Some Vegetables" and "Vitamin Value of Selected Vegetables."

Table 1. Nutrient Composition of Some Vegetables, Compared with Pulses and Starchy Foods

Type of Produce	waste %	dry matter g	energy Kcal	protein g	fibre g	Ca mg	iron mg	Vit. A value I.U.	thiamine mg	riboflavin mg	niacin mg	vit. C mg
						per 100 g edible portion						
fruit-vegetables												
tomato	6	6.2	20	1.2	0.7	7	0 6	900	0.06	0.04	0.6	23
eggplant	4	8.0	26	1.6	1.0	22	0.9	*	0.08	0.07	0.7	6
sweet peppers (green)	13	8.0	26	1.3	1.4	12	0.9	630	0.07	0.08	0.8	103
pepper, hot (dry)	13	34.6	116	6.3	15.0	86	3.6	20,000	0.37	0.51	2.5	96
okra	10	10.4	31	1.8	0.9	90	1.0	[illegible]	0.07	0.08	0.8	18
cucumber	20	3.8	12	0.6	0.5	21	0.4	*	0.03	0.04	0.2	11
pumpkin	17	8.1	27	0.7	0.8	24	0.7	3,400	0.03	0.04	0.5	14
watermelon	37	6.8	21	0.6	0.2	8	0.2	30	0.03	0.03	0.2	6
bitter gourd	20	6.0	19	0.8	1.0	26	2.3	—	0.06	0.04	0.3	57
carrots	10	10.0	33	1.0	0.8	40	0.7	12,000	0.05	0.05	0.5	6
beans (fresh, green)	55	30.0	104	7.0	2.5	40	2.0	150	0.03	0.15	1.5	25
leafy vegetables												
amaranth	40	10.7	26	3.6	1.3	154	2.9	3,000	0.04	0.22	0.7	23
kangkong	28	10.0	30	2.7	1.1	60	2.5	—	0.09	0.16	1.1	47
Chinese cabbage	14	5.8	17	1.7	0.7	102	2.6	30	0.07	0.13	0.8	53
leaf type lettuce	26	6.4	20	1.4	0.6	56	2.1	300	0.06	0.12	0.5	17
white cabbage	15	7.0	22	1.6	0.8	55	0.8	30	0.06	0.06	0.3	46
cassava leaves	13	19.0	60	6.9	2.1	144	2.8	3,000	0.16	0.[illegible]	1.8	82
leguminous vegetables												
hyacinth bean (dry)	[illegible]0	87.9	334	21.5	6.8	98	3.[illegible]	0	0.40	0.12	1.8	0
lima bean (fresh)	43	31.5	119	8.4	1.0	25	2.2	0.1	0.16	0.16	1.5	30
mung bean (sprouted)	7	9.9	30	4.2	0.9	15	1.2	0	0.11	0.10	0.8	18
sprouts, bulbs, tubers, etc.												
onion (dry)	6	11.4	38	1.6	0.7	30	1.0	0	0.05	0.04	0.2	9
bamboo shoots	44	9.0	28	2.5	1.2	17	0.9	0	0.11	0.09	0.6	9
mushroom	9	11.3	37	2.7	0.9	8	1.0	0	0.10	0.42	4.8	3
taro (as vegetable)	16	24.6	94	2.2	0.8	34	1.2	0	0.12	0.04	1.0	8
starchy basic food												
maize	—	88	362	9.5	1.5	12	2.5	0	0.35	0.13	2.0	0
rice	—	88	354	8.0	0.5	10	2.0	0	0.25	0.05	2.0	0
cassava	—	40	153	0.7	1.0	25	1.0	0	0.07	0.03	0.7	30
sweet potato	—	30	114	1.5	1.0	25	1.0	0.06	0.10	0.04	0.7	30
pulses												
groundnut (dry)	30	92	579	27.0	3.0	50	2.5	*	0.9	0.15	17.0	*
groundnut (fresh)	35	55	332	15.0	1.5	30	1.5	*	0.5	0.10	10.0	10
cowpea	—	90	340	22.0	4.0	90	5.0	0.01	0.9	0.15	2.0	0

* Contains too small a quantity to be significant in dietary evaluations.

— Not available.

Table 1. Nutrient Composition of Some Vegetables, Compared with Pulses and Starchy Foods

Table 2. VITAMIN VALUE OF SELECTED VEGETABLES[1]

Nutritional Group	Vegetables	Vitamin A[2] (I.U.)	Vitamin C[3] (mg.)	Calories[4]
	Parsley	8500	172	44
	Spinach	8100	28	23
HIGH IN BOTH	Collards	7800	76	33
VITAMINS A & C	Turnip greens	6300	69	20
	Mustard greens	5800	48	23
	Cantaloupe	3400	22	30
	Broccoli	2500	90	26
	Hot red pepper	21,600	369	65
	Carrots, raw	11,000	8	42
	Carrots, cooked	10,500	6	31
HIGH IN VITAMIN A	Sweetpotatoes	8100	22	141
	Swiss chard	5400	16	18
	Green onions	2000	32	36
	Beet greens	5000	13	16
	Leaf lettuce	1900	18	18
HIGH IN VITAMIN C	Peppers, green	550	120	22
	Cauliflower	60	55	22
	Chinese cabbage	150	25	14
	Cabbage	130	33	33
	Radish roots	320	26	17
	Tomatoes, ripe, raw	900	23	22
	Green beans	540	12	25
	Head lettuce	330	6	13
	Okra	490	20	29
	Sweet corn (yellow)	400	9	91
	Onions (bulb)	40	10	38
	Cowpeas	350	17	108
LESS NUTRITIOUS	Baked potato with skin	trace	20	93
	Beet roots	20	6	33
	Cucumbers	250	11	15
	Eggplant	10	3	19
	Turnip roots	trace	22	23
	Watermelon	270	3	12

1. Per 100 gram portion (3.5 oz.) of cooked vegetable unless normally eaten raw.

2. Daily vitamin A requirements are about 5000 I.U. for active men and 4000 for active women.

3. Daily vitamin C requirement is about 45 mg. for both.

4. Calorie requirement is about 2700/day for men and 2000 for women and up to 50% more if very active.

CALCULATING HOW MUCH SEED TO BUY

Most commercial seed is sold by weight, not by number of seeds. Imported commercial vegetable seed usualy comes in 1 lb. cans and is then sold by the ounce or gram to small farmers. Buying seed by the packet is much more expensive, and it usually hasn't been treated with a fungicide.

To find out how many ounces or grams of seed to buy, first calculate the approximate number of seeds needed given the seeding rate and row spacing to be used. Then convert seed number to weight needed by using the table below.

Number of Seeds per Ounce and Per Gram

	Seeds/oz.	Seeds/gram
Bean	100	3-4
Beet	1600	55
Broccoli	9000	320
Cabbage	8500	300
Carrot	23000	800
Cauliflower	10000	350
Chard, Swiss	1200	40
Chinese cabbage	8500	300
Collards	8000	280
Corn, sweet	100-200	4-8
Corn, field	50-80	2-3
Cowpea	125	4-5
Cucumber	1000	35
Eggplant	6000	210
Lettuce	25000	880
Mustard	15000	525
N.Z. spinach	350	12
Okra	500	17
Onion	9500	330
Pepper	4500	160
Radish	2000	70
Spinach	2800	100
Squash, bush	300	10
Squash, vining	100	4
Tomato	11000	390
Turnip	13000	450
Watermelon	225-300	8-10

NOTE: The number of seeds will also vary a bit with the variety.

FIELD CROPS

	Seeds/lb.	Seeds/kg
Maize	800-1300	1750-2850
Sorghum	12000-20000	26,000-44,000
Peanuts	500-700	1000-1550

A Sample Seed Calculation Problem

1. Determine the dimensions of the plot where the crop will be planted.

   For example, suppose you wanted to plan a 1 x 6 meter seedbed to Chinese cabbage.

2. Determine your between-row spacing (i.e. the row width).

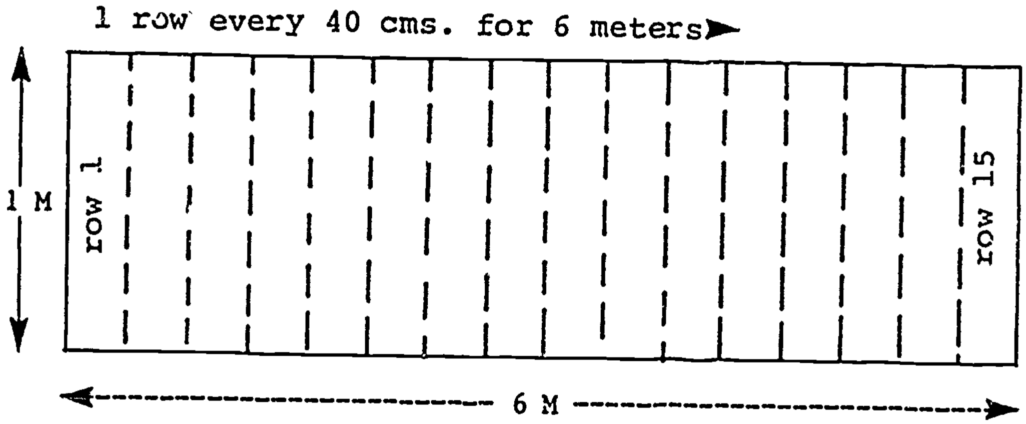
   a. Use a planting chart such as the one on p. 41 of the "Crops Guidelines".

   b. Or use common sense or experience (see p. 58).

   How many rows will fit across your plot?

   For example, suppose you settle on a row spacing of 40 cm for the Chinese cabbage with the rows running the short way across the 1 x 6 m bed. You'd end up with about 15 rows:

$$\frac{6 \text{ meters}}{0.4 \text{ meters}} = 15 \text{ rows}$$



3. Determine your final in-row plant spacing (what it would be after thinning). Consider the following:

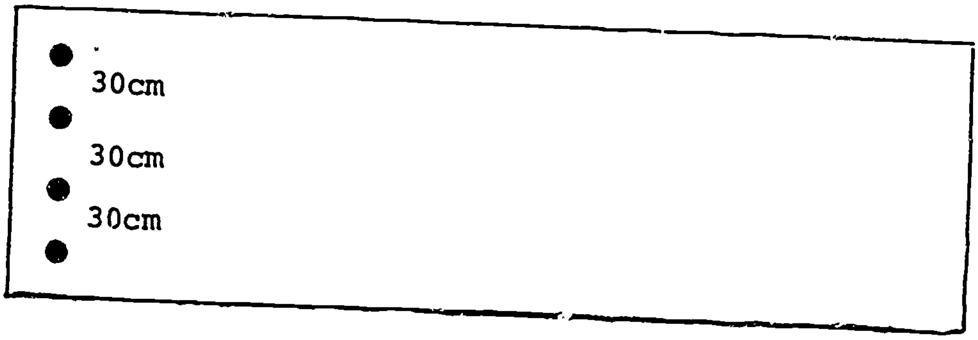
   a. The chart on p. 41.

   b. Vegetable type and variety (head lettuce needs more room than leaf lettuce; okra needs much more space than radishes).

   c. Growing conditions: Are conditions (climate, etc.) ideal for optimum growth and size?

   How many plants at final spacing will fit into one of your rows?

   For example, suppose you decide on a 30 cm final spacing for the Chinese cabbage. You would have 4 plants per 1 meter of row at the final spacing:



4. Determine the <u>amount of overplanting</u> needed to provide the final stand you're aiming for. Consider the following:

   <u>Vegetable crops</u>: Usually overplanted <u>3-10 fold</u>, depending on soil and moisture conditions, germination rate of the seed, and typical seedling survivability. Excess seedlings should be thinned gradually over the first 2-3 weeks of growth to achieve the final stand. Weaker seeds and seedlings like carrots, lettuce, beets, and onions need more overplanting than stronger ones like radish, spinach, and Chinese cabbage.

   <u>Field crops</u>: Usually overplanted only 15-25% (1.15-1.25 fold) due to their hardiness and higher seedling survival rates compared with the veggies. Thinning is seldom practiced with field crops.

   <u>A Note on Germination Rates</u>: Good quality seed should have a germination rate of at least 70%. Seed whose germination is much below 60% is likely to produce weak seedlings and shouldn't be used if possible.

   In our example, Chinese cabbage has a relatively good seedling survival rate and probably needs only a 3 or 4 fold overplanting rate.

5. Determine the <u>amount of seed needed</u> for your total planting area:

   Number of rows x Plants/row (at final spacing) x Amount of overplanting needed (i.e. 3 fold, 8 fold, etc.) = NUMBER OF SEEDS NEEDED!

   In our example, it would work out like this:

   15 rows x 4 plants/row x 4-fold overplanting = 240 seeds

6. Determine the grams (or ounces) of seeded needed, because seeds are usually sold by <u>weight</u>, not by number.

   See conversion chart on p. 48 of the Crops Guidelines. In our example, 240 Chinese cabbage seeds weigh slightly less than a gram.

If purchasing seed, buy at least 25% more than you think you will need in case you need to do some replanting.

7. Determine the actual seed spacing in the row, given the amount of overplanting and whether you'll be "cluster" planting the seed or "drilling" them (dribbling them out).

In our example, suppose we will cluster plant the Chinese cabbage. Since we're overplanting 4 fold, we'd plant 4 seeds per group with the groups 30 cm apart (i.e. final spacing).

If we decided to "drill" plant the seeds instead, we'd plant one seed every 7.5 cm:

$$\frac{\text{30 cm final spacing}}{\text{4 fold overplanting}} = \text{7.5 cm between seeds}$$

SELECTING THE RIGHT TYPE AND VARIETY OF VEGETABLE

I. VEGETABLE TYPE

There are a number of factors th determine the types of vegetables (i.e., carrots vs. tomatoes, etc.) g . by farmers or school garden projects. Let's look at the main ones:

1. Climate

Temperature: Look over the chart on page 42 and you'll see that not all vegies tolerate hot weather well, while others actually prefer it. Heat tolerant vegies like eggplant, cucumber, and okra will do quite well in mild weather too (as long as night temperatures are above the low 40's), but "cool season" ones like head lettuce, peas, and cauliflower won't produce reasonable yields in hot weather.

If close to the Equator, your area's elevation will largely determine the feasibility of growing cool season vegies. Generally, the choice of vegetable types increases with elevation. If you're more than 15° from the Equator, there's likely to be significant seasonal temperature variations which will affect crop choice.

Mulching and partial shading may help minimize heat stress on cool season vegies or those in the "touchy" category.

Rainfall and Humidity: Diseases are generally more prevalent under high rainfall and humidity, but some crops may suffer more than others. Tomatoes, eggplant, peppers, cucumbers, and melons are among the more sensitive.

2. Marketing Factors

Market price as determined by supply and demand influences crop choice but in a rather haphazard manner. Farmers often tend to get locked into a monoculture pattern which limits their flexibility even though feasible crop alternatives exist.

Many vegies are highly perishable which limits their transportability to more distant markets unless refrigeration is available. Others like cabbage, carrots, beets, sweetpotatoes, and other root crops store and ship well.

Consumer preference is a critical consideration and must be determined before embarking on a vegetable that is new to an area.

3. Soil Conditions

Most vegetables grow well on a wide variety of soils as long as drainage and depth are adequate. Root crops usually prefer sandy or loamy type soils since high clay content may hinder root or tuber growth as well as harvest operations.

4. Management and Capital Requirements, Labor

Crops like radishes, beans, mustard, beets, and squash require less management ability and capital input (especially for fungicides and insecticides) than tomatoes, broccoli, peppers, eggplant, potatoes, and cauliflower.

5. Nutritional Value and Consumer Acceptance

Commercial farmers rarely consider this a factor, but it's important for home and school garden projects. Look at the table on page 47, and you'll see that vegies vary markedly in their vitamin content. Eggplant, cucumber, onion bulbs, and beet roots are notably low in food value, while carrots, collards, mustard, and broccoli are excellent. Note that vitamin content (especially vitamin A) is closely correlated with leaf exposure to sunlight in the case of leafy vegies. That's why open leaf collards have about 60 times more vitamin A than their tight headed relative, cabbage. Of course, taste acceptance by the family or school kids is essential. Turnip and radish greens (high in vitamins) are much more palatable if disguised in a stew or mixed with other vegies.

II. THE RIGHT VARIETY

Successful vegetable production starts with the selection of a suitable adapted variety. The yield difference between an adapted variety and one that isn't can easily make the difference between profit and loss. One common mistake PC has made in some countries is to recommend that PCV's bring seeds with them from the states without stating which varieties of a vegetable they should buy.[1]

Vegetable varieties vary considerably in the following characteristics:

1. Time to Maturity: Varieties are classed as early, medium, and late. Although early varieties reach harvest sooner, yields tend to be lower than with longer duration varieties. However, they may be advantageous in terms of hitting the early market, avoiding disease buildup, and enabling more crops to be grown in the same field.

2. Resistance to disease, nematodes, and physiologic disorders: Resistance to these problems varies a lot with the variety and is a very important consideration in selection. For example, the tomato hybrid Better Boy VFN is resistant to Fusarium and Verticillium wilts as well as nematodes. The Walter tomato variety is resistant to Fusarium wilt, gray leafspot, and radial fruit cracking (a physiologic disorder).

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1. The Ministry of Agriculture in your host country should be able to provide a list of recommended vegetable varieties for different regions of the country.

3. Color, shape, size, quality, storability, etc.: Variations are numerous. Market considerations have a lot to do with the choice

4. Heat or cold tolerance: In most PC countries, heat tolerance is an important factor, and there is some variation among varieties, especially among the less heat tolerant vegies. The K-K and K-Y Cross cabbage hybrids have been specially developed for the tropics

5. Growth habit and duration of harvest: Det. vs. indet. tomato varieties, bush vs. vining beans, etc.

Hybrid vs. Open-pollinated Varities

In horticulture, the word "variety" (or "cultivar") refers to an agriculturally derived plant (i.e. evolved by farmers or plant breeders). Varieties may be either open-pollinated or hybrids.

An open-pollinated variety is produced through natural pollination which may be cross-pollination (i.e. corn, cabbage family, beets) or self-pollination (tomato, beans, lettuce).

A hybrid variety is produced through man-aided cross-pollination between two more more distinct varieties. This requires much more care and effort than that involved in producing open-pollinated varieties, so seed is usually quite a bit more costly. However, hybrids generally have improved vigor and disease resistance, and are often more uniform in size. Just as much care is needed when selecting among hybrids for an adapted variety as with open-pollinated varieties. Unlike open-pollinated varieties, the seed harvested from planting a hybrid can't be replanted since it will degenerate back into the original (and usually weaker) varieties from which it was developed.

STORING SEED AND TESTING GERMINATION

I. SEED STORAGE

Seed viability deteriorates rapidly under high humidity and temperatures and becomes a serious problem in the tropics. High temperatures speed up the seed's life processes which causes further heat and encourages molds and fungus; high humidity accelerates mold and fungus growth.

Under cool, dry conditions, fresh corn, onion, and okra seed store well for up to 2 years, while most other seeds are good for up to 5 years. High temperatures and humidity can ruin seed in a matter of days or weeks.

Moisture guidelines: Beans and cereal crops (corn, rice, etc.) should contain no more than 13% moisture for safe storage; most vegetable seeds should not exceed 9%, though they're also harmed by excessive drying (like below 4-5%). Vegetable seed moisture content is difficult to measure without a special meter, but these figures emphasize the importance of dryness.

Temperatures: Best place to store seed is in a refrigerator just slightly above freezing.

Most of the commercial imported vegetable seed you'll see overseas comes in one pound sealed cans which have far better storage life (until opened) than packet seed.[1] All reputable seed is dated so check the label. By the way, it's much cheaper to buy seed in bulk (by the ounce, etc.) out of cans compared to the cost of an equal amount of seed in packages. Also, most "canned" seed has been treated with a fungicide--not so with packet seed.

Storage Tips:

1. Store seed in airtight containers (jars, etc.) partially filled with a dessicant like calcium chloride, quicklime (burned lime, calcium oxide), or silica gel. Be sure to separate the seed (placed in envelopes) from the dessicant with a layer of cardboard or cotton, etc. Oven dry rice kernels are an excellent dessicant.

2. Never allow seed to become damp; even if redried, its germination will be reduced.

II. HOW TO TEST GERMINATION

In the tropics, it's always a good idea to run a germination test on seed before it's planted. Here's a simple but reliable way to do it.

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1. Some seed companies use a foil lined packet which should keep out damaging humidity until opened.

Count out 100 seeds and place them about 1/2" apart on a square of moist newspaper several layers thick. Carefully roll up the newspaper several layers thick. Carefully roll up the newspaper so that the seeds remain separated from each other and remain pressed to the newspaper. Place in a plastic bag or periodically remoisten the newspaper so it won't dry out. Sprouting time varies a little with temperature and seed type, but begin checking after 4 days. Pepper, parsley, parsnip, okra, eggplant, and asparagus may take 7-10 days. Good seed should have a germination rate of at least 80%.

Up to a point you can compensate for low germination by planting more seed, but seed with a germination much lower than 50% or so usually produces less vigorous seedlings.

CHOOSING A VEGETABLE GARDEN LOCATION

Here are some important factors to consider:

1. Soil factors: Good drainage is a must and can be enhanced by using some form of raised seedbed. Very clayey or sandy soils can be improved by large additions of organic matter (compost, manure for both; rice hulls help loosen up clay). Try to avoid very rocky or shallow (less than 18") soil. If the slope is much more than 3-4% (3-4 ft. drop per 100 ft.), some erosion control measures will be needed like contour planting or mulching.

2. Shade: Less of a problem in the tropics due to the higher sun angle, but beware of nearby tall trees. Most vegies prefer at least 7-8 hours of sun a day. However, partial shading may be beneficial when trying to grow heat sensitive vegies like lettuce in hot weather. Watch out also from competition from tree roots.

3. Availability of water: Even very rainy climates have dry spells, but provision for irrigation water is vital in areas with a distinct dry season.

4. Protection from animals: Many garden projects have been temporarily devastated by animals, especially cattle, pigs, and goats. Some type of protective fencing is necessary.

5. Wind Protection: Exposed plants can be seriously damaged by whipping or stem breakage due to heavy winds. In hot, semi-arid areas such as along the Senegal River in Mauritania, hot, drying winds can literally dry up plants. Some windbreak protection is usually needed for most gardens (i.e. buildings, a wall, planted windbreaks, trees).

6. Protection from pilferage: The best security is locating the site near a house.

USING THE RIGHT TYPE OF SEEDBED

The right type of seedbed varies more with climate and soil than with the crop. The common ones are:

RAISED BEDS OR RIDGES: Under conditions of high rainfall and/or poor drainage, crops are usually planted on raised up beds or ridges to keep them from getting "wet feet"; they're also essential when furrow irrigation is used. (In some areas, at the start of the wet season when rains are lighter, field crops like maize, sorghum, and beans are planted on flat beds and then gradually hilled up as the season progresses; this only works with plants that have enough stem height and leaf clearance to tolerate this partial burial).

Raised beds are especially well suited for intensive vegetable growing for reasons beyond drainage:

1. They keep the soil looser since there's no need to walk on them. The bed's width should allow all the plants to be reached by hand from the alleyways (about 1-1.5 meters is best).

2. There's less bending over involved.

3. You end up with a double thick layer of topsoil.

4. They reduce the incidence of soil-borne diseases caused by poor drainage.

5. The raised bed makes it possible to use very narrow rows or even equidistant plant spacing, since you don't need to walk among the plants.

Raised beds can also be used under low rainfall or for sandy soils, but their height should be reduced (maybe 8-10cm high vs. 15-20cm high). Mulching would help cut down the extra moisture losses raised beds are subject to under dry conditions. Making a "lip" around the edge of the bed will also help.

wet season style raised bed

raised bed with a "lip" to help retain water under drier conditions

FLAT SEEDBEDS: Used where moisture is adequate for crop growth and there are no drainage problems.

~~SUNKEN SEEDBEDS: Under rainfall or very sandy soil conditions, vegies~~ may be planted in slightly sunken beds or in slightly sunken furrows to improve moisture availability. In arid conditions, shallow rooted crops like onions that have frequent watering needs can be grown in sunken beds a few centimeters below normal soil level.

PLANT SPACING GUIDELINES

Several factors influence row spacing:

1. Plant "spread": It's obvious that radishes, carrots, and beets can be grown in narrower rows than tomatoes, cucumbers, or squash. Trellising and staking both enable row widths to be reduced through the "skyscraper" principle.

2. Type of equipment used and need for foot traffic: The use of tractor or animal-drawn equipment requires wider row widths than when only hoes and hand-operated sprayers are used. Using raised beds allows for the closest row spacing possible or even equidistant spacing. Some of the popular bio-dynamic gardening books promote these close spacings in which the plants form a "living mulch". Yields are often consideraly higher in mild climate, low humidity ares where these methods first were used (Europe, California, New England). However, under hot, humid conditions, super close plant spacings may accentuate fungal and bacterial leafspots.

   There are numerous ways of arranging rows. They can be spaced uniformly with alleyways on each side for machinery or foot traffic. Groups of close spaced rows can be alternated with alleyways without using raised beds.

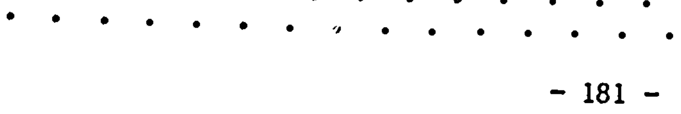
What about in-the-row spacings?

This depends mainly on plant "spread" (width), although some crops like beans respond positively to super close in-the-row spacings far above what their size might seem to suggest. However, cramming plants together too tightly causes legginess (spindly plants), excessive plant competition (especially for sunlight), and lower yields. Leafy vegies (those whose leaf parts are the real product) like cabbage, lettuce, and Chinese cabbage will produce overly small heads if too crowded. Beets, carrots, turnips, and radishes can be spaced much more closely in the row than peppers, tomatoes, eggplant, cabbage, and broccoli. It's mainly common sense.

What about Broadcast, Band, and Equidistant Planting?

Some "small spread" vegies like carrots, radishes, and leaf lettuce can be broadcast planted (scatter planted) instead of using a definite row arrangement. Carrots and radishes can also be planted in bands 8-12 cm wide and then thinned to stand 3-4 abreast. The big advantage of single row planting is ease of weeding. Broadcast plantings should be confined to beds 1-1.5 meters wide with alleyways left between the beds so that weeding is possible without stepping on the beds.

Equidistant planting: Again, this is part of the bio-dynamic approach and uses a hexagonal plant spacing pattern to achieve maximum plant populations with minimum competition for sunlight.



Example of equidistant spacing

Leaf lettuce might be planted on 20 cm equi-spacings. Naturally, a bed arrangement is also necessary for this method. Such a pattern also utilizes the shade effect of the vegies to help keep down weeds and form a "living mulch." However, under high humidity, such close spacing may accentuate fungal and bacterial leafspot problems.

INTERCROPPING

Intercropping consists of growing two or more different crops together at once, either side by side or in adjacent rows. It's also called "interplanting" or "companion planting". Experience and research have shown that certain crop combinations are especially well suited to this practice which has several benefits:

1. Better use of space: Growing a quick maturing crop like radishes, leaf lettuce, and spinach in between rows of a slower crop like tomatoes, peppers, and eggplant takes good advantage of the vacant space surrounding these latter crops early in the growing period. Radishes and carrots are another compatible combination.

2. Shade provision: Cucumber, squash, and pumpkin tolerate or even appreciate some shade and grow well when interplanted among sweet maize or field maize. The maize may also benefit from the soil mulching provided by the other crop's leaves. Likewise, the adverse effect of hot weather on cool season crops like lettuce and spinach may be partially offset by interplanting them among taller crops like tomato, eggplant, and pepper.

3. Insect control: The use of aromatic herbs like mint and thyme or other pungent plants like onions and garlic as companion crops to other veggies may reduce insect damage somewhat, but this effect is generally much overrated. However, stands of a single crop by itself tend to be more vulnerable to insect attack than interplantings, whether or not herbs or onions are used.

4. Miscellaneous: Pole (vining) beans are often interplanted with maize whose stalks serve as supports. Beans are a nitrogen fixing legume, although only of moderate effectiveness; nevertheless, a small but significant amount of N is passed on to the maize. See pp. 9?-98 of the PC/ICE Traditional Field Crops Manual for more details.

SUCCESSION PLANTING: SYSTEMATIZING PRODUCTION

Succession planting is a very useful planting strategy which will greatly benefit any garden project. Its goal is to coordinate the planting-harvest cycles of the garden's crops into an efficient system so that land is kept in continual production and the flow of produce made more uniform throughout the growing season. Succession planting requires careful planning and timing; here are some helpful guidelines.

Timing Transplant Production

If tomatoes are to follow a crop of beets, the preparation and planting of the tomato nursery seedbed should be timed so that the transplant will be ready for field setting as soon as the beets are harvested.

Staggering Plantings of a Crop

A common problem for most garden projects is that each crop's production flow tends to be very uneven. This "feast or famine" syndrome can be largely overcome by making a series of staggered plantings of the crop at weekly to monthly intervals rather than one planting alone. Another means is to plant early, medium, and late maturing varieties of a crop simultaneously to extend the harvest period.

Aside from evening out the flow of produce for home consumption, staggered plantings have several important advantages for market gardens:

a. Buyers are usually partial to producers who can provide a reliable supply of produce over a long period.

b. By spreading out the marketing period for a veggie, growers can usually take advantage of favorable market price fluctuations, rather than gambling on a good price for a single marketing. Also, there is less likelihood of glutting the market and causing drastic price declines.

In selecting an appropriate time interval between staggered plantings, it's important to consider the harvest duration of each planting. Some suggestions:

a. A planting of sweet corn will remain at a harvestable stage for only 7-10 days; thus, succession plantings would be needed at 7-10 days intervals for an even flow of produce. Another approach would be to plant an early (about 65 days to maturity), medium (80 days), and late (90 days) variety at the same time which would provide a harvesting period of about a month.

b. The harvest duration of tomatoes varies greatly with the type. The short, bushy, determinate varieties have a harvest duration of only 2-3 weeks, while the tall growing, indeterminate varieties can continue producing for several months if the plants aren't killed off by fungal leaf spot diseases.

c. Some veggies such as Swiss chard, spinach, leaf lettuce, mustard, and collards can be harvested either all at once (i.e. pulling out or cutting off the entire plant) or they can be picked a few leaves at a time over a number of weeks (new leaves continue to be produced from the base).

WATERING VEGETABLES
WHEN? HOW OFTEN? HOW MUCH?

There are no quick and easy methods for determining how much water plants need and how often it should be applied. The so-called "shiny" or "shiny layer" method popularized in some garden books just isn't reliable enough. (With this method, the soil supposedly has received enough water when a shiny layer of water remains on the soil surface for a certain number of seconds when watering is stopped). However, if you're willing to learn some fairly straightforward concepts and figures, you'll be able to greatly improve on "eyeball" methods. Here goes:

1. The frequency and amount of watering plants need depend on: soil texture, root depth, crop stage, crop type, temperature, humidity, and wind. As temperature and/or wind increase and humidity decreases, water needs go up. We'll cover the other factors farther on.

2. Sandy soils need more frequent (about twice as often) but lighter waterings than clayey soils since they can store only about half as much water per unit of depth.

3. The shallower the root system of the soil, the more often watering is needed. Tiny seedlings with roots only a few centimeters deep may need water 1-2 times a day on a very sandy soil and once every 1-2 days on a clay or clay loam soil (depending on temperature, humidity, and wind). As roots grow deeper, watering intervals can be spread out. However, well-established lettuce, onions, cabbage, and other naturally shallow rooted crops will need more frequent (but lighter) waterings than tomatoes, eggplant, field corn, and other deeper rooted crops.

4. Crops themselves vary in the weekly and total amounts of water needed to grow them, but there's much variation among field crops than among vegies. Millet is the most drought resistant, followed by sorghum, and then peanuts and cowpeas.

5. Plant demand for water increases with growth and reaches a peak around flowering or fruiting time which continues until harvest is over for vegies. Field crops which are harvested in a much more mature state (hard, dry seeds) taper off from this peak as maturity sets in.

   Some useful figures: In warm weather, most very young plants will use about 19-25 mm (1.9-2.5cm or 0.75-1.0") of water per week. This is equivalent filling up a flat tub that is as big as the planted area to a depth of 19-25mm. This includes soil evaporation and plant usage.

   1" of water = 7 gallons (25 liters) per sq. meter

   Peak usage rates for established crops run around 45-75mm (4.5-7.0 cm or 1.75-2.75") a week, depending on temperature, wind, relative humidity, and crop type (not a real important factor with vegies).

This equals 12-19 gallons (45-70 liters) per sq. meter (11 sq. ft.) per week.

6. Surprised at the high amount of water established plants need? That's the reason why most people overwater young plants (in terms of frequency and amount) and underwater older plants by putting on too little too often. Shallow watering produces a shallow root system, since roots won't penetrate into dry soil. It's a self-perpetuating cycle since the plants begin showing moisture stress signs far too soon after each watering, which sets them up for more of the same treatment.

   On the other hand, putting too much water on can cause drainage problems and leaching losses of nutrients like nitrogen and also accentuate soil-borne fungal and bacterial diseases. Watering too often (regardless of quantity) promotes "damping off" in seedlings and fungal and bacterial leafspots in older plants plus soil-borne fungal, bacterial wilts.

   NOTE: 1 mm = 1 liter per sq. meter

   Pre-irrigation: Farmers in low rainfall, irrigated areas should usually pre-irrigate the soil to full eventual rooting depth before planting to avoid getting behind later on in the season when demand really increases. It's a good idea, since the water will not be lost except for a small amount that evaporates from near the soil surface. The only water that drains downward is excess water that the soil's small pore spaces can't hold. Check the PC/ICE Soils, Crops and Fertilizer manual (pp. 15-16) for a full explanation.

How Can I Tell When Plants Need Watering?

Wilting, leaf curling (or rolling), and, in some cases, color changes (maize turns bluish green, bean leaves turn dark green) are the initial signs of moisture stress (lack of water). Yellowing and eventual browning ("firing") of the leaves, starting at the tips, are very advanced symptoms that occur after days of continuous moisture stress. However, most of these symptoms can also be caused by anything else that interferes with water uptake or water transport such as nematodes, soil insects, fungal and bacterial wilts, stem borers, and even very high temperatures. N deficiency can cause yellowing too.

Although young plants can usually tolerate the initial symptoms (wilting, curling, color change) without any significant yield drop, older plants (especially those that are flowering and fruiting) should not be allowed to reach this stage or yields may be seriously affected. For example, if corn wilts for 2-4 days during pollination, yields are usually cut by 50%!

Now for some more guidelines:

- Very young plants: When roots are very shallow, you can use a simple "scratch" test. Take your finger and scratch down a few centimeters. If the soil is dry more than 2-3 cm down, it may be time to water if seedlings are small and still shallow rooted. Look at the seedlings too for signs. Remember, young seedlings need frequent but light waterings; frequency will depend on weather and soil texture as well as root depth.

Older plants: Check over the water quantity guidelines on the previous page. As plants get older, you want to make less frequent but larger applications. The amount per application will range from about 25-65 mm (1-2.5" or about 25-65 liters per sq. meter) and will depend on weather, soil texture, and root depth. The frequency will be inversely proportional to the amount applied and will vary from about one up to as much as 3 times a week. For example, in warm weather, cabbage might need two 30 mm waterings per week since it's shallow rooted, while deeper rooted tomatoes might require a 60 mm watering (60 liters/sq. meter) once very 4-6 days. Remember that hardpans and excessive sub-soil compaction can restrict root growth.

Other Guidelines for Older Plants: Another guide is to apply water before one half of the root zone's available water has been used up. Sounds complicated, but hold on. Plants take up about 40% of their water needs from the top quarter of the root zone; once this top quarter gets down to 0% available water, it will soon be time to apply more. You can get a very good estimate of the percentage of available water remaining by using the "squeeze test" on p. 153 of the Soils, Crops, and Fertilizer Use manual (don't confuse this with the "feel" test for texture.

Measuring the Depth that Water has Penetrated: Use a 10-15mm (about 0.5") diameter iron rod about 1-1.5 mm long that is slightly tapered at one end. Wait about 1/2-1 day after watering and then push it into the ground. It should penetrate fairly easily until it strikes dried out soil (hardpans may affect the accuracy of this method).

What about Rainfall?: Buy a rain gauge or make one out of a tin can for checking rainfall, since its frequency and amount will affect the need for supplemental watering. Amounts much below 6 mm (1/4") aren't much use to plants, since much of this is lost by evaporation from the upper soil surface. Don't try to "eyeball" rainfall - it's very deceiving. Remember also that heavy downpours result in a lot of useless water runoff.

What about the Best Time of Day to Water?: This is important for minimizing "damping off" problems with seedlings and fungal and bacterial leafspots with older plants. Water in the morning whenever possible to give the foliage and the soil surface opportunity to dry out as the day wears on. Watering late in the afternoon is not a good practice. You can water in the heat of the day without fear of "burning".

Other Application Tips: Water gently to avoid splashing and erosion, especially when plants are young and the soil exposed. When possible, avoid watering the leaves themselves to help cut down on foliar diseases.

SOMETHING TO TRY: The Evaporation Pan Method

Water needs of plants can be closely correlated with the amount of water evaporation from a pan or can exposed to the elements. Rather cumbersome set-ups are used at research stations, but there are some good homemade substitutes. One of them uses 5 quart (4.7 liter) oil cans 9.5" (24 cm) high. Paint the can with metallic zinc paint for uniformity and to prevent rust. Set the can with 1/4 of its height in the ground, and fill it with 7" (17.5 cm) of water as soon as you finish watering your plants. It will be time to water again once the water level in the can has fallen an amount equal to that applied at each irrigation. Fill the can up to the starting level each time you water the plants or following a rainfall that's equal to or greater than one of your waterings, but make some allowance for runoff if you get a real downpour. Smaller rains will contribute water to the pan as well as the soil, maintaining both in balance. Note that the can also serves as a rain gauge.

Location criteria for the can: Level ground, preferably surrounded by grass, away from trees, buildings, and bushes. Keep the weeds or grass right around the can below its height. No shadows should hit the can except for brief periods near sunrise and sunset.

HOW TO GROW SUPER TRANSPLANTS

I. WHY TRANSPLANT ANYWAY?

TOMATOES, CABBAGE, BROCCOLI, HEAD LETTUCE, EGGPLANT, PEPPER, and ONIONS are usually sown in seedboxes or nursery seedbeds and then transplanted to the field a few weeks later. Transplanting takes extra labor and lengthens the growing period by a week or two, but it's well worth it. Here's why:

1. A seedbox or nursery seedbed provides more controlled and protected conditions for young seedlings compared to direct field planting. Also, small seeds like tomato, lettuce, and cabbage usually have a poorer germination rate when field planted due to cloddiness, insects, and variations in soil moisture.

2. It's much easier to care for the young plants in a concentrated area.

3. More efficient use of garden space

   a. During the 3-6 weeks it takes to grow transplants, the garden can be used for short term vegies like radishes.

   b. Transplants can be started while another crop is still finishing up in the garden.

4. Better final plant spacing in the field. Direct planting often makes for lots of gaps where seedlings died or seeds didn't germinate; healthy transplants have a high survival rate.

5. In cooler climates, transplanting makes for a crucial ju[illegible] on the market since plants can be started indoors or in a cold frame long before frost is over.

6. Plants can be started in dry season.

Some say that transplanting stimulates a stronger root system due to branching at the ruptured root ends, but tests don't prove it.

Why Not Transplant All Vegies?

1. Not all will tolerate it. Broccoli, brussels sprouts, cabbage, cauliflower, lettuce, and tomato easily survive transplanting; celery, eggplant, onion, and pepper take more care; beans, corn, cucumber, peas, turnips, and melons are usually severely set back by transplanting.

2. It's not worth the effort to transplant a crop that has very close field spacing like radishes, beets, carrots, etc. A wide spaced vegie like tomato has a high field area-to-seedbox area ratio--1 sq. ft. of seedbox provides enough transplants for 40-200 sq. ft. of field.

II. HOW TO GROW SUPER TRANSPLANTS

Growing healthy, vigorous transplants is the old science-and-an-art trip. Without good management, you'll end up with entries for an ag gong show.

THREE WAYS TO START 'EM: Nursery Seedbed, Seedbox, Individual Containers

1. In-the-Ground Nursery Seedbed Method: The plants are grown outdoors on raised seedbeds made from ordinary soil or preferably a specially prepared soil mix (see p. 67). Seeds are planted in rows 2-3" apart and then transplanted to the field 3-6 weeks later. In the rainy season, a removable thatch roof of permanent clear plastic roof should be built over the seedbed to prevent damage from heavy rain. Partial shade may be necesssary if heat and sunlight are intense.

2. Seedbox Method: A good seedbox can be made from 1/2" wood and should be 3-4" deep and an easy to handle size (no bigger than 16 x 24" or so) with drainage holes in the bottom. A soil-compost, rice hull-soil, or other loose and well-drained mix is used. The seedbox is kept in full or partial sunlight either outdoors with a removable or clear plastic roof or else in a greenhouse; it should be raised up on blocks or stilts to cut animal and ant damage. Seedboxes offer more controlled, protected conditions than nursery seedbeds and are recommended when only a few hundred transplants are needed. About 400 transplants can be grown per sq. meter of seedbox space.

   The plants can remain in the seedbox until full transplant size if properly spaced and progressively thinned to give at least a 2" x 2" final spacing. Some growers prefer starting out seeds in shallow flats a couple of inches deep and then transplanting to a deeper seedbox or nursery seedbed when the seedlings have formed their first pair of true leaves (as opposed to the initial pair of "seed" leaves). The only real advantage of this double transplant method is that most of the seedlings can be used instead of throwing the thinnings away. There's no evidence that transplanting stimulates a better root system.

3. Individual Container Method: Seedlings are raised in individual peat, plastic, or paper (homemade) pots. A special potting mix like vermiculite or peatlite can be used or you can easily make your own (see p. 67). Two or three seeds are planted per pot and thinned to one plant at the first true leaf stage. Big advantage of containers is that root injury is minimized during transplanting.

Whatever method you choose, remember that care and management are more important than the actual method.

SOIL MIXES FOR TRANSPLANTING

Straight soil seldom makes a good planting medium compared to a mix. It's either too clayey (makes it tight and poorly drained) or too sandy (low water holding ability). When confined in a shallow pot or seedbox, most natural soil tends to become very poorly drained near the bottom no matter how many drainage holes you make--there's no soil below to provide a suction force to draw the water away, and gravity by itself isn't strong enough. That's the main reason you should use an extra coarse soil mix which will facilitate drainage yet still hold an adequate amount of moisture. Soil mixes also are usually lighter than regular soil, making it easier to move seedboxes around.

Here are a few recipes for soil mixes (variations are endless):

1. 1:1:1 sand-soil-compost. Modify the ratio to suit the soil you're using. Well rotted manure can be used.

2. A 2:1 or 1:1 rice hulls-soil mix.

3. A 1:3 sand-compost mix. Rotted coconut husk fibers run through a 1/4" mesh screen make great compost.

FERTILIZING

Don't rely on compost alone to supply the needed nutrients; it's a low analysis, slow release source. Compost that's only partly rotted is not adequate.

Too much or unbalanced fertilizing produces overly succulent and leggy plants (makes 'em especially prone to damping-off disease. Use an NPK fertilizer with a high P ratio (like 12-24-12 or 10-30-10). Aim for an application equal to 80-100 lbs. (kgs) N, 150-250 lbs. (kgs.) P_2O_5, and 100-200 lbs. (kgs.) K_2O per acre (hectare). That's equal to 80 grams per sq. meter of 12-24-12 or 10-30-10 or about 5 level tablespoons (about 1/2 tablespoon per sq. foot).

How to Apply Fertilizer: Mix it in thoroughly with the seedbox soil mix or broadcast and work it into the top 4" of the nursery seedbed.

Nitrogen Deficiency: May show up after a few weeks due to the extra high leaching losses occurring in shallow containers. Leaves start turning a pale yellow. Water the seedlings with 1 tablespoon ammonium sulfate (or 1-1/2 teaspoons urea) dissolved in 1 gal. of water. Once should do it. Wash off leaves with plain water afterwards.

SOIL STERILIZATION BEFORE PLANTING

This control soil-borne fungus and bacterial diseases as well as nematodes. It's a must, especially in the hot, moist tropics. Here are several methods:

1. NON CHEMICAL:

   Boiling Water: Convenient for small areas, like nursery seedboxes. Really sock it on.

   Baking the Soil: Wet soil heats up better, and the resulting steam helps. An oven can be used for small amounts. For larger quantities, use half of a 55 gal. drum split lengthwise supported over a fire or use galvanized roofing the same way. 1/2 hour at 185°F does the trick; don't overcook the soil as it may release toxic amounts of certain elements. One way of checking is to bury a potato or sweetpotato midway down in the soil; when it's cooked, the soil is ready (and you get a snack too).

   Steaming: Very effective.

   Burning Debris on the Surface: Burning rice straw or other residues on the soil surface is not an effective method.

2. CHEMICAL: Fumigants like methyl bromide, Basamid, and Vapam are broad-sprectrum sterilants. Formaldehyde controls fungus and bacteria but not nematodes. See pp. 150-152 for details.

Whatever method you use, be sure to sterilize the entire soil mix (compost and manure included). Seedboxes should be sterilized with boiling water. Avoid recontaminating the soil with unsterilized implements, etc.

CONTROLLING DAMPING-OFF DISEASE

Damping-off is a fungus disease caused by any of several soil-borne fungi that attack the germinating seed or young seedlings at the base of the stem.

Symptoms of Damping-off

Pre-emergence damping-off attacks the germinating seeds and can cause many to rot. Low germination (if not due to poor seed) may be a sign of damping-off.

Post-emergence damping-off attacks seedlings soon after they emerge while their stems are still young and tender. The plants collapse at the base of the stem. A closer look shows a water soaked constriction of the stem where it meets the soil. (High heat can sometimes cause a similar girdling of the stem.)

Prevention and Control

1. Soil sterilization should control it unless the soil becomes recontaminated by unclean tools or further additions of unsterilized soil.

2. Seed treatment with a fungicide dust: Use Captan (Orthocide) or

Arasan (thiram). Provides good seed protection but won't protect the seedlings. Most commercial bulk seed (as opposed to packet seed) is already treated; check the label or look for a purple or reddish tinge to the seed. NOTE: Demosan (Tersan, chloroneb) seed treatment is highly effective on post-emergence damping-off as well and is used on beans, cotton, and sugarbeets in the U.S.

3. Keep the soil surface dry: Avoid excessive shade and watering too frequently; a continually wet soil surface is a turn-on for damping off fungi. Water thoroughly once a day in the morning rather than making several light waterings.

4. Don't crowd plants!: Keep the rows a minimum of 2" apart and thin plants as required. Overcrowding makes for spindly plants with tender attack-prone stems.

5. Keep'em growing!: Damping-off is only a problem during the first week or two of growth. After than, stems toughen up and become resistant. Anything that slows down growth (lack of sunlight or fertilizer, etc.) is a no-no.

6. A fungicide soil drench will help prevent damping-off if no sterilization was used; it'll also help control damping-off if an outbreak erupts. Here's 2 recipes:

   a. 1-1/2 - 2 level teaspoons (7-1/2 - 10 c.c.) of Captan (Or Bo-cide) per gal. of water. Apply at the ra__ of 1/2 gal. per sq. yard (9 sq. ft.) immediately after planting or as soon as damping-off symptoms occur.

   b. For cabbage and broccoli: a drench of 1 level tablespoon of PCNB (Terrachlor, Brassicol) + 2 tablespoons Captan 50W per gal. of water applied at 1 gal. per 50 sq. feet of seedbed immediately after planting.

PLANTING THE SEEDS

Use Adapted Varieties

Numerous varieties are available for each vegetable, but only a few are adapted to any particular area. Varieties very in their time to maturity, disease resistance, and heat tolerance, etc. Check with your host country extension service for recommended varieties. DON'T use CARE seeds even though they're free - they're seldom the correct variety and are usually old.

Run a Germination Test First

Once out of a freshly opened sealed can, seed can deteriorate rapidly under hot, humid conditions. Test the germination by either making a trial planting or placing 100 seeds inside wet newspaper and counting the germination in a few days. (See p. 55 for storage tips.)

Planting Depth

1/4-1/2" (.6-1.2cm) deep for small seeded vegies. If too shallow, soil may dry out too quickly; if too deep, they may have trouble pushing through or may rot. Planting too deep is a common mistake.

Seed Spacing

Rows should be 5-7cm apart. There are 2 ways of spacing seeds in the row:

1. Dribble them out uniformly at about 15-30 seeds/foot (about 1 every centimeter). Since you'll be thinning them progressively for a final 5-7cm spacing, you'll waste a bit of seed unless you double transplant.

2. Cluster planting: plant in groups of 3 seeds per group with 5-7cm between groups; thin to one seedling per group once the first true leaves start forming. If care is taken to align the groups both in the row as well as from row to row, blocking is greatly facilitated (see next page). Use a board with mounted dowels to mark out the holes.

3. Container planting: 3 seeds per container and then thinned to one plant each.

Other Planting Tips

1. Firming the soil over the seed will help improve contact between seed and soil moisture.

2. In ε   cases, you can improve the emergence percentage of difficult seeds like carrots and lettuce by covering them only with a thin layer of sawdust or rice hulls.

3. Covering the seedbox or seedbed with a 5-10cm. thick mulch of straw or grass (newspaper works too) helps hold in moisture and protects against seed washout. However, be sure to remove the mulch as soon as seedlings start emerging to avoid leggy, weak plants and increased damping-off problems. Before applying the hay or straw, dry it out well in the sun to help decontaminate it from damping-out organisms or use a Captan drench over it. You can also try using a "grow through" mulch like rice hulls about 1cm thick or so.

SEEDLING CARE

1. Overplanting and underthinning are common mistakes. You're shooting for strong, stocky seedlings, so overcrowding is a no-no.

2. In high rainfall conditions, a clear plastic canopy or removable thatch roof set-up will be needed.

3. During the early stages of growth, partial shade may be needed under high temperature, intense sunlight conditions, but don't overdo it.

4. Water in the mornings; this helps keep the soil surface dry to minimize damping-off problems.

5. Insects: Malathion 50% or 57% liquid at a 3 cc/liter (2 teaspoons/gal.) or Sevin 80% WP at 10 cc/liter (2 tablespoons/gal.) will control most leaf feeding insects (Sevin won't control aphids well). Don't spray unless needed!

6. Leaf spot fungus diseases: use Maneb or Manzate (Dithane M-45) at 6 cc/liter (1.5 tablespoons/gal.) or Captan 50W at 8-12 cc/liter (2-3 tablespoons/gal.).

7. Hardening and blocking: See "Tips on Transplanting Vegetables" (p. 72)

TIPS ON TRANSPLANTING VEGETABLES

I. PRE-TRANSPLANT GUIDELINES

Size & Age of Transplants

Use only healthy, vigorous transplants. Over-planting and under-thinning produce spindly, weak seedlings - so does too much fertilizer (especially N) or excessive shade. Follow the tips above in "How to Grow Super Transplants" and shoot for sturdy, stocky seedlings that are disease-free.

In warm climates, it takes about 3 1/2-6 weeks to grow seedlings to transplant size. Tomatoes, cabbage, broccoli, and leaf lettuce (leaf lettuce is usually direct planted) are the quickest and pepper and eggplant the slowest.

Most plants are ready when they have 4-6 true leaves (i.e. not counting the first 2 "seed" leaves). Size and appearance should be like so:

TOMATOES: 15-20cm tall, pencil thickness stem; should be stocky (wider than tall) and not leggy.

CABBAGE: 6 leaf stage; use stocky plants.

PEPPER, EGGPLANT: 10-12cm tall.

Don't use overly old seedlings; the growth check is much greater since more roots are damaged during transplanting and older roots don't regenerate as well. Also, old seedlings are likely to have stunted root systems due to confinement in a limited area. Tomatoes are somewhat of an exception (see p. 74).

Hardening and Blocking

Hardening toughens up seedlings and prepares them for the shock of transplanting; the process slows growth, increases food storage, and toughens up plant tissue. When transplanted, hardened plants produce new roots faster and are more resistant to moisture stress and temperature extremes.

The hardening process should be started about 7-10 days before transplanting and consists of one of the following:

1. Exposing plants to below optimum temperatures for growth; not practical in the tropics.

2. Gradually reducing the water supply, but don't let the plant bed dry out suddenly or let the seedlings wilt severely. Blocking the plants (see below) may be enough to produce adequate hardening by itself.

Blocking consists of cutting the seedbox soil to full depth by passing a sharp knife length-wise and cross-wise between the plants about 7-10 days before transplanting. A 5x5 or 5x8cm plant spacing facilitates the operation. Blocking lessens transplant shock in several ways:

1. It keeps the roots of adjacent seedlings from entangling each other which causes lots of root loss when the seedlings are removed.

2. It stimulates root branching within the seedling's soil cube which helps hold it all together when lifted out.

3. The severed roots have a chance to at least partially recover before transplanting which causes little additional root damage.

Exposure to Full Sunlight

If the seedlings have been grown under partial shade due to intense heat and sunlight, they must gradually be acclimated to full sun during the 2 weeks prior to transplanting. It's a good idea to use as little shade as possible; overdoing it slows down growth, makes for leggy plants, increases damping-off problems, and may cause increased transplanting mortality.

II. THE TRANSPLANT OPERATION

Weather Conditions: Transplant in the late afternoon or on a cloudy day - it helps avoid severe wilting. Shading the transplants (see p. 74) for the first couple days is often necessary if heat and sun are intense.

Extracting the Seedlings: Try to retain as much of the seedling's root system as possible when removing it from the seedbox. Blocking (see above) is a big help; soaking the soil may help too.

Using a Starter Fertilizer Solution

A liquid starter fertilizer solution poured into the transplant hole helps get the plants off and running again. Use a fertilizer with a high ratio of P like 12-24-12 or 10-30-10, or 5-10-5 if possible (P helps stimulate new root growth). Or use:

Manure Tea: 1 part manure to 3 parts water. Probably not a quick release source of P.

Recipe: 2-4 level tablespoons of fertilizer per gallon of water (8-15 cc/liter). Don't expect it all to dissolve (using hot water and mashing the fertilizer will help).

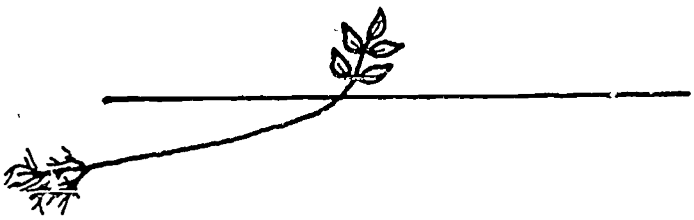
Dosage: About a cup (250 cc) per transplant hole. Pour it in before transplanting and let it drain completely before setting the plants.

Remember that the starter solution is only a temporary "fix", since the amount of NPK applied is pretty small. In addition, a regular application of NPK fertilizer should be placed in a half circle 8-10 cm deep and 8-10cm out from the plant's stem. Or you can try relying completely on a high rate of manure or compost (at least 4 kg./sq. meter; half this for poultry and sheep manure; it should be broadcast and worked into the top 15-20 cm of soil about a week or two before transplanting).

How Deep Should Transplants be Set?

Eggplant, pepper, and cabbage family transplants should be set slightly deeper (like 1-2 cm) than they were originally. Setting cabbage family plants as deep as the first true leaves will prevent leaving lots of curly stem above ground that might be broken by wind knocking the plants around.

Tomatoes are a very special case since any portion of the stem that is buried will form roots. In fact, tomatoes love being set super deep in the soil, since it gives them a better root system. You can bury them deep by setting them in vertically, but if the plants are very old and leggy (much above 20 cm or so, use the horizontal method shown below, but be careful not to snap off the top part of the plant by bending it too much. The horizontal method avoids setting the plants too far down into subsoil that might be too cold, poorly drained or very infertile. You can set plants 30-50 cm tall (way too old to be ideal) leaving only 10 cm above ground, and it'll help turn back the clock.



Don't be afraid to pinch off some of the lower branches in order to "deep six" the tomato plants; they like it.

Setting the Plants In (Normal tomatoes and other)

Hold the plant gently (don't squeeze the stem) so the roots dangle down vertically and aren't scrunched up. If the plants are container grown, take off the container and loosen up the roots a bit. Set the plant in to the proper depth and fill in soil so no air pockets are left. Firm the soil around the plant to assure no air pockets (they cause roots to rot).

Leave a slight depression around the plant (above 20 cm diameter) to help retain water unless conditions are very wet.

Applying Solid Fertilizer: See Soils, Crops, and Fertilizer manual (PC/ICE), pp. 124-27.

Watering and Shading

Water the plants well immediately after transplanting. If the soil is dry, put on about 25 liters/sq. meter broadcast to help build up the moisture reserve; the young transplants won't actually need much at once due to their tiny root system, so you may have to water every day or two with a much smaller amount in addition to this initial deluge.

Shading: In hot, sunny weather, the plants will usually need shading (possibly not if they were container grown under full sun) to preven high mortality from water stress. Make party hats (or cones - they're quicker) out of newspaper or use banana leaves, etc. Put a ventilation hole in the party hats. Shade may be needed for several days and can be gradually withdrawn.

Mulching

In most cases, a 10-15 cm layer of mulch around the plants is very beneficial. It reduces evaporation of water, cools the soil (not good in cool weather), cuts down weeds, and eventually adds organic matter to the soil. Mulch may attract termites (dry areas especially), crickets, or slugs and snails (wet conditions). It may also encourage "damping off" if placed too close to young seedlings.

GUIDELINES FOR INDIVIDUAL VEGETABLES

Tomato
Eggplant
Pepper
Cabbage & Chinese cabbage
Cucumber
Squash
Onion

There's no one right way to grow vegetables so the guidelines below are very general. The specifics depend on the soil, climate, available inputs and equipment, and the farmer's management ability and capital.

TOMATOES

Days til harvest: 55-90 from transplanting

Good yield: 2-6+ kg/sq. meter depending on conditions.

Determinate varieties are low growing and bushy; blossoms and fruit develop over a short period, and harvest lasts only 1-3 weeks. Indeterminates keep on producing more leaves, stem, flowers, and fruits; harvest may last several months if not cut short by diseases. Indeterminates are usually staked.

Choice of variety is very important since there's much variation in disease resistance, time til harvest, size and shape of fruits, and use. Here are some common ones - get local recommendations from the ministry of ag:

Variety[1]	Days til harvest (From transplanting)	Disease Resistance[2,3]	Fruit Size Shape
Floradel (I)	77 days	F_1, graywall, gray leaf spot	Large, round
Tropic (I)	75	N, F_1, V_1, graywall, gray leaf spot	" "
Walter (D)	75	$F_{1,2}$, graywall, gray leaf spot, radial fruit cracking	"
Better Boy (I)	72	VFN	"
Manapal (I)	75	F_1, graywall, gray leaf spot	"
Roma (D)	75	V, F (new strain also resistant to namatodes)	Small pear for canning, pasta
Chico III (D)	75	F (sets fruit at high temperatures)	" " "

Growing Transplants: (See section titled "How to Grow Super Transplants"). Ideal transplant has 4-6 leaves (not counting original seed leaves), is 6-8" tall with pencil thickness stem, and is stocky not leggy. Allow 4 sq. in. per plant in the seedbox.

Transplanting: Set them deep so first leaf is just above soil. Leggy plants should be set extra deep (lay part of stem horizontally underground after pulling off some of the lower leaves). Remember that tomatoes are one of the few vegies that have the ability to produce roots from the buried stem.

How to root cuttings: A quick way to produce transplants. Cut a 6" long healthy sucker at a slant; dip in rooting hormone and insert into a moist medium like peatmoss, compost, etc. Will root in a couple of weeks.

Blossom drop: Nite temperatures above 75°F (24°C.) may cause blossom drop in some varieties. Same with night temps below 55°F. Hot, dry winds may cause blossom drop.

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1. "I" = indeterminate, "D" = determinate

2. F = race 1 Frusarium wilt, F_2 = race 2; V_1 = race 1 Verticillium wilt, N = nematodes; radial fruit cracking and graywall are physiologic disorders.

3. Disease resistance doesn't imply 100% immunity but only better tolerance.

Fertilizing

Seedbox: See: "How to Grow Super Transplants" or Soils, Crops, and Fertilizer Use manual (PC/ICE)

At transplanting: Use a starter solution (see "Tips on Transplanting" or the fertilizer manual) as well as the usual solid fertilizer application (use half-circle method). Good managers can profitably use up to 200 lbs. P_2O_5/acre (kgs./Ha.) and 60-150 lbs./A (kgs./Ha.) K_2O. Total N can go as high as 100-150 lbs./A (kgs./Ha.) but apply only 1/3 at transplanting and sidedress the rest 3-4 week intervals.

Sidedressing: Use N only unless under high rainfall or very sandy conditions where K losses may be high. Apply 30-40 lbs./A N every 3-4 weeks.

Tomatoes are especially susceptible to Calcium, Magnesium, boron, and manganese deficiencies.

Staking and Pruning

In the States, the tall growing indeterminates are staked while the bushy determinates are often allowed to sprawl on the ground especially if a protective plastic mulch is used). Under wet tropical conditions, staking is often essential for both types to prevent fruit rot and foliage diseases being aggravated by ground contact. Instead of staking the bushy determinate varieties, you could try heavy mulching with straw or rice hulls, etc.

Under drier conditions, unstaked plants will usually outyield staked plants on a per plant basis, but allowing them to sprawl exposes the fruit to more sunscald than under staking. On a per area basis, however, staked plants usually yield more, since they can be spaced twice as close as unstaked plants. Use stakes at least 1.6m long and sink them at least 30cm into the ground. Best time to put in the stakes is right at transplanting.

Wire Cages: Cages 45-60 cm in diameter made from strong wire mesh (10-15cm mesh) is ideal for supporting tomato plants. Concrete reinforcing wire can be used, but cost is a big problem. The plants need no pruning with this method.

Pruning: The main purpose of pruning is to facilitate staking and tying by cutting down on the number of stems per plant. Pruning to a single stem will speed up maturity by a week or two, but at the expense of yield. Usually, pruning to leave 2-3 stems is ideal and also gives better foliage coverage to protect the fruits from the sun. One way to obtain an early initial harvest and later sun protection is to remove all "suckers" (potential stems that form in the joint between the stem and the leaf branches) up to about 40-45 cm and let the others grow to form a canopy effect. A common and effective pruning method is to let one or two suckers grow out from near the plant's base to form a 2-3 stem plant. Note that each of these 2-3 stems will also produce further suckers which need to be removed; pruning is a fairly continual process. A TIP: Allow the suckers to develop two side leaves, and then pinc off the shoot above the side leaves - it makes for better foliage cover for fruit protection. Severely pruned plants (one stem) are more susceptible to blossom and rot.

Insects: Aphids, tomato fruitworms (corn earworms), hornworms, cutworms, and stinkbugs are some of the more common pests. (See the insect control section below.)

Nematodes: Tomatoes are especially susceptible to rootknot nematodes (see nematodes section of this tech reference package).

Diseases

Fusarium wilt, Verticillium wilt, bacterial wilt, early and late blight, gray leaf spot, Septoria leafspot, and several viruses are the more common problems. Use resistant varieties whenever possible where the fungal wilts are a problem. Benlate (benomyl) as a soil drench (500 cc/plant of a solution made of 1 gram Benlate per 3 liters water) applied in the transplant hole before transplanting has proven very effective as a preventative against Verticillium (also helps with Fusarium). For leaf fungal diseases, prevention applications of foliar fungicides should be made every 4-10 days (depending on rainfall frequency and disease severity) beginning around blossom time. Practice crop rotation (especially good for soil-borne disease control) by not growing tomatoes, peppers, eggplant, potato or tobacco on the same ground within 3 years. Don't use tobacco products when working with tomatoes--it spreads tobacco mosaic virus. Wash hands well with strong soap, rubbing alcohol or skim milk (the latter is very effective) before entering the field if you're a tobacco user.

Physiologic Problems

Blossom drop: see start of tomato section.

High temperatures: Nighttime temperatures over 85° (29.5°C) prevent ripening fruit from attaining a normal red color.

Blossom End Rot: Water soaked spot at blossom end of fruit that enlarges to cover up to half the fruit; usually hits when fruit is 1/3-1/2 grown. Most common when a dry spell follows a period of rapid growth. Unusually heavy rain, excessive N, wide fluctuations in the water supply, and heavy pruning can also be factors. The main problem is really a calcium deficiency. Calcium isn't moved from older to younger tissues, so it doesn't take long for a deficiency to injure new growth (i.e. the fruit). Control: Spray the foliage once or twice a week when problems arise with a solution of 4-5 lbs. of calcium chloride per 100 gals. water (4.8-6 grams/liter). Higher rates may burn the crop. Apply only during the period of unfavorable conditions. Liming a very acid soil also gives good control (see the soils and fertilizer manual).

Leaf Curling (Rolling): Some kinds are normal and are more pronounced in some varieties. Overwatering, prolonged heavy rainfall, or severe pruning promote it. This normal curling consists of upward rolling of the leaflets on the lower leaves, making for a cup-like appearance.

Graywall: Gray to grayish-brown blotches on the surface of green fruits; also called "blotchy ripening." May be caused by low light intensity, high soil moisture, soil compaction, or cold weather. Resistant varieties are the best control.

Cat-facing: Fruit shows a severe malformation and scarring at the blossom end; fruit is puckered with irregular, swollen protuberances at the blossom end. Thought to be caused by any serious disturbance (stress) during flowering; 2,4-D herbicide damage can cause it too. Varieties vary in their susceptibility.

Growth Cracks: The cracks can be either concentric or radial (down the sides) and are most common during high rainfall and temperatures which favor extra rapid growth. Varieties vary in their susceptibility. In dry areas, avoid irrigating tomatoes right before harvest.

Sunscald: Due to sun exposure of the fruit and very common where plants have been prematurely defoliated due to leaf spot diseases. Excessive irrigation or rain fall can also kill the older foliage. First symptoms are a yellow or white patch on the side of the fruit facing the sun; it may remain yellow, but usually a blister-like area forms and later shrinks to a large, grayish-white spot with a paper-like surface. Covering the fruits (if the plants are sprawling and unstaked) with a light layer of straw helps. Sunscald is most common on immature, green fruit.

EGGPLANT

Time til harvest: 75-100 days from transplant.

Good yield: 4+ kg/sq. meter depending on conditions

Characteristics: Likes hot weather; usually grown as an annual but it's a perennial; requires care in transplanting; soaking seeds overnite improves germination.

Varieties: Purple, yellow, white fruits; small and large fruited varieties; some are resistant to bacterial wilt, a very destructive disease.

Transplanting: Care is required (keep as much soil as possible around the roots when the plants are pulled). Set out plants in the field when 12-18cm tall. Can also be grown in 5 gal. containers.

Plants may need staking. Control plant size by pinching off the growing point.

Fertilizing: see peppers.

Diseases: Bacterial wilt, verticillium wilt, anthracnose. Don't plant eggplant, pepper, tomato or potato on the same ground within 2 years.

Insects: Flea beetles, aphids, hornworms, lace bugs, etc.

PEPPERS (Sweet)

Time til harvest: 60-90 days after transplanting.

Good yield: 12,000 lbs./acre (kgs./Ha.)

Characteristics: Not as heat tolerant as eggplant; hot peppers have better heat resistance. Bell (sweet) peppers ripen from green to red, sometimes yellow. Night temperatures above 75°F (24°C) or much below 60°F (15-5°C) encourage blossom drop as well as daytime highs above 90°F (32°C). Some natural blossom drop occurs even at ideal temperatures so the plant doesn't overload. Seed germinates slowly.

Transplanting: It takes 6-8 weeks to grow transplants; set out in field when 8-12cm.

Fertilizing: Good managers can use up to 80+ lbs. N, 80-200 lbs. P_2O_5, and 0-100 lbs. K_2O per acre (kgs./Ha.) according to soil test results and capital available. Apply all the P and K at planting (unless K leaching is likely to be high) and 1/3 of the N. Sidedress every 3-4 weeks afterwards with about 30 lbs. N/acre (kgs./Ha.). Also use a starter fertilizer solution at transplanting time.

Varieties: Here are some of the more common ones with their characteristics:

Yolo Wonder: Resistant to tobacco mosaic. Medium season. Yolo Wonder L is a taller type with better fruit protection against sunscald. 78 days (fr. transplant)

Early Calwonder: Early season with a medium thick wall. Yields over a shorter period.

Worldbeater: Thinner walled than Calwonder types, less blocky in shape. 70 days.

Florida Resistant Giant: Thick walled Calwonder type that's resistant to tobacco mosaic.

Insects: Aphids, flea beetles, armyworms, leaf miners, cutworms, pepper weevil.

Nematodes: Susceptible to rootknot, sting, and several other types.

Diseases: Common diseases are mosaic virus, bacterial wilt, bacterial leaf spot, anthracnose, and several other leaf spots. Foliar fungicides will control foliar spots if applied regularly; use copper base sprays on bacterial leaf spots. Don't use tobacco products while working with peppers; wash hands thoroughly before entering the field if you're a tobacco user to avoid spreading mosaic virus. To avoid bacterial soft rot, don't handle plants when wet and avoid wounding the fruit. Practice crop rotation by not planting pepper, eggplant, tomato, or potato on the same field within 2 years.

Sweet vs. hot peppers: Sweet varieties are less heat and drought resistant than hot varieties. Sweet varieties are usually harvested at the mature green stage, while hot varieties are picked at the mature red stage (hot wax types are picked when yellow).

CABBAGE

Time til harvest: 61-90 days after transplanting.

Good Yield: 2-6 kg/sq. meter

Characteristics: Prefers mild temperatures but passable yields can be obtained in warmer areas if heat tolerant varieties like KY and KK Cross (hybrids) are used; mulching helps reduce soil temperature. Heads weighing 2-4 lbs. are possible in warm weather while 4-6 lbs. heads are common when it's cool.

Transplanting: Transplants can be grown in about 4 weeks and are ready at the 4-6 leaf stage. If shooting for large heads, space plants about 20" (50cms) apart, otherwise 12-16" (30-40cms). Use a starter fertilizer solution (see "Tips on Transplanting") in addition to the usual NPK solid fertilizer. Set them firmly into the ground to avoid air pockets.

Other tips: Cabbage is shallow rooted and easily injured by cultivation deeper than 1-1/2". Large heads sometimes split during hot weather; splitting can be prevented by harvesting a bit early or twisting the plant 1/4-1/2 turn near maturity til you hear some roots snap - it'll slow growth. Some variety hybrids are available.

Fertilizing: Good managers can apply up to 100-120 lbs. N (1/3 at transplanting), 60-150 lbs. P_2O_5, and 60-150 lbs. K_2O per acre (kgs./Ha). Apply the remainder of the N in 1-2 side-dressings. Cabbage is susceptible to magnesium, sulfur, boron, and molybdenum deficiencies.

Insects: Cabbage loopers, diamond back moth caterpillar, aphids, leaf miners, cutworms, wireworms. Try Bacillus thuringiensis (Dipel, Biotrol, Thuricide) for loopers, diamond back moth, imported cabbageworm.

Diseases: Bacterial black rot (Xanthomonas), bacterial soft rot, and leaf spots like Alternaria, Cercospora, and downy mildew. Foliar fungicides will help control downy mildew and leaf spots. Don't grow cabbage family members on the same land within 2 years of each other if possible. Club root and Fusarium yellows are 3 other soil-borne diseases.

Nematodes: Susceptible to rootknot, sting, cyst, and several other nematodes.

Consider growing COLLARDS: Collards are a non-heading cabbage and have 2 advantages: They're much higher in vitamin A (50-60 times higher) than cabbage, tolerate heat better, and can be harvested leaf by leaf. Cabbage loop control is easier since there's no head for th- to hide in.

CHINESE CABBAGE

Time til Harvest: 70-90 days after direct seeding

Characteristics: One of the easiest and most productive vegies in the tropics, although it prefers cooler weather. Tolerates direct field planting well. Doesn't store or ship as well as cabbage. Can be cooked or eaten fresh. Forms a semi-loose cylindrical head. Can be harvested at maturity when heads are 6-9" across or you can pick the outer leaves as they reach about 6-8" in length; new ones will continue developing for many weeks. Once the heart starts to form, tying the leaves together at the top and bottom will help blanch (whiten) the leaves.

CUCUMBER

Time til harvest: 45-65 days

Good yield: 0.8-3.2 kg/sq. meter depending on conditions

Characteristics: Prefers hot weather but does best under low humidity; good root system but easily burned by fertilizer.

Fresh market (slicing) vs. pickling cucumbers: Most pickling cukes are black spined while fresh market ones are white spined. WS varieties turn a creamy color when mature, but BS varieties turn yellowish orange inside. Fresh market cukes are long and narrow while pickling types are short and fat, but they can be used interchangeably.

Flowering and Fruiting: Most of the standard open-pollinated varieties have a mix of male and female flowers (monoecious). Male flowers open first but don't set fruit. Female flowers open about a week later--you can tell them by the miniature cuke right beneath the flower. Many of the new hybrids are gynoecious: they have nearly all female flowers; they're packaged with a few normal seeds (dyed for identification) to supply pollen. They have higher yield potential and often better disease resistance. All varieties are pollinated by bees, and commercial growers in the U.S. use 1 hive for every 3-5 acres. Apply insecticides only in the late afternoon (when bees have returned home) to avoid bee kill during flowering. Don't use Sevin since its residue is toxic to bees for 7-12 days.

Varieties: Here's a list of some of the more common fresh market varieties and their characteristics:

Ashley: Open-pollinated, dark green, 7-8" long, early to midseason, resistant to downy mildew, fairly tolerant to powdery mildew. Until recently, all varieties were of the vining type. Now there are several bush varieties which take up less space.

Poinsett: Dark green, 8-8-1/2" long, mid-season; tolerant to downy and powdery mildew, anthraacnose, and angular leaf spot (bacteria). Open-pollinated.

Victory: A gynoecious hybrid, 7-8" long, dark green, early variety, resistant to down mildew, moderately tolerant to powdery mildew, scab, anthracnose, and angular leaf spot.

Gemini: A gynnoecious hybrid, draw green, 7-8" long, mid-season, tolerant to downy mildew, powdery mildew, scab, mosaic, and anthracnose.

Sprint: Dark green gynoecious hybrid, 7-9" long; high tolerance to scab; tolerant to angular leaf spot, cucumber mosaic, downy mildew, powdery mildew, and one race of anthracnose.

Slicemaster: Gynoecious hybrid, dark green, early variety, 7-9" long; high tolerance to anthracnose, scab, mosaic, angular leaf spot, and downy and powdery mildew.

Row vs. Hill Planting--Trellising uses less space and produces more attractive fruit (straighter).

Row planting is the best system when trellising is used. Plant 4-5 seeds per foot and thin to one plant every 10-12" with the rows 4-5 ft. apart. Plant on a slight ridge, especially during the rainy season. Use 3-ft. rows if trellised.

In hill planting, sow 6 seeds per hill and thin down to 3 with the rows 4-5 ft. apart. The "hill" should be a slight mound, but first dig out a 2-ft. diameter hole about 12-18" deep and fill with well rotted manure or with compost about half way up. Mix in soil and build up the mound so it's about 3" or so above ground in the center (don't make it too high or it'll tend to dry out quickly). Space the hills about 3 ft. apart. Hill planting makes for easier watering.

Fertilizing: see squash next page.

Insects: Cucumber beetle, vine and fruit borers, aphids, leaf miners, flea beetles, stink bugs, cutworms, armyworms.

Nematodes: Very susceptible to rootknot and sting nematodes

Disease: Downy mildew (likes high humidity), powdery mildew (more common under low humidity), cucumber mosaic virus (transmitted by aphids from wild host plants and other cukes), angular leaf spot (use copper base fungicides), scab and anthracnose. The mildews, scab, and anthracnose can be controlled with fungicide sprays.

Other tips: Train vines into the row to keep them out of pickers' way--stepping on them greatly reduces the yield. Harvest starts about 7-10 days after female flowering.

Bitterness: Most likely caused by lack of H_2O or too much variation in soil moisture.

SQUASH

Time til harvest: 50-60 days (summer squash)
85-125 days (winter squash)

Good yield: 2-8 kg/sq. meter, depending on conditions

Summer vs. Winter Squash: Sumer squash varieties are bred to be picked in the young tender stage; winter squash types are picked in the mature hard stage. Zucchini and Yellow Crookneck are summer squash types; butternut and acorn squash are winter types. Each country has many native varieties (especially winter types) but they tend to be low yielders (but good disease resistance).

Vining vs. Bush Varieties: Vining types need 8-10 ft. between rows, bush types need about 5 ft. between rows.

Flowering and fruiting: Like cucumber, squash has both male and female flowers; only the females produce squash. Pollination is by bees. Commercial growers in the U.S. use one hive per 3-5 acres. Apply insecticides in the later afternoon when bees have gone home to reduce bee kill; don't use Sevin during flowering since its residue is toxic to bees for 7-12 days.

Planting: Use the "hill" method as with cukes and plant 6 seeds, thinning down to 3 plants. Plant vine types in hills 3 ft. apart with about 8-10 ft. between rows; plant bush types in hills 3 ft. apart with 5-6 ft. between rows.

Fertilizer: Good managers can use up to 75-100 lbs. kg/Ha. N/acre (kgs./Ha.) with 1/3 applied at planting along with 50-125 lbs./A (kgs./Ha.) P_2O_5 and K_2O according to the soil's estimated P and K status. Use the half-circle method at planting and make it 3-4" deep and 4" from the seeds. Instead, you can broadcast the NPK fertilizer over the hill and work it in well (use this method if you have chucked in a lot of organic matter when making the hill; it'll help protect the broadcast P from tie-up).

Insects, Diseases, Nematodes: See cukes

ONIONS

Time till harvest: 100-140 days (bulb onions)
45-60 days for green onions

Good yield: 1.5-6 kg./sq. meter (bulb onions)

Bulb vs. Green Onions: Bulb varieties can be eaten as green onions if harvested early (plant 'em close together so they'll form long white stems instead of bulbs). True green bunching onions have no distinct bulb but continue to form new shoots during the growing season; these multiplier types are sometimes called scallions.

Daylength and Bulb Production: Some onion varieties need long days (14 hours or more) to bulb. Bermuda types will bulb under short days but Spanish and American types won't. If you're closer than latitude 24° to the Equator, daylength never exceeds 14 hours even on the longest day. Bulb onions usually do best if planted so that bulb maturation occurs during the time of the year when daylenth is increasing.

Bulb Onion Varieties: Bermuda onions store poorly (yellow types store better than white types but still no more than a few weeks at best). Here are some short daylength varieties and their characteristics:

Yellow Bermuda: Flat bulbs, soft-mild, short storage life.

Tropicana: Red, resistant to purple blotch disease, pungent, stores well.

Red Creole C-5: Red skinned, resistant to purple blotch, small, very pungent, stores well.

Texas Grano 502: Large size, yellow skinned, stores well.

Granex: Hybrid, very resistant to pink root disease. Both yellow and white skinned varieties are available.

Excel: Amber skinned, medium size, very resistant to pink root disease.

Eclipse: White skinned, very resistant to pink root.

Early Grano: Straw colored, soft-mild, short storage life.

Direct Planting vs. Transplanting: Direct planting bulb onions speeds up maturity by about a month. The catch is that onion seedlings need abundant and uniform moisture which is more easily provided in a nursery seedbed. Weeds are also more of a problem with direct planting. Onions are ready for transplant when stems are about pencil size.

Fertilizer: Good managers can apply up to 100 lbs./A N (1/3 at planting or transplanting) and 50-150 lbs. P_2O_5 and K_2O per acre (kgs./Ha.) depending on the soil's P and K status. Use the band method and place the NPK fertilizer 3-4" deep and 2" from the row (2-3" if transplanting).

Insects: Thrips, leaf miners, cutworms, wireworms

Diseases: Purple blotch (Alternaria), Botrytis leaf blight, and downy mildew can be controlled with foliar fungicides; pink foot can be controlled with resistant varieties or using soil fumigants like Vapam.

Nematodes: Onions are very susceptible to rootknot, sting, and several other types of nematodes.

Other tips: Emerging seedlings are very easily damaged by windblown particles like sand so windbreaks may be needed in some cases. Maintaining a uniform moisture content is especially important once bulbs start maturing; water should be cut down during maturation since excess water encourages the sprouting of new roots which hinders curing.

WHEN TO HARVEST VEGETABLES

BEANS, green: Harvest bush beans while the pods will still "snap" and before they become lumpy. Bush bean varieties have a harvest period of about 2-3 weeks; pole (vine) varieties have a 6-8 week harvest period, and the pods are picked when large and thick.

BEETS: Ready to harvest as soon as they're 1-1/4-2" in diameter (about golf ball size). Sugar content increases with age but so does toughness.

BROCCOLI: Harvest just after the individual flower buds become distinguishable but before the clusters begin to open and turn yellow. Center head is usually 3-6" across; side shoots continue developing after center head is cut and will reach 1-3" in diameter. Making a slanting cut may help prevent stem rot.

CABBAGE: Can be harvested as soon as the head has formed since flavor doesn't change much with maturity—you'll sacrifice yield though. Use a sharp knife and cut close to the head. Heads will sometimes split during hot weather when large; twist the plant about 1/4-1/2 turn til you hear some of the roots snap—it'll slow growth and reduce splitting (do it near maturity). If bacterial soft rot is a problem, dip knife and stem of cabbage in a 1% solution of household bleach in water (10 c.c. bleach per liter).

CARROT: Harvest can start when the roots are about 1" in diameter at the crown; don't let 'em get more than 1-1/2".

CANTALOUPE (Muskmelon): A common guide is the ease of melon removal from the vine; fully ripe ones (called "full slips") separate easily and leave a clean stem cavity; full slips have poor storage life except under refrigeration. Half slips are less mature and take more pressure to detach (about half of stem next to the melon remains attached) and store longer. Both full and half slip melons are fully netted and the color has changed from cucumber green to mottled green and light yellow.

CAULIFLOWER: Timely harvest is important to prevent ricey or fuzzy curds. If weather is warm, heads can mature within 3-5 days after blanching (see below) starts but can take up to 2 weeks in cooler weather. Mature heads are fully developed, compart, and clear white; about 6" is the best size for harvest. Use a large knife to cut the heads from the plants and leave one or more sets of leaves attached to protect the curds; avoid overmature, open heads.

Blanching: Curd becomes discolored and sometimes off-flavored if exposed to sunlight; when small, they're protected by the inner leaves; as curds enlarge, in most varieties they force the inner leaves apart, so blanching is needed. Gather longest leaves together over the curd and tie with soft twine; since the plants mature at different rates; you'll need to go through the field every 2-3 days to do blanching: using different color twine each day will aid in maturity detection. Some self-blanching varieties are available.

CHARD, Swiss: Harvest outer leaves first as they reach tender maturity (blade will be about 6-10" long); new ones will continue developing.

CHINESE CABBAGE: There are 2 ways to harvest Chinese Cabbage:

1. Harvest when heads are solid and 6-8" across. Cut with a knife at the base of the head and remove any dead, yellowed or dirty leaves around the outside. It doesn't store or ship as well as regular cabbage; the heads can be packed loose in boxes or first rolled in newspaper. Letting the heads wilt before boxing them helps prevent breakage--buyers can recrisp them by soaking them for a few minutes.

2. Harvest the outer leaves as they reach about 6-8" in length; new ones will continue developing for many weeks. They'll also be much higher in vitamin A due to better sun exposure (i.e. compared to the paler leaves inside a head).

CHAYOTE (Guisquil, Vegetable Pear): 25-30 days after fruit set.

COLLARDS: Two ways to do it:

1. Harvest outer leaves when full size but still tender.

2. Harvest the entire plant at once before leaf stems become tough and fibrous.

CUCUMBER: Fresh market (slicing) cukes can be picked at any size, but a medium size, dark green cuke is best. Don't let them reach the full yellow ripe stage since it'll reduce total yield. Picking should be done every 2-3 days; hold the vine and twist off the fruit (pulling may damage vines).

EGGPLANT: Higher total yields are attained if the fruits are picked before reaching full size; they're ready anytime after the fruit is 1/3 size with skin showing a slick luster; skin should be firm to the touch. If the seeds are brown or the skin remains indented after being pressed with the thumb, it's over-ripe. Cut off the fruit, don't pull, leave the calyx (cap) attached to the fruit. Handle carefully to avoid bruising.

GARLIC: Ready to harvest after the tops have died; in rich soil, tops may need to be broken over to prevent too much top growth. Plants are pulled and placed in windows with tops covering bulbs to prevent sunscald. Curing takes several days and can be done indoors if rainy.

LETTUCE: Leaf lettuce is ready as soon as the leaves are big enough; the entire plant can be harvested or you can prolong the harvest (up to 2 months or more) by picking the outer leaves as they develop.

MUSTARD: Pick outer leaves when 4-6" long; plant will continue producing new leaves.

NEW ZEALAND SPINACH: Pinch off about 3" of branch tips with leaves; more side shoots will keep appearing.

OKRA: Pods are usually picked 3-5 days after flowering when 2-3" long; pick pods daily to keep plant producing and to avoid overmaturity. Okra deteriorates rapidly after harvest.

ONIONS: Can be harvested either as green bunch or mature bulbs; suitable for green bunch harvest from the time they're pencil size. As mature bulb stage nears, some of the tops will fall over at the neck. Break over all tops at this time to assure uniform maturity. In the dry season, they can be cured in the field--shade the bulbs with the tops to minimize sunscald. One half to one inch of top is usually left on the bulb to prevent disease entrance.

Once way to speed up maturation and get larger bulbs is to break over the tops when the outer leaves turn yellow; 2 weeks later, loosen the bulbs by pushing a spading fork beneath them and lifting slightly; in another 2 weeks, lift them out after they're dried; spread out in a warm, airy place for a few days to cure, then braid 'em together and hang 'em up.

PEPPER: Bell peppers are usually picked while still green (before they turn yellow or red); they can be harvested for home use when quite young, but the fruit will wilt quickly. Cut, don't tear the fruit from the plant and leave a portion of the stem on the fruit.

POTATO: Can be harvested at any size but usually best to let them grow to full size (until the vines die off), barring market considerations. The vines should be dead before harvest for 2 reasons: (1) So the skins will "set" (harden); (2) To prevent transfer of late blight spores from the vines to the tubers which can cause them to rot; vines can be killed by topping or with Gramoxone or Reglone. Handle carefully to avoid bruising.

RADISH: Harvest can start as soon as they reach small acorn size. Once much bigger than 1", they begin to split and get hot and pithy. Normal harvest is 3-4 weeks after planting. Use the tops as greens (much higher in vitamins, minerals).

SQUASH: Summer varieties like Zucchini and Yellow Crookneck are ready when the thumb makes an imprint on the skin; winter types are ready when the skin resists thumb pressure; cut off the fruits, don't twist or pull (avoids vine damage).

SWEET POTATOES: Best way is to dig up a few and see if they're the size you want: small fruits have more flavor and are easier to bake; large tubers mean larger yields. Yellowing of the lower leaves is usually a sign of approaching maturity.

TOMATO: For canning and pasta, harvest fully ripe, for local markets, pick at the hard ripe to pink stage. For distant shipping, at the mature green stage. The longer they can be left on the vine, the higher the quality. Mature greens ripen in 6-20 days at 70°F and don't color faster at higher temperatures; keep out of sun; ripen best in dark.

Mature green test: Cut cross-wise with a sharp knife; if the seeds give way without being cut, it's mature; fruit also has a brownish ring at the stem scar after the calyx (cap) is removed, and the light green color at the blossom end has turned yellow green.

Hard ripe stage: nearly all red or pink but flesh is firm.

Over-ripe: Fully colored but soft.

Leaving fruits on the vine won't reduce yields.

TURNIPS: When roots reach 2 to 2-1/2" in diameter; use the tops as greens; they're much higher in vitamins and minerals.

WATERMELON: Don't harvest immature or won't have good flavor or color; here's several tests:

1. "Thump" test: Green ones have a metallic ring; mature ones, a muffled sound.
2. Watch the tendrils (pig tails) on the stem near the fruit; the 1st tendril going to the fruit will die (wither) first, but don't pick yet; wait til the tendrils on either side of the one attached to the fruit die.
3. Watch bottom of melon where it rests on the ground; when it changes from white to light yellow with little or no green, it's ready.
4. The melon will lose its shine and have a slight cast to it.

Leave about 2" of stem attached to the fruit when picking.

INTRODUCTION TO INSECTS AND INSECT CONTROL

I. SOME IMPORTANT FACTS ON INSECTS

How Insects Damage Plants

Insects can often be identified by the type of damage they cause:

1. Chewing and Boring Insects

   a. Caterpillars are larvae of moths. They damage plants by feeding on leaves and making holes in them or by boring into stalks, pods, and maize ears. The cutworm caterpillar is unusual in that it lives in the soil and emerges at night to cut off plant stems near ground level.

   b. Beetles feed on plant leaves and chew holes in them; some beetles of the weevil family bore into pods and seeds and deposit eggs inside. Certain beetles can also transmit bacterial and virus diseases.

   c. Most beetle larvae like white grubs, wireworms, and rootworms live in the soil and damage roots and the underground portion of the stem by chewing or boring. A few beetle larvae such as those of the Mexican bean beetle and Colorado potato beetle live above ground and feed on leaves.

2. Sucking Insects

   Aphids, leafhoppers, stinkbugs, harlequin bugs, whiteflies, and mites have piercing and sucking mouthparts and feed on plant sap from leaves, pods, and stems. They transmit a number of plant diseases, especially viruses. Sucking insects do not make holes in the leaves but usually cause leaf yellowing, curling, or crinkling.

Insect Life Cycles

A general understanding of insect life cycles will also help you identify insect problems in the field. Beetles and moths go through a complete metamorphosis (changes in form) of 4 stages, while aphids, leafhoppers, whiteflies and other sucking insects go through only 3 stages.

(Adult stage) MOTH → EGG → (larva) CATERPILLAR → PUPA

- MOTH: (Does no damage)
- CATERPILLAR: (Usually feeds on leaves)
- PUPA: (Dormant stage turns into a moth)

(Adult stage) BEETLE → EGG → LARVA → PUPA

- BEETLE: (Feeds on leaves, pods)
- LARVA: (Grubs, wireworms, rootworms, etc. Feed on plants roots.)
- PUPA: (Dormant stage; turns into a beetle.)

(Adult stage)
APHIDS, LEAFHOPPERS, ——————► EGG ——————————► NYMPH
STINKBUGS, WHITEFLIES,
OTHER SUCKING INSECTS

(Looks like a miniature adult; sucks sap also; turns into the adult stage.)

II. HOW TO IDENTIFY INSECTS AND THEIR DAMAGE

1. BE OBSERVANT! Troubleshooting takes practice, but a sharp eye is essential. When walking through a field, closely examine the plants for insects or their damage symptoms. Check both sides of the leaves since many insects prefer the undersides of leaves. A magnifying glass can be very helpful.

2. Identifying Insect Damage:* Very often you'll be able to identify insects by the damage they cause.

   a. Holes in leaves: Caterpillars, beetles, crickets, snails, and slugs; snails and slugs aren't insects but do attack plant foliage (look for slime trails on leaves). Caterpillars leave green or brown sawdust-like excrement.

   b. Wilting: Soil insects like white grubs and wireworms if root feeding or tunneling of the underground portion of the stem has been serious; stem borers. Remember that wilting can be caused by other factors too: dry soil, very high temperatures, root rots, bacterial and fungal wilts, and nematodes.

      (1) Dig up the affected plants and check the root system and underground portion of the stem for insect and disease damage; look for soil insects.

      (2) Slit the stem lengthwise with a pocket knife and check for borers or rotted tissue

   c. Leaf curling, crinkling, or yellowing: Sucking insects, especially aphids, leafhoppers, and mites. Viruses and some nutrient deficiences also produce these symptoms. Nematodes and poor drainage cause yellowing too.

3. Identifying Insects: Spend time with locally experienced extension workers in the field and have them point out the prevalent crop insect pests (and beneficial predator insects) in your work area. Seek out host country or regional insect guides such as extension bulletins. The publications listed below are also very useful:

Insect Pests, a Golden Guide, Geo. Fichter, Golden Press, New York. Available from Dept. M, Western Publishing Co., 1220 Mound Ave.,

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* Refer also to the troubleshooting guide to common crop problems on pp. 158-162.

Racine Wisconsin, U.S.A. 53404. $1.95 plus postage. A good general guide that includes many insects with their scientific and common names.

Agricultural Pests of the Tropics and Their Control, D. Hill, Cambridge University Press, London, 1975.

Field Problems of Beans in Latin America, CIAT, Apdo. Aereo 6713, Cali, COLOMBIA. $5.60 plus postage.

III. THE USE OF SCIENTIFIC NAMES FOR INSECTS

Each insect is known by many different local names throughout the world, which can make proper identification confusing. Fortunately, all insects (as well as plants, animals, and diseases) are assigned standardized scientific names derived from Latin.

> Example: The corn earworm has been given the scientific names of *Heliothis zea*. The first word of the two part name refers to the insect's genus and the second part of its species.

Host country agronomists and extension workers may often refer to insects using their genus such as "heliothis". Farmers will usually use local names for insects. Since this genus-species is being continually revised, an insect may have more than one commonly used scientific name; for example, the fall armyworm has had its scientific name changed from *Laphygma frugiperda* to *Spodoptera frugiperda*. When referring to several insects of different species that are all within the same genus, publications will often place the abbreviation "spp." after the genus. Thus, *Heliothis spp.* refers to several types of heliothis caterpillars.

IV. METHODS OF INSECT CONTROL AND THEIR EFFECTIVENESS

Let's compare the effectiveness of non-chemical, chemical, and integrated insect control methods:

NON-CHEMICAL METHODS

Natural Balance

Many natural controls act to keep insects in balance:

1. Weather factors like temperature and rainfall can restrict the distribution of an insect species; for example, mites and leafhoppers are usually more prevalent under dry conditions.

2. Geographic barriers like large bodies of water, mountains, and deserts can also limit insect distribution.

3. Frogs, toads, lizards, moles, and birds are some of the many animals that feed largely on insects.

4. Beneficial predator insects like lady bugs feed on aphids, while others like the braconid wasp and tachinid fly lay eggs on or in

certain pests which are killed by the developing larvae. Some predator insects like praying mantis also eat beneficial insects as well, however.

5. Insects are also attacked by viruses, fungi, and bacteria which help keep populations down.

As agricultural activities have increased, many of these natural balances have been upset and can no longer be relied upon to keep harmful insects under control. Monoculture and the existence of vast areas under cropping have led to marked increases in a number of insect pests. Many of the traditional crop varieties, despite their lower productivity, have better insect resistance than some of the improved varieties. Indiscriminate use of pesticides has also resulted in an actual buildup of harmful insects in some cases.

Biological Control

Biological control is the purposeful introduction of predators, parasites, or diseases to combat a harmful insect species. About 120 different insects have been partially or completely controlled by this method in various parts of the world. Microbial insecticides such as Bacillus thuringiensis (effective against a few types of caterpillars) are now commonly used by farmers and gardeners in many areas. Unfortunately, biological control measures are presently effective against a very small portion of harmful insect species.

Cultural controls

Cultural controls such as crop rotation, intercropping, burying crop residues, timing the crop calendar to avoid certain insects, and controlling weeds and natural vegetation that harbor insects are all effective control methods for some insects. In most cases, however, cultural controls need to be supplemented by other methods.

Varietal Resistance

Crop varieties vary considerably in their resistance to certain insects. For example, maize varieties whose ears have long, tight husks show good resistance to earworms and weevils; CIAT found that some bean varieties were relatively unaffected by leafhopper damage during the wet season, while others suffered yield losses up to 40%. Screening for insect resistance is an important part of crop breeding programs.

"Organic" Controls

"Organic" control refers to non-chemical methods in general, including the application of homemade "natural" sprays made from garlic, pepper, onions, soap, salt, etc., and the use of materials like beer to kill slugs and wood ashes to deter cutworms and other insects. Some of these "alternative" insecticides are slightly to fairly effective on small areas like home gardens and where insect populations are relatively low. They are seldom feasible or effective on larger plots, especially under tropical conditions that favor insect buildup.

CHEMICAL CONTROL

Chemical control refers to the use of commerical insecticides in the form of sprays, dusts, granules, baits, fumigants, and seed treatments. While some of these insecticides like Bacillus thuringiensis, rotenone, and pyrethrin are naturally derived, most are synthetic organic compounds that have been developed through research.

Advantages of Insecticides

1. Rapid action.

2. They are the only practical means of control once an insect reaches the economic threshold of damage on a commercial size plot.
3. Insecticides are available in a wide range of properties, species effectiveness, and application methods.

4. They are relatively inexpensive, and their proper usage can often return \$4-\$5 for every \$1 spent.

Disadvantages of Insecticides

1. Insect resistance to pesticides is a growing problem. In 1961, about 60-70 species had developed resistance to certain products, and the number had increased to around 200 by the mid-1970's.

2. Outbreaks of secondary pests: Few insecticides kill all types of insects, and some actually promote the increase of certain pests. For example, continual use of Sevin (carbaryl) in the same field may increase problems with some types of aphids which it doesn't control well.

3. Damage to non-target species such as beneficial predators, bees, and wildlife.

4. Residue hazards: Some chlorinated hydrocarbon compounds like DDT, Aldrin, Endrin, Dieldrin, and Heptachlor are highly persistant in the environment and may accumulate in the fatty tissues of wildlife, livestock, and humans. It's important to realize that many other insecticides are broken down into harmless compounds fairly rapidly.

5. Immediate toxicity: Some insecticides are extremely toxic in small amounts to humans and animals. Again, it's important to realize that insecticides vary greatly in their toxicity.

Current Status of Insecticide Use

At the present time and for the immediate future, insecticide usage will often be an essential part of any package of improved practices for the reference crops. For this reason, we urge all ag field workers to learn the basic principles of safe and effective insecticide application. Even though you may be personally opposed to these chemicals, you should realize that farmers throughout the LDC's are using them, often in an unsafe and indiscriminate manner. Most of these countries have few, if any, pesticide regulations or restrictions on environmentally harmfully products like Aldrin or highly toxic ones like Parathion. By instructing farmers in safety precautions and in the appropriate choice and use of insecticides, the incidence of human poisoning and possible environmental damage can be greatly reduced.

INTEGRATED PEST CONTROL

The disadvantages of total reliance on insecticides have given rise to integrated pest control or pest management which involves the judicious use of these chemicals based on the following guidelines and principles:

1. The development and use of cultural and other non-chemical control methods to avoid or reduce insect problems.

2. (Economic Threshold) Determining crop tolerance to pest damage based on the principle that complete freedom from pests is seldom necessary for high yields. Nearly all plants can tolerate a surprising amount of leaf loss before yields are seriously affected.

3. The appropriate timing and frequency of treatments to replace routine, preventative spraying. Treatments are not initiated before the particular insect has reached the economic damage threshold which will vary considerably with the species. Insect scouting and population counts are an essential part of this system.

The advent of integrated pest control dates back to the early 1970's and much of the efforts have been directed at cotton where insecticides frequently account for up to 80% of total production costs. Some remarkable successes have been achieved with other other crops as well. In terms of the reference crops, integrated pest control is still in the very early stage, especially in the LDC's.

SOME "ORGANIC" (NON-CHEMICAL) PEST CONTROLS

CUTWORMS: Place a collar made of cardboard or a paper cup around the stem so that it extends from about 2 cm below the soil surface to about 5 cm above ground. Don't place the collar deeper or you may restrict the root system of the transplant. Wrapping the stem with several layers of newspaper or a couple layers of tin foil works great too. So do small juice cans or beer cans cut down to the right size.

SLUGS & SNAILS: Stale beer (or water and yeast) placed in shallow pans in the garden is very effective at attracting and drowning the critters. However, if the container is placed on top of the mulch, slugs are unlikely to reach it. Other remedies are:

1. Place a wide board on the ground in the late afternoon. By next morning, lots of slugs and snails can be found under it; crush them.

2. Sprinkling coarse sand, wood ashes, lime, or diatomaceous earth around the plants' base will repel them. (Caution: too much lime may raise the pH too much.)

3. If using mulch, keep it several inches away from the plant rows; slugs like to hide and feed under it.

4. Keep the field clean of weeds and debris.

ANTS: Pouring boiling water over nests is very effective for fire ants. Steamed bone meal supposedly repels ants (don't try making your own bone meal out of old cattle bones; they can harbor dangerous anthrax disease).

NEMATODES

1. Crop rotation: Sometimes difficult or impractical since most types of nematodes have many crop hosts (see section on nematodes later on in this tech reference package).

2. Resistant crop varieties: Varieties of a crop will vary in their resistance, and some (i.e. Roma VFN and Better Boy VFN tomatoes, Nemagold sweet potatoes, and others) are good enough to rate the name "nematode resistant variety". Check out what's available in your host country.

3. Plowing up roots of nematode infested crops right after harvest will expose them to sunlight and drying, which will kill many of the nematodes; however, many are likely to be left in the soil itself.

4. Flooding: One month of flooding followed by a month of drying and a further month of flooding will greatly reduce nematode problems but is seldom practical.

5. Antagonistic plants: Many organic garden books suggest interplanting marigolds among susceptible crops to control nematodes. Unfortunately, research has shown that marigold species vary in their nematode fighting ability which is also limited mainly to certain types of nematodes (root knot, root lesion). Furthermore, nematodes aren't killed by marigolds but only repelled or starved out; this means that interplanting marigolds among susceptible crops isn't effective, since the nematodes still have a food source. You would need to plant marigolds solidly and exclusively for a few months. (See p. 270)

   Two legume green manure or cover crops, Crotalaria spectabilis (showy crotalaria or rattlebox) and Indigofera hirsuta (hairy indigo) can reduce populations of most types of nematodes. Showy crotalaria is poisonous to livestock.

6. Good soil fertility and high organic matter levels help somewhat.

7. Sugar: 8 kg of sugar/sq. meter worked into the top 15 cm of soil is said to control root knot nematodes; this may be worth a try if you're in a low-cost sugar area.

COCKROACHES: 1 lb. boric acid crystals mixed with 1 can of condensed milk (the thick, sugary stuff). Make pea size pellets out of this, place on pieces of tinfoil and use one per room. Will keep a year under refrigeration. Results vary from mediocre to fairly good.

BIRDS: Soaking large seeds like maize in turpentine before planting may be a fair repellant to seed eating birds. An effective method for vegetable gardens and larger plots is continuous string flagging which uses cloth or plastic streamers 5-6 cm wide and 50-60 cm long. The streamers are attached at 1.5 meter intervals to string twine which is strung along heavy stakes at least 1.2 m tall which are spaced about 15 m apart.

ANOTHER CUTWORM REMEDY: Tie wild or cultivated onion stems around the stems of susceptible plants at the soil surface.

CORN EARWORM: Inject 1/4 of a medicine dropper's worth of mineral oil into the tip of each corn ear; begin as soon as silks appear and repeat every 3 days until silks begin to brown.

HAND PICKING: Very feasible for small areas and larger insects like beetles and caterpillars.

INTERPLANTING GARLIC AND ONIONS among other crops to repel insects: Gives poor to sometimes fair control of some insects, but don't rely on it under high insect pressure.

BENEFICIAL PREDATOR INSECTS: Lady bugs, lacewing bugs, tachnid flies, braconid wasps, praying mantids are among the more common. Where they occur naturally, they can make a big contribution. Trying to introduce them is seldom effective, since they tend to disperse.

BIOLOGICAL INSECTICIDES

1. Bacillus thruingiensis (Dipel, Thuricide, Biotrol): Made from a natural bacteria that kills many types of caterpillars such as cabbageworms, earworms, armyworms, and hornworms. Non-toxic to humans and animals. Slow acting--insects don't die immediately but stop feeding within a few hours; apply while they're still young for best results.

2. Bacillus popillae: Causes milky spore disease in Japanese beetle grubs and some other beetle grubs when applied to the soil.

HOMEMADE ORGANIC SPRAYS

All of them except nicotine spray (which isn't really "organic") will only repel some types of insects to varying degrees and may need daily application.

Bug Juice Spray: You need a strong stomach for this one, and it's of fickle effectiveness. Collect up to half a cup of a bad guy insect like cabbage loopers, stinkbugs, etc. Add 2 cups of water, place in a blender, and whiz it up. Organic Gardening says this solution can be diluted up to 1:25,000 but that sounds like a misprint! Try it 1:5 or 1:10 for starters. Use it within an hour or two or freeze it to prevent possible contamination by Salmonella bacteria (food poisoning). Clean your blender well. In some cases, bug juice actually attracts insects; cutworm juice is known to attract cutworms. Some success has been reported with aphids, cabbage loopers, and stinkbugs plus a few more. Don't use flies, ticks, fleas, or mosquitos since they may harbor diseases or parasites.

Plant Juice Spray: Find a non-poisonous weed or plant leaf unbothered by insects; choose smooth leaf plants, not hairy ones, and then dilute no more than 5 fold with water. Wormwood is said to kill slugs, crickets, and aphids.

Hot Pepper Spray: Grind hot pepper pods and mix with an equal amount of water. Add a little soap powder. Try it at a 1:20-1:30 dilution with water. Be sure to strain it well before putting it in the sprayer tank.

Garlic-Pepper-Soap Spray: 4 crushed garlic cloves, 4 tablespoons hot pepper, one cake of strong soap, one cup of hot water. Strain and dissolve in 2-4 gallons warm water. Use as a general purpose spray. Results are variable.

Citrus and Banana Peel Spray: Let banana and citrus peels soak in a pail for several days. Spray the mixture on plants and place the spent peels at their base.

Milk Spray: Using milk full strength is deadly to many bugs but what a waste of protein! By the way, it's been shown that dipping one's hands periodically in milk or a powdered milk solution when transplanting tomatoes can significantly cut down the spread of mosaic virus by contact from plant to plant.

Salt Spray: A tablespoon in 2 gallons of water supposedly gives fair to good control of cabbage worms; 2 tablespoons/gallon supposedly controls spider mites but test a plant or two for leaf burn first with the spray.

Molasses spray: Diluted 1:50 with water and used as a general purpose spray. Sounds doubtful.

Vegetable oil; Apply with a sprayer; may kill insects by plugging up their pores.

Soap spray: For soft bodied insects like aphids, thrips, whiteflies, mites, but not leafhoppers. Vegetable or plant derived soaps are better for this than petroleum derived ones.

Nicotine Extract: For sucking insects like aphids, leafhoppers, whiteflies, thrips, and spider mites along with many other non-suckers. Most effective during warm weather. Soak 1-2 cheap shredded cigars overnite in 1 gallon water. Strain and add one teaspoon of household detergent. CAUTION: Nicotine is poisonous to humans and animals; it can be absorbed through the skin in harmful amounts. It can also spread tobacco mosaic virus to tomatoes, peppers, eggplant, and potatoes.

MISCELLANEOUS

Flour: Sprinkle on cabbage plants in early morning when dew is heavy. Supposedly controls cabbageworms and their moths by sticking to them and then hardening as it dries out.

Wood ashes: May repel some types of insects of sprinkled on plants; if spread in a ring around plants and moistened, they may repel cutworms.

USING CHEMICAL INSECTICIDES

Before using any insecticide, be sure you've read over and understood the Safety Guidelines on pp. 227-228.

I. SOME IMPORTANT FACTS ON INSECTICIDES

Pesticide Terminology

Pesticide: A general term referring to chemicals that control crop insects, weeds, diseases, and nematodes.

Miticide (acaricide): A pesticide that kills mites; mites are more related to spiders than insects and not all insecticides will kill them. Some pesticides like dicofol (Kelthane) control only mites, while others like Diazinon (Basudin) and Malathion kill mites and other insects. Sevin (carbaryl) won't control mites.

Nematocide: A pesticide that kills nematodes (see p. 268). A few insecticides like Furadan and Mocap will also control nematodes, but most will not. Some nematocides like Nemagon control only nematodes, while others like VAPAM, Basamid, and methyl bromide are general soil sterilants that kill insects, weeds, fungus, and bacteria as well.

How Insecticides Kill Insects

Nearly all modern insecticides are contact poisons that kill insects by being absorbed through their bodies. Contact poisons act as stomach poisons if eaten by insects.

Systemic vs. Non-Systemic Insecticides

Most insecticides are non-systemic and are not absorbed into the plant. Systemic insecticides are absorbed into the plant sap, and most are translocated (transported) throughout the plant. Most systemic insecticides like Metasystox, Dimethoate (Rogor, Perfekthion), and Lannate are sprayed on plant foliage. Others like Furadan, Thimet, and Di-syston are applied to the soil in a band along the crop row where they are absorbed by the plant roots and then translocated to the stems and leaves. Some of these soil applied systemics will also control certain soil insects.

When choosing between a systemic and non-systemic insecticide, you should consider the following:

1. Systemic insecticides are especially effective against sucking insects like aphids, leafhoppers, stinkbugs, and thrips since these feed on the plant sap. However, many non-systemic contact insecticides will also control sucking insects adequately.

2. Most systemics are less effective against caterpillars and beetles but may give good control of some stem borers.

3. Foliar applied systemics may remain in the plant for up to 3 weeks. Soil applied systemics may provide control for up to 6 weeks. However, this also means that they must not be applied close enough to harvest time to cause residue problems.

4. Most systemics will not harm beneficial insects.

5. Foliar applied systemics are not broken down by sunlight or washed off the leaves by rainfall as with non-systemics.

6. Since they are translocated, systemics don't require uniform spray coverage when they are applied to the leaves. New growth occuring after application is also protected.

7. Some systemics like Thimet, Di-syston, and Systox are highly toxic both orally and dermally. However, the same is also true with some non-systemics like Parathion and Endrin. See pp. 251-257.

Types of Pesticide Formulations

Most insecticides are available in several types of formulations:

1. WETTABLE POWDERS, SOLUBLE POWDERS: These range in strength from 25-95% active ingredient and are meant to be diluted with water and applied with a sprayer. Wettable powders are often abbreviated as "WP" or "W"; for example, Sevin 50 W is a wettable powder containing 50% pure Sevin by weight. Once mixed with water, wettable powders require periodic agitation (shaking or stirring) to keep them from settling to the bottom. Soluble powders ("SP") are completely soluble and do not require agitation.

2. EMULSIFIABLE CONCENTRATES ("EC" or "E") are high strength liquid formulations. Like wettable powders, EC's are meant to be diluted with water and applied with a sprayer. They contain about 20-75% active ingredient (pure chemical).

   Labeling Systems for EC's: In countries using pounds and gallons, a label that reads "Malathion 5 E" would refer to a liquid formulation of malathion that contains 5 lbs. active ingredient per gallon. Where liters and grams are used, EC's are often labeled in terms of grams of active ingredient per liter; for example, Tamaron 600 is a liquid formulation of Tamaron containing 600 grams of active ingredient per liter.

3. DUSTS ("D"): Unlike WP's and EC's, dusts are low strength formulations (about 1-5% active ingredient) and are meant to be applied without dilution by a duster. Dusts are usually more expensive than WP's or EC's due to higher transport costs per unit of active ingredient; however, if dusts are blended within the country, they

may be competitive cost-wise and are especially suited to situations where a farmer has difficulty tranporting water to his field. They do not stick to the leaves as well as sprays and are more easily washed off by rainfall; retention is improved if they are applied while the leaves have dew on them. Dusts pose more of an inhalation hazard than sprays. They should never be mixed with water.

4. GRANULES ("G"): Like dusts, granules are low-strength formulations meant to be applied without dilution. They're especially well suited for soil applications and for placement in the leaf whorls of maize and sorghum to control armyworms. Granules can't be effectively applied to leaves, because they roll off. Furadan 3G is a granular formulation that contains 3% pure Furadan.

5. BAITS are usually the most effective formulation for controlling cutworms, crickets, slugs, and snails. Most contain about 3-5% active ingredient mixed with a carrier like sawdust, bran or corn meal; usually an attractant like molasses is also added. Commercial baits may be available in your country, but it's usually cheaper to make them up on the farm.

6. FUMIGANTS are available as pellets, granules, liquids, and gasses whose fumes kill pests. They are used to kill insects in stored grain or applied to the soil to kill insects, nematodes, and other pests.

Chemical Classes of Insecticides

Most manufactured insecticides fall into 3 main chemical classes or groups:

1. CHLORINATED HYDROCARBONS (Organochlorines): Most of the insecticides in this group such as DDT, Endrin, Aldrin, Chlordane, and Heptachlor have long residue lives and have caused environmental problems. However, other members like Methoxychlor are readily biodegradable. Toxicity to humans and animals varies greatly within this group (See pp. 251-257.)

2. ORGANIC PHOSPHATES (Organophosphates): OP's such as Malathion, Dipterex (trichlorfon), Diazinon, and Parathion have much shorter residue lives than most of the CH's. Their toxicity to humans and animals varies greatly. Some like Parathion, TEPP, AND Thimet are highly dangerous, while others like Malathion, Gardona, and Actellic are among the safest chemical insecticides available.

3. CARBAMATES: Relatively few chemical insecticides belong to this group and they tend to be of moderate to low toxicity for humans and animals. However, a few like Furadan and Lannate (methemyl) have high oral toxicities. Sevin (carbaryl) and Baygon (propoxur) are probably the best known carbamate insecticides. The residual life of the carbamate group varies from short to moderate.

II. INSECTICIDE SAFETY GUIDELINES

1. READ AND FOLLOW LABEL INSTRUCTIONS: If the label is vague, try and obtain a descriptive pamphlet. Not all insecticides can be applied to all crops; inappropriate use can damage plants or result in undesirable residues. The label should state the minimum allowable interval between application and harvest.

2. Never buy insecticides that come in unlabeled bottles or bags; you may not be buying what you think. This is a serious problem in the LDC's where small farmers often purchase insecticides in Coke bottles, etc.

3. When working with farmers, especially those using backpack sprayers instead of tractor sprayers, NEVER use or recommend those insecticides in toxicity Class 1. Their safe use requires extraordinary precautions and safety devices (gloves, special respirators, protective clothing, etc.). Whenever possible, avoid using Class 2 products. Unfortunately, extension pamphlets in many LDC's commonly recommend Class 1 and Class 2 products.*

4. If using Class 2 insecticides, wear rubber gloves and a suitable respirator (good ones cost $15-$25), as well as long pants and long sleeve shirt; wear rubber boots if using a backpack sprayer. This clothing should be washed separately from other garments.

5. Don't handle plants within 5 days after treatment with a Class 1 insecticide or with Gusathion (Guthion). Don't handle plants within one day of using methyl parathion.

6. Class 1 and 2 insecticides are likely to be especially common in tobacco and cotton growing areas.

7. Don't smoke or eat while applying pesticides; wash up well afterwards.

8. Repair all leaking hoses and connections before using a sprayer.

9. Prepare insecticide solutions in a well ventilated place, preferably outdoors.

10. Never spray or dust on very windy days or against a breeze.

11. Notify beekeepers the day before spraying.

12. Insecticide poisoning hazards increase in hot weather.

13. Store insecticides out of reach of children and away from food and living quarters. Store them in their original labeled containers which should be tightly sealed.

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* Refer to toxicity table on pp. 251-257.

14. Leftover spray mixtures should be poured into a hole dug in the ground well away from streams and wells.

15. Don't contaminate streams or other water sources with insecticides either during application or when cleaning equipment.

16. Make sure insecticide containers are never put to any other use. Burn sacks and plastic containers (don't breathe the smoke): punch holes in metal ones and bury them.

17. Make sure that farmers are well aware of safety precautions. It's important that they understand that insecticides vary greatly in their toxicity, but that all are dangerous.

18. Make sure that you and your client farmers are familiar with the symptoms of insecticide poisoning and the first aid procedures given below.

19. Observe the minimum application to harvest interval for the particular insecticide and crop involved. (See table on p. 231.)

A Special Note on ALDRIN, DIELDRIN, ENDRIN, DDT, HEPTACHLOR, and CHLORDANE: Use of these chlorinated hydrocarbon insecticides has been severely restricted or banned in the U.S. and several other countries due to their persistence in the environment, fish kill, and accumulation in the body fat of humans and animals. Few LDC's have enacted pesticide regulations, so expect to see these freely marketed.

What about Fungicides?: Except for mercury based fungicides used for seed treatment like Agallol, Semesan, and Ceresan, fungicides pose relatively little hazard to health. Their oral toxicity is comparatively low, and there is little danger of dermal absorption. Some may cause allergies in sensitive people through skin contact and can be eye irritants as well.

What about Herbicides?: PARAQUAT (Gramoxone) has an unusually high oral toxicity and even a small amount can be fatal. Give clay or activated charcoal (mixed with water) orally immediately to deactivate the poison.

RELATIVE TOXICITY RATINGS FOR INSECTICIDES

Insecticides vary greatly in their relative toxicity to humans which is measured in terms of an LD_{50} rating (LD = lethal dosage). The LD50 rating indicates the amount of 100% strength chemical (i.e. active ingredient) needed to kill 50% of the test animals (usually rats or rabbits). Both oral and dermal (skin absorption) ratings are determined.

Before using any insecticide, you should be aware of its particular LD_{50} rating. Ratings for most insecticides can be found in the toxicity tables on pp. 251-257.

III. SYMPTOMS OF INSECTICIDE POISONING

Organic Phosphates & Carbamates (Parathion, Malathion, Sevin, etc.)

Both groups affect mammals by inhibiting the body's production of the enzyme cholinesterase which regulates the involuntary nervous system (breathing, urinary and bowel control, and muscle movements).

Initial Symptoms: Dizziness, headaches, nausea, vomiting, tightness of the chest, excesssive sweating. These are followed or accompanied by blurring of vision, diarrhea, watering of the eyes, excessive salivation, muscle twitching, and mental confusion. Tiny (pinpoint) pupils are another sign.

Late Symptoms: Fluid in chest, convulsions, coma, loss of urinary or bowel control, loss of breathing.

NOTE: Repeated exposure to these organic phosphate and carbamate insecticides may increase susceptibility to poisoning by gradually lowering the body's cholinesterase level without producing symptoms. This is a temporary condition. Commercial insecticide applicators in the U.S. usually have their cholinesterase levels routinely monitored.

Symptoms of Chlorinated Hydrocarbon Poisoning (Aldrin, Endrin, Chlordane, Dieldrin, etc.)

Apprehension, dizziness, hyper-excitability, headache, fatigue, and convulsions. Oral ingestion may cause convulsions and tremors as the first symptoms.

IV. FIRST AID MEASURES

1. In severe poisoning, breathing may stop which makes mouth to mouth resuscitation the first priority; use full CPR if the heart has stopped.

2. If the insecticide has been swallowed and the patient has not vomited, induce vomiting by giving a tablespoon of salt dissolved in half a glass of warm water; an emetic like Emesis (syrup of Ipecac) may be more effective. This should be followed by 30 grams (1 oz.) of activated charcoal dissolved in water to help absorb the remaining insecticide from the gut.*

3. Get the patient to a doctor as soon as possible. Bring along the insecticide label.

4. In the meantime, make the patient lie down and keep warm.

5. If excessive amounts are spilled on the skin (especially in the concentrate form), immediately remove clothing and bathe the skin in generous amounts of water and soap.

6. If the eyes have been contaminated by dusts and sprays, flush them immediately for at least 5 minutes with copious amounts of water; insecticide absorption through the eyes is very rapid.

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* Activated charcoal is made by heating charcoal to drive off its absorbed gasses.

WHAT ABOUT ANTIDOTES?

Whenever possible, antidotes should be given only under medical supervision. Too much or too little can be fatal. If the patient is unconscious or vomiting, antidotes need to be injected.

Antidotes for Organic Phosphate Insecticides

Atropine (atropine sulfate) is the general antidote, especially in the early stages. Diazepam (an anti-convulsant) is often used along with atropine. 2-PAM (2-pyridine aldoxime methiodide) is used in the advanced stages of organic phosphate poisoning where atropine becomes ineffective.

Atropine Dosage: Usually 2 tablets (1/100th grain each) are given immediately, followed by additional dosages at hourly intervals until the pupils of the eyes dilate (enlarge). Up to 0.3 grains per day (30 tablets) may be given to control respiratory symptoms if needed. CAUTION!: Atropine may give only temporary relief of what may prove to be a serious case of poisoning; if treatment is halted too soon, symptoms may reappear. DO NOT TAKE ATROPINE AS A PREVENTATIVE!

Antidotes for Carbamate Insecticides

Use atropine as above. DO NOT USE 2-PAM for carbamate poisoning. Diazepam (an anti-convulsant) is often used along with atropine.

Antidotes for Chlorinated Hydrocarbon Insecticides

Diazepam or phenobarbitol are often used to control convulsions.

WARNING: Do not treat lightly what appears to be only a mild case of poisoning. Always seek medical attention, especially when antidotes have already been used--they may wear off and bring on a reoccurrence of symptoms.

BEE POISONING HAZARD OF PESTICIDES

Most bee poisoning occurs when insecticides are applied during the crop's flowering period. Spray drift is another hazard. Avoid bee kill by:

1. Not applying insecticides toxic to bees when crops are flowering.
2. Not dumping unused quantities of dusts or sprays where they might become a bee hazard; bees will sometimes collect any type of fine dust when pollen is scarce.
3. Using insecticides of relatively low toxicity and residual effect for bees.
4. Plugging up or covering the hive entrances the night before spraying and then reopening them once the residual effect is over.

CHART

MINIMUM APPLICATION TILL HARVEST INTERVALS FOR SOME COMMON INSECTICIDES

<u>Minimum Application til Harvest Intervals for some Common Insecticides</u>: Always check the insecticide label for further information.

INSECTICIDE	Beans	Cabbage	Radish	Turnip	Onion	Eggplant	Pepper	Tomato	Lettuce	Cucumber	Summer Squash
Bacillus t.	--	0	0	0	--	--	--	0	0	--	--
Carbaryl (Sevin)	0	3[A]	3	3,14[B]	--	0	0	0	14	0	0
Diazinon	7	7	10	10	10	--	5	1	10	7	7
Dicofol (Kelthane)	7[D]	--	--	--	--	2	2	3	--	2	2
Dimethoate (Cygon, Rogor, Perfekthion)	0[D]	3[A]	--	14	--	--	0	7	14	--	--
Malathion	1	7	7	3	3	3	3	1	14	1	1
Methomyl (Lannate)	1	1	--	--	--	10	10	2	10	3	3
Monitor (Tamaron)	--	35	--	--	--	--	--	14	--	--	--
Oxydemeton methyl (Meta-systox-R)	--	--	--	--	--	7[E]	0[C]	--	--	--	--
Trichlorfon (Dipterex, Dylox)	--	21[G]	--	28[D]	--	--	21	21	28[F]	--	--

A. 14 days for collars
B. If tops are to be used as feed
C. Not more than twice per season
D. Don't use tops for feed or food
E. Not more than 3 times per seanos
G. 28 days for collards

None of the fungicides is toxic to bees; the same is true with most herbicides, although Gesaprim (AAtrex, Atrazine) and the 2, 4-D type herbicides are low to moderate in toxicity.

Here's a partial guide to the relative toxicity of various insecticides for bees. Note the difference in residual effect.

WHEN APPLIED AS A SPRAY

Insecticide	Toxicity to Bees	Residual Effect
Aldrin	Very high	Several days
Diazinon	High	One day
Dipterex	Low to High	2-5 hours
Lebaycid	Very high	2-3 days
Kelthane (dicofol)	Low	
Methyl parathion	High	Less than one day
Malathion	Moderate (liquid) High (wettable powder)	Less than 2 hours Less than one day
Metasystox	Moderate	None
Dimethoate	Very High	1-2 days
Sevin	Moderate to High	7-12 days

V. GUIDELINES FOR APPLYING INSECTICIDES

When is Treatment Necessary?

1. Farmers should apply insecticides in response to actual insect problems rather than on a routine and indiscriminate basis. Ideally, insecticides should be used only when damage has reached the economic threshold which varies with insect species, the crop, and the type and extent of damage.

2. General guidelines (see also the unit on major reference crop insects):

   a. Soil insect problems should be treated preventatively in the sense of making pre-planting or at-planting insecticide applications *if* a known problem exists. Treatments after planting are generally not effective except in the case of cutworm baits.

   b. Leaf eating insects (beetles, caterpillars): Crops can tolerate considerable defoliation as long as new leaves are being continually produced. However, loss of leaf area becomes more serious as the vegetative stage nears its end, although defoliation in the very late stages of grain development won't have a big effect on yield.

c. When present, stem borers usually cause more serious damage at much lower populations than most leaf eating insects. The sorghum shoot fly, sorghum midge, and one species of bean leafhopper (Empoasca kraemeri) are other examples of insects that reach the economic threshold of damage at relatively low populations.

d. Sucking insects: Not all species of aphids and leafhoppers spread virus diseases. For example, CIAT found that bean yields were reduced about 6% for each Empoasca kraemeri leafhopper present per leaf, even though this species does not transmit any viruses. Bean plants can tolerate aphids well unless they are of a species capable of transmitting common bean mosaic virus.

USING A SPRAYER EFFECTIVELY

Achieving the Correct Coverage

The extent and uniformity of coverage needed depend on the insects' location and whether or not a systemic insecticide is being used. In some cases such as armyworms feeding in the maize leaf whorl, the insect is very localized, so general coverage isn't needed. Other insects are more general feeders and require thorough spray coverage over the whole plant. Since they are translocated, systemic insecticides do not require as uniform coverage as non-systemics.

How Much Water is Needed for Adequate Coverage?

This varies with plant size, density, type of product (systemic vs. non-systemic), and insect location, but here are some rough guidelines:

Water rates for insecticides: When covering the entire foliage of full size plants, use at least 500-550 liters of water per hectare (55-60 gals./acre) when using conventional sprayers. When spraying is localized or plants are very small, water volume may be only 1/4 this amount.

You can tell if too much spray is being applied if there is a visible amount of runoff from the leaves, although this can also be caused by not using enough wetting agent (spreader; see below).

Use a Spreader and a Sticker to Improve Coverage and Adhesion

A spreader (wetting agent) reduces the surface tension of spray droplets, allowing them to spread out rather than remain as individual globules on the leaf surface. Spreaders markedly improve the uniformity of spray coverage and also help prevent droplets from rolling off the leaves.

A sticker (adherent) is a glue-like substance that helps the spray stick to the leaf surface and resist being washed off by rainfall or sprinkler irrigation.

Many commercial stickers and spreaders are available, including combination sticker-spreaders. Some insecticide formulations already contain them (check the label), but many do not. In some cases, a sticker and/or spreader isn't recommended (check the label). If spraying the soil, neither a spreader or a sticker is needed; when spraying the leaf whorl of maize, a spreader isn't needed though a sticker might be helpful. Use of a sticker and spreader is especially important when applying most foliar fungicides.

Homemade stickers and spreaders: Egg white, cassava (yuca, manioc) flour, and corn starch can be used as stickers at about a tablespoon (15 cc) per 15 liters. Liquid dishwashing detergent makes a satisfactory spreader at about one half the above rate. Commercial stickers and spreaders are relatively cheap. Dissolved hand soap can also be used.

Non-ionic spreaders: Paraquat (Gramoxone) and diquat (Reglone) post-emergence herbicides are unusual in that they require the use of special non-ionic spreaders in order to avoid deactiviation (loss of effectiveness). Such spreaders do not ionize into + and - charged molecules as with most types. Ortho-77 is one commonly available non-ionic spreader.

Choosing the Right Type of Spray Nozzle

Spray nozzles are available in a wide variety differing in output, spray pattern angle, and type of spray pattern. Proper nozzle selection has an important influence on pesticide effectiveness.

Nozzle Output: Many backpack (knapsack) sprayers come equipped with adjustable nozzles which allow the farmer to vary the output by making the spray finer or coarser. This would seem to be an advantage, but such nozzles usually don't maintain their setting well and output can change considerably during application; this is unsatisfactory where accurate dosages are necessary, and it makes sprayer calibration difficult. Fixed orifice nozzles are available in a wide range of outputs and should be used whenever possible.

Spray Pattern Angle: See under flat spray nozzles below.

Type of Spray Pattern: Care should be taken to choose the right spray pattern for the job.

1. Flat (Fan) Spray Nozzles are ideal for making broadcast (full coverage) applications of insecticides or herbicides over the soil surface and small weeds. The application rate decreases at both edges, so the spray patterns of adjacent nozzles should be overlapped about 3-4 fingers width at the soil surface to achieve even distribution (see boom sprayer guidelines in section H of this chapter). Fan nozzles don't provide as good a coverage as cone nozzles when used to spray crop foliage. Fan nozzles are available in several different angles of spray width; wider angles allow the spray boom to be carried closer to the ground and this lessen spray drift problems on windy days.

2. Even Flat (Fan) Spray Nozzles should be used for making band applications of pesticides to the soil. Spray output does not decrease at the edges, so spray patterns should not be overlapped and used for broadcast applications.

3. Solid Cone Spray Nozzles provide better coverage of plant foliage than fan nozzles but should not be used to apply herbicides and insecticides to the soil.

4. Hollow Cone Spray Nozzles offer somewhat better foliar coverage than solid cone nozzles due to greater leaf agitation as the spray pattern passes over the plants.

5. Whirlchamber (nonclog) Spray Nozzles are special wide angle hollow cone nozzles that can be used in place of fan nozzles. Their design reduces clogging, and drift is minimized because of the wide angle pattern (enabling lower boom height) and larger droplet size.

Nozzle Screens: Nozzles used on tractor boom sprayers usually have mesh or slotted strainers to help prevent clogging. Some backpack sprayers have strainers or can have them added on. Routine cleaning is required, especially when wettable powders are used.

Tips on Using Backpack Sprayers to Apply Insecticides

1. Use good pressure and a fairly fine spray; pressure is too high if excessive spray drift (misting) occurs.

2. Maintain a steady pace through the field; avoid pausing at each plant unless the crop is very large.

3. Rotate your wrist while spraying so that the spray hits the foliage from different angles.

4. Keep the nozzle far enough away from the foliage so that the spray has a chance to spread out before hitting the leaves.

5. If using a wettable powder, remember to periodically shake the sprayer to keep the pesticide in solution.

6. Keep a piece of soft wire handy for cleaning out clogged nozzles, but use it gently to avoid damaging the nozzle opening.

7. Don't spray plants when their leaves are wet or when rain is likely within a few hours afterwards.

8. Don't add wettable powders or EC's directly to the sprayer tank but first mix them thoroughly in a bucket with several liters of water; make sure wettable powders are completely dissolved.

PESTICIDE COMPATABILITY

Most pesticides are compatible with each other in the spray tank, but check the label to make sure. In some crops like peanuts and vegetables, foliar insecticides and fungicides are often applied together. Maneb, Zineb, Captan, Manzate, and the Dithanes are compatible with most insecticides. Most copper base fungicides are incompatible with most insecticides; lime sulfur and Bordeaux fungicides are incompatible with each other and nearly all other pesticides.

Spray compatibility charts are available from many pesticide companies.

Water pH

Water with a pH of 8.0 or above (alkaline) causes a rapid breakdown of organic phosphate insecticides like Malathion, Dipterex, and Diazion. Such high pH water is usually confined to limestone or low rainfall areas. Special buffering agents are available to lower the pH if necessary.

Plant Sensitivity to Insecticides

Certain insecticides are phytotoxic (injurious) to certain crops. Always check the label instructions.

Sorghym: Dipterex (trichlorfon) causes severe injury; Azodrin (Nuvacron, monocrotophos) and methyl parathion cause some injury.

Peanuts: Minor foliar injury which shows up as reddish brown spots on the earliest leaves is sometimes caused by soil applications of Furadan (carbofuran), Thimet, and Di-syston. The plants usually outgrow the damage with no yield reduction. Runner varieties on sandy soils are the most sensitive, and dosage should be reduced by 25% under these conditions.

NOTE: In the case of sensitive crops, wettable powder formulations tend to be less phytotoxic than EC's, especially at temperatures over 32°C (90°F).

TABLE 21

General Effectiveness of Some Insecticides[3]

Most insecticides will not give satisfactory control of all types of insects. For additional information in this manual, refer to the insecticide descriptions and recommendations at the end of this section. In addition, consult the recommendations put out by your country's extenson service as well as the insecticide's label; ask for technical information from pesticide distributors.

	Caterpillars	Beetles	Aphids	Leafhoppers	Stinkbugs, Harlequin bugs	Mites	Thrips	Locusts
Aldrin[1]	+	+	-	+	-	-	-	+
Actellic	+	+	-	-	+	-	+	+
Bacillus thuringiensis (Dipel, Biotrol, Thuricide)[2]	+	-	-	-	-	-	-	-
BHC (HCH, etc.)	-	+	+	+	+	-	+	+
Diazinon (Basudin)	-	+	+	+	+	+	+	-
Dieldrin[1]	+	+	+	+	+	-	+	+
Dimethoate (Perfekthion, etc.)	-	-	+	+	+	+	+	-
Dipterex (trichlorfon)	+	+	-	+	+	-	-	-
Endrin[1]	+	+	+	+	+	+	+	+
Furadan[1]	+	+	+	+	-	+	+	-
Lannate (methomyl)[1]	+	+	+	-	-	+	-	-
Malathion	+	+	+	+	+	+	+	+
Metasystox	-	-	+	+	-	+	+	-
Methyl Parathion[1]	+	+	+	+	+	-	-	-
Sevin (carbaryl)	+	+	-	+	+	-	+	+
Thiodan (endosulfan)	-	+	+	+	+	+	-	-
Volaon (phoxim)	+	+	-	-	-	-	-	+

1. These products pose safety and/or environmental hazards; see pp. 226-230.

2. B. thuringiensis is effective only against certain caterpillars, among which are cabbage loppers and hornworms.

3. Based on information from Table 2, p. 48 of Agric. Pests of the Tropics and their Control, D. Hill, Cambridge Univ. Press, London, 1975.

NOTE: + = effective
- = little or no effectiveness

VI. SOME INSECTICIDE RECOMMENDATIONS FOR THE REFERENCE CROPS

Contents: Baits for cutworms, slugs, and snails.

General dosage recommendations for common insecticides and product information.

Some specific insecticide recommendations for the reference crops.

Some Important Advice

1. Whenever possible, rely on the insecticide recommendations of your country's extension service if they are known to be effective and if they do not involve the use of high toxicity Class 1 chemicals (see pp. 251-257).

2. Before using any insecticide, refer to the safety guidelines on pp. 227-228 and toxicity data on pp. 251-257. Always know the relative toxicity and environmental hazards of the products you use or recommend.

Baits for Cutworms, Slugs, and Snails

Cutworms are most effectively controlled with baits rather than with sprays. Scatter the baits near the plants in the late afternoon if rainfall is unlikely. Don't leave the bait in clumps which might poison birds or livestock. One kg of bait should cover about 400 sq. meters (4300 sq. ft.).

Cutworm bait recipe:

25 kg of carrier (sawdust, rice bran, maize flour, etc.)
3 liters of molasses
1 - 1.25 kg active ingredient of Dipterex (trichlorfon) or Sevin (carbayl)
Add water, if needed, to make the bait moist

Slugs and snails can be controlled by applying baits in the late afternoon in a band along the field's borders or within problem areas. Don't apply if rain is expected that night.

Slug and snail bait recipe:

25 kg maize flour or bran
10 liters molasses
65 grams metaldehyde (a stomach poison of low dermal toxicity) or 0.5 kg active ingredient Dipterex (trichlorfon) or 0.5 kg active ingredient Sevin (carbaryl).

Information on Common Insecticides and General Dosage Rates*

General dosage are given for the insecticides listed below. Whenever possible, follow label dosage instructions rather than relying solely on this manual.

NOTE: All tablespoon and teaspoon recommendations are in terms of level ones and are based on measuring spoons.

Some Conversions

1 TABLESPOON (measuring type) = 3 teaspoons = 15 cc.
1 LITER = 1000 cc = 1000 ml = 1.06 U.S. quarts
1 U.S. GALLON = 3.78 liters = 16 U.S. cups = 128 fluid oz.
1 FLUID OUNCE = 30 cc = 2 tablespoons
1 KILOGRAM = 1000 grams = 2.2 lbs.
1 POUND = 454 grams = o.454 kg

Bacillus thuringiensis
Diazinon (Basudin)
Dimethoate (Perfekthion)
Dipterex (trichlorfon)
Furadan (carbofuran)
Kelthane (dicofol)
Lannate (methomyl)
Labaycid (fenthion)
Malathion
Metasystox
Methyl Parathion
Sevin (carbaryl)
Tamaron (Monitor)
Volaton (phoxim)

Lannate, methyl parathion, and Tamaron are Class 2 toxicity (dangerous) but frequently used by small farmers. Their dosage are given below not to encourage their use but so that at least you'll know if farmers are using higher rates than needed.

BACILLUS THURINGIENSIS

A biological insecticide made from a natural bacteria that kills only certain types of caterpillars; most effective against cabbage loopers but also against hornworms (Protoparce) and earworms (Heliothis). Non-toxic to humans and animals. Insects don't die immediately but stop feeding within a few hours--it may take a few days for them to die. Apply before the caterpillars are large for best results. Needs no sticker-spreader for most formulations. Compatible with most other pesticides. Don't store the diluted spray for more than 12 hours. Dosage varies widely with the particular formulation.

DIAZINON (Basudin, Diazol, etc.)

Fairly broad-spectrum including control of many soil insects but not as effective on beetles (except for the Mexican bean beetle). Highly toxic to bees (see p. 230).

Above-ground insect control: 4 cc/liter or 1 tablespoon/gallon of Diazinon 25% EC or Basudin 40% WP.

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* If you are unfamiliar with methods of stating pesticide dosage, refer to pp. 244-245.

(Diazinon, continued)

Soil insects: See the specific reference crop recommendations at the end of this unit.

DIMETHOATE (Perfekthion, Cygon, Rogor, etc.)

A systemic insecticide of moderate toxicity to humans (Class 3). Specifically for sucking insects (aphids, leafhoppers, thrips, stinkbugs, mites, etc.) and leaf miners. Should provide control for 10-14 days. Don't apply within 14-21 days of harvest. Highly toxic to bees with a 1-2 day residual effect.

General dosages for the 3 most common formulations (all EC's) are given below:

Formulation of dimethoate	Dosage Fl. oz/100 gals.	Dosage cc/100 liters
200 grams active ingred./liter	13-26	100-200
400 grams a.i./liter	7-13	50-100
500 grams a.i./liter	7-10	50-75

DIPTEREX (Trichlorfon, Dylox, Danex, Klorfon, etc.)

Provides fairly broad-spectrum insect control but not as effective on aphids, mites, and thrips. Dipterex causes severe injury when applied to sorghum. Low to high toxicity for bees with 2-5 hours residual effect. Class 3 toxicity for humans.

General above-ground insect control: 125-250 cc (100-200 grams) of Dipterex SP 95 per 100 liters of water or 5-10 cc (1-2 teaspoons) per gallon.

Armyworms or earworms feeding in the leaf whorl of maize: Dipterex 2.5% granules give longer control than sprays; apply a pinch in each whorl which works out to about 10-15 kg/ha (lbs./acre) of granules. 100 cc of the granules weigh about 60 grams.

FURADAN (Carbofuran)

A systemic insecticide-nematocide available in 3 granular formulations (3%, 5%, 10%) and as a wettable powder. The pure strength chemical has an extremely high oral but very low dermal toxicity (see p. 133). Furadan is usually applied to the soil either in the seed furrow or in a band centered over the crop row; it kills soil nematodes and soil insects but is also absorbed by the roots and translocated throughout the plant where it controls sucking insects, stem borers, and leaf feeding beetles and caterpillars for up to 30-40 days. Band treatments are recommended for root feeding soil insects, while seed furrow applications can be used for foliar insects. Furadan can also be band applied during the growing season if it is cultivated into the soil or can be applied to the leaf whorl or maize.

(Furadan, continued)

May cause minor foliar injury to peanuts; do not place in contact with sorghum or bean seed.

KELTHANE (Dicofol, Acarin, Mitigan, Carbax)

Kills mites only; not harmful to beneficial insects. Gives good initial control of mites and has good residual activity against them; non-systemic. Spray undersides of leaves. Don't feed crop residues to dairy or slaughter animals. Low toxicity (Class 4).

General dosage: Use the 35% WP formulation at 4-5 cc per liter of water or 1 tablespoon per gallon. Use the 18.5% EC at 1.5 cc per liter of water or 1 teaspoon per gallon.

LANNATE (Methomyl, Nudrin)

A partially systemic carbamate insecticide especially effective against caterpillars, beetles, and aphids. High oral but moderate dermal toxicity (see pp. 128-134); toxic to bees, fish, wildlife if used improperly. Don't apply within 20-25 days of harvest on peanuts or dry beans (3 days for green beans).

CAUTION: Wear an effective respirator mask (charcoal filter), gloves, long pants and shirt, and rubber boots when applying Lannate; goggles are advisable.

General dosage for Lannate: General dosages aren't advisable; Lannate is usually applied at 0.17-1.0 kg active ingredient per hectare (0.15-0.9 lbs. a.i./acre).

LEBAYCID (Fenthion, Baytex, Baycid)

A relatively low toxicity (Class 3) organic phosphate for chewing and sucking insects, including mites. Don't spray plants when temperatures exceed 32°C (90°F). Very toxic to bees with 2-3 days residual activity.

General dosage for Lebaycid: Use Lebaycid 40% WP at 1.5-2 grams per liter of water; use Lebaycid 50% EC at 1-1.5 cc/liter of water.

MALATHION (Cythion, Unithion, Malaspray)

A broad-spectrum insecticide of low human toxicity (Class 4). Not as effective on armyworms, earworms, and flea beetles. Its residual activity is decreased if mixed with water above pH 8.0

(Malathion, continued)

Can be mixed with other pesticides except Bordeaux and lime sulfur. Liquid formulations are moderately toxic to bees with less than 2 hours residual effect; wettable powder formulations are highly toxic but have less than 1 day residual effect on bees.

General dosage for Malathion: 4-5 cc of Malathion 50% or 57% EC per liter of water (1 tablespoon/gallon). Use Malathion 25% WP at 12 cc/liter or 3 tablespoons per gallon.

Household uses: For ants, cockroaches, and spiders, use Malathion 50% or 57% EC at 40-50 cc per liter of water or kerosene (10-12 tablespoons/gallon). For fleas, use 40 cc/liter of water. For bedbugs, use 20 cc/liter of water and spray the slats, frame, and springs; spray mattress very lightly. Cythion is a special premium grade of Malathion with less odor.

Lice on swine: Use Malathion 50% or 57% EC at 8 cc per liter of water (2 tablespoons/gallon); don't spray pigs less than 1 month old. Repeat in 2-3 weeks if needed.

Lice or mites on poultry: Use Malathion 50% or 57% EC at 20 cc per liter of water or 4.5 tablespoons/gallon; spray roosts and bedding at 1-2 liters per 25 sq. meters (1-2 gals/1000 sq. ft.).

METASYSTOX

A systemic used mainly for sucking insects. High oral toxicity for humans; moderate for bees (no residual activity for bees). Won't harm beneficial insects. Gives control for 10-14 days. Most labels say not to add a sticker or spreader. Don't apply within 21 days of harvest.

General Dosage for Metasystox: Bayer Leverkusen recommends that its 25% EC formulation be used at 100 cc/100 liters of water or 4 cc/gallon. Use the 50% at 50 cc/100 liters.

METHYL PARATHION (Folidol M, Parathion M, Nitrox, etc.)

Very toxic to humans both orally and dermally but commonly used by small farmers in many countries since it's effective against a broad range of insects. Methyl parathion is also very toxic to bees with a residual effect of less than 1 day. Rubber gloves, respirator mask (charcoal filter), full coverage clothing, and goggles should ideally be worn during application and mixing. Stay out of the field for a day after spraying. AVOID USING whenever possible. NEVER use methyl parathion's close relative, ETHYL parathion (E-605, Bladan, Niran, Folidol E, etc.) since it has an even greater dermal toxicity.

(Methyl parathion, continued)

General dosage for methyl parathion: Bayer recommends that its Folidol M-48 EC (49% strength) be used at 25-50 cc per 15 liters (4 gals.) of water. Don't apply within 14 days of harvest; check sprayer carefully for leaks before application. Again, avoid using whenever possible.

SEVIN (carbaryl, Vetox, Ravyon, etc.)

Broad-spectrum insect control except for aphids and mites. Very low toxicity for humans (Class 4). Very toxic to bees with a 7-12 day residual effect.

General dosage for Sevin: Use the 50% WP at 8-16 cc/liter (2-4 tablespoons/gallon). Use the 80% WP at 5-10 cc/liter or 1.25-2.5 tablespoons/gallon. Can be applied right up to harvest time on the reference crops.

Household dosages: For cockroaches and ants, use as a 2.5% strength spray (active ingredient basis); this equals about 100 cc of Sevin 80 WP per liter of water or 25 tablespoons per gallon; don't use more than twice a week.

Ticks, lice, fleas, horn flies on beef cattle, horses, swine: Use 20 cc Sevin 80% WP per liter of water (5 tablesppons/gal.). Don't spray within 5 days of slaughter.

Mites, lice, fleas on poultry: Use at same rate as for beef cattle and apply about 4 liters per 100 birds; don't apply within 7 days of slaughter.

TAMARON (Monitor, methamidophos)

A broad-spectrum insecticide-miticide with systemic and contact action. About as toxic to humans as methyl parathion and highly toxic to bees. AVOID using if possible. Follow the same safety precautions as for methyl parathion; don't use within 3 weeks of harvest.

General dosage for Tamaron: Bayer's Tamaron 600 (600 grams a.i. per liter) is recommended at 12 cc per 15 liters of water (4 gals.); use Tamaron 400 at 20 cc per 15 liters of water (see Appendix M).

VOLATON (Valexon, phoxim)

A less toxic and persistent replacement for Aldrin for soil insect control. Low toxicity for humans. Also available as a liquid formulation for leaf insects.

General dosage for Volaton: Use the 2.5% granules at 60 kg/ha (lbs./acre) for furrow application and 120 kg/ha for broadcast application. Work into the top 5-7 5 cm (2-3") of soil.

VII. INSECTICIDE MATH AND DOSAGE CALCULATIONS

This section applies to all types of pesticides. There are 4 basic ways of stating dosages:

1. Amount of active ingredient (pure chemical) needed per hectare or acre.

2. Amount of actual formulation (i.e. Sevin 50 WP or Furadan 3 G, etc.) needed per hectare or acre.

3. Amount of actual formulation needed per liter or gallon of water.

4. As a percentage concentration in the spray water.

Type 1 and 2 dosages are suited more to large plots or to those pesticides (especially herbicides) needing very accurate dosage application. Sprayer calibration (p. 248) is needed in both cases to determine how much water to use and how much pesticide to add to each tankful.

Type 3 and 4 are very general recommendations best suited to smaller plots or where dosage accuracy is not critical.

Let's look at each of these 4 types of dosages in detail to clear up any questions:

1. AMOUNT OF ACTIVE INGREDIENT NEEDED PER HECTARE (ACRE): For example, a dosage might be given as 2 kg active ingredient (a.i.) Sevin per hectare. This means 2 kgs. of pure (100%) Sevin. Since actual pesticide formulations vary in strength from 1% up to 95%, it takes some math to figure out how much of a given formulation is needed to supply a given amount of active ingredient. If the local ag supply store sells Seven 50% WP, the farmer would need 4 kg for each hectare in order to supply 2 kg active ingredient.

   Note that nothing is said about how much water the farmer should mix with the pesticide when he sprays it on the plants. This will depend on plant size, plant density, and the degree of coverage desired. The only way to find out how much water is needed is to calibrate the sprayer.

2. AMOUNT OF ACTUAL FORMULATION NEEDED PER HECTARE OR ACRE: For example, a recommendation calling for 4 liters of Malathion 50% EC per hectare or another one for 2.5 lbs. of Sevin 80% WP per acre. This type of recommendation is somewhat simpler than type 1 since it's given in terms of actual formulation rather than active ingredient. However, the farmer still needs to know how much formu lation he needs for his field's area and how much water it will take to provide adequate coverage with his sprayer. This requires sprayer calibration.

3. AMOUNT OF ACTUAL FORMULATION NEEDED PER LITER OR GALLON OF WATER: For example, 5 cc of Malthion 50% EC per liter of water or 2 tablespoons of Sevin 80% WP per gallon of water. This type of recommen-

dation is much more convenient than types 1 and 2 since no sprayer calibration or dosage calculation is needed. The drawback is that the actual amount of pesticide the farmer actually applies on his field depends entirely on how fast he/she walks while spraying, how coarse or fine the spray is, and how much pressure is used. However, if proper guidelines are followed, type 3 recommendations are precise enough for most conditions and are the most feasible for small farmers. They should not be used for most herbicides where accuracy of dosage is critical.

4. AS A PERCENTAGE CONCENTRATION IN THE SPRAY WATER: This is basically the same as type 3, except that the concentration of pesticide in the spray water is given in terms of percent rather than cc/liter or tablespoons/gallon. Such recommendations are usually based on percentage by weight,, although sometimes a volume basis is used when dealing with EC's (the actual differences are slight). In additon, the percentage figure given may refer to active ingredient or to actual formulation. We'll go over the calculations in the pesticide math selection below. As with type 3 recommendations, no sprayer calibration is needed, and dosage accuracy is not as good as with types 1 and 2.

Pesticide Math

1. How to convert recommendations from an active ingredient basis to an actual formulation basis.

   a. For solid formulations (WP's, EC's, G's)

   $$\text{kg/Ha or lbs./acre of actual formulation needed} = \frac{\text{Amount of a.i. recommended (kg/ha, lbs./acre)}}{\text{\% active ingredient in formulation}}$$

   Example: A recommendation for aphids calls for using Malathion at 2 kg active ingredient/hectare. How much Malathion 40% WP would be needed per hectare?

   Solution

   $$\text{kg/ha of Malathion 40\% WP needed} = \frac{2\text{ kg}}{40\%} = \frac{2\text{ kg}}{0.4} = 5\text{ kg}$$

   b. For liquid formulations (EC's)

   $$\text{liters/ha of EC needed} = \frac{\text{kg/ha of a.i. recommended}}{\text{\% a.i. in EC}}$$

   OR

   $$\text{liters/ha of EC needed} \quad \frac{\text{kg/ha of a.i. recommended x 1000}}{\text{grams of a.i. per liter of EC}}$$

   $$\text{Gallons/acre of EC needed} = \frac{\text{lbs./acre of a.i. recommended}}{\text{lbs. of a.i. per gallon of EC}}$$

Example: How much Perfekthion 20% EC would be needed per hectare if a recommendation for mites calls for 0.2 kg a.i. Perfekthion per hectare?

Solution

$$\text{liters of Perfekthion 20\% EC needed} = \frac{0.2 \text{ kg}}{20\%} = \frac{0.2}{0.2} = 1 \text{ liter}$$

2. How to determine the amount of actual formulation needed for a farmer's field, given the dosage per hectare or acre.

Once you know how much actual formulation is needed per hectare or acre, you can easily calculate how much is needed for farmer's fields of varying sizes.

Hectare basis

$$\text{Amount of formulation needed for a farmer's field} = \frac{\text{Amount of formulation needed/acre} \times \text{Field area (sq. m)}}{10{,}000}$$

Acre basis

$$\text{Amount of formulation needed for a farmer's field} = \frac{\text{Amount of formulation needed/acre} \times \text{Field area (sq. ft.)}}{44{,}000}$$

Example: The local extension service recommends applying Volaton 2.5% strength granules broadcast at 120 kg/ha for controlling soil insects in maize. If Leticia's field measures 35 x 40 meters, how much Volation will she need?

Solution

$$\text{kg of Volation 2.5\% granules needed for Leticia's field} = \frac{120 \times 1400 \text{ sq. m}}{10{,}000 \text{ sq. m}} = 16.8 \text{ kg}$$

3. How to follow a percentage strength spray recommendation.

Determine first whether the spray's percentage strengths to be calculated in terms of active ingredient or in terms of actual formulation. For example, you might see a recommendation for 2% strength spray in terms of pure Malathion for controlling household fleas; another recommendation might call for using a 0.1% strength spray in terms of Lebaycid 50% EC for controlling thrips on peanuts.

Use the metric system: Percentage spray calculations are much simpler in the metric system compared to using lbs., oz., and gallons. 1 liter = 1000 cc (or Ml); 1 liter of water weights 1 kg (1000 g); 1 U.S. gallon ≈ 3.78 liters; 1 lb. = 0.454 kg = 454 g; 1 kg = 2.2 lbs.

a. For wettable powders

When using WP's, a percentage strength spray is based on weight of pesticide to weight of water. Since 1 liter of water weighs 1 kg, we can use these formulas:

Active ingredient basis

Grams of wettable power needed per liter of water = % strength spray desired x 1000 / % a.i. in wettable powder

Example: How many grams of Malathion 40% WP should be added per liter of water to make up a 2% strength spray (active ingredient basis) for controlling household fleas?

Solution

Grams of Malathion 40% WP needed per liter of water = $\frac{2\% \times 1000}{40\%} = \frac{20}{0.4} = 50$ g

NOTE: Remember that in order to multiply by percent you first must move the decimal point two places to the left (i.e. 2% 0.02; 0.1% = 0.001).

Actual product basis

Grams of wettable powder needed per liter or water = % strength spray desired x 1000

Example: How much Dipterix SP 95 is needed to make up a 0.15% strength spray (actual product basis) for controllig armyworms in maize?

Solution

Grams of Dipterex SP 95 needed per liter of water = 0.15% x 1000 = 0.0015 x 1000 = 1.5 g

b. For liquids (EC's)

Active ingredient basis

cc (ml) of EC needed per liter of water = % strength spray desired x 1000 / % a.i. in the EC

Example: How much Malathion 57% EC should be added per liter of water to make up a 2% strength spray (active ingredient basis) for controlling household fleas?

Solution

cc (ml) of Malathion 57% EC needed per liter of water = $\frac{2\% \times 1000}{57\%} = \frac{20}{0.57} = 35$ cc (ml)

HOW TO CALIBRATE BACKPACK AND TRACTOR SPRAYERS

When and Why Should Sprayers be Calibrated?: The farmer should calibrate his/ her sprayer when a pesticide needs to be applied at an accurate dosage in order to avoid applying too much which wastes money and might injure the crop or to avoid applying too little which might make the product ineffective. When working with small fields, farmers can usually use generalized recommendations given in cc/liter or tablespoons/gallon for insecticides and most fungicides. However, most herbicides require more accurate application which means that sprayer calibration is usually needed.

The Principles Involved

When a pesticide recommendation is given in terms of kg/ha or lbs./acre of active ingredient or actual product, the farmer needs to kn. , 2 things before he/she can apply the correct dosage:

1. The amount of pesticide needed for his/her particular field.

2. The amount of water needed to convey the pesticide to the plants or soil and give adequate coverage.

Once these are known, it's a simple matter of mixing the correct amounts of water and pesticide together and then spraying.

CALIBRATION OF BACKPACK SPRAYERS

NOTE: Only backpack sprayers with continuous pumping action should be used when calibration is needed; compression type sprayers (the garden variety that needs to be set down to be pumped up) are not suitable because of their uneven pressure.

STEP 1: Fill the sprayer with 3-4 liters of water and begin spraying the soil or crop using the same speed, coverage, and pressure that will be used in applying the pesticide. Measure the area covered by this amount of water. Repeat this procedure several times to determine the average area sprayed. You can measure the area in terms of sq. ft., sq. meters or in terms of row length.

STEP 2: Based on the area covered, you can calculate the amount of water needed to cover the field. For example, if 3 liters covered 60 sq. meter and the field measures 20 x 30 meters, it would take 30 liters of water to cover the field.

STEP 3: Determine the number of sprayer tankfuls of water needed to cover the field. For example, if the backpack sprayer holds 15 liters, it will take 2 tankfuls to cover the field.

STEP 4: Determine how much actual pesticide is needed for the field. If 4 kg of Sevin 50% wettable powder are needed per hectare and the farmer's field is 600 sq. meters, this would mean that 240 grams of the insecticide are required. Here's how we worked it out:

$$\frac{600 \text{ sq. m}}{10{,}000 \text{ sq. m}} = \frac{X \text{ grams}}{.000 \text{ grams}}$$

$$x = 240 \text{ grams}$$

STEP 5: Divide the amount of pesticide needed for the field by the number of sprayer tankfuls of water to determine how much pesticide is needed per tankful:

$$\frac{240 \text{ grams Sevin 50\% WP}}{2 \text{ tankfuls}} = 120 \text{ grams Sevin/tankful}$$

NOTE: A sprayer should be recalibrated each time it's used on a different crop, different stage of crop growth, or when another pesticide is used.

Alternate Method Using Row Length

When a pesticide is to be applied to a crop grown in rows, you can use row length instead of area as the basis for calibration.

PROBLEM: Label instructions advise Juan to apply Malathion 50% strength liquid at the rate of 4 liters per hectare. His field measures 40 x 50 meters and the bean rows are spaced 60 cm apart. His backpack sprayer holds 15 liters, and he needs to know how much Malathion should be added to each tankful.

SOLUTION

1. Follow the same procedure as with Step 1 of the first method but measure the amount of row length covered by the 3-4 liters instead of area. Suppose that Juan was able to cover 150 meters of row length with 3 liters.

2. Find out how many meters of row length his field has. Let's say the crop rows are running the long way (i.e. 50 meters).

   Number of rows x 50 meters = field's total row length

   $$\text{Number of rows} = \frac{40 \text{ meters (i.e. the field's width)}}{0.8 \text{ m (80 cm)}}$$

   $$\frac{40 \text{ m}}{0.8 \text{ m}} = 50 \text{ rows on Juan's field, each of them 50 mts. long}$$

   50 rows x 50 meters = 2500 meters of row length in Juan's field

3. Find out how much water will be needed to cover the 2500 mts. of row length based on 3 liters per each 150 mts.

   $$\frac{150 \text{ m}}{2500 \text{ m}} = \frac{3 \text{ liters}}{X \text{ liters}}$$

   $$150X = 7500$$

   $X = 50$ liters of water needed to cover the field

4. Find out how much Malathion 50% liquid will be needed for the field based on 4 liters of the pesticide per hectare. (10000 sq. m). Since Juan's field measures 40 x 50 mts., its area is 2000 sq. mts.

$$\frac{\text{2000 sq. m}}{\text{10000 sq. m}} = \frac{\text{X liters Malathion}}{\text{4 liters Malathion}}$$

X = 0.8 liters or 800 cc of Malathion needed.

5. Find out how much Malathion is needed per sprayer tankful based on a capacity of 15 liters.

$$\frac{\text{50 liters of water needed}}{\text{15 liters tank capacity}} = \text{3.33 tankfuls needed}$$

$$\frac{\text{800 cc Malathion}}{\text{3.33 tankfuls}} = \text{240 cc of Malathion 50\% liquid needed per sprayer tankful}$$

NOTE: There are several different ways of doing the math involved, and we have shown only one.

INSECTICIDE TOXICITY TABLES

I. A QUICK REFERENCE INSECTICIDE GROUP AND TOXICITY GUIDE

The table below gives the relative human toxicity of common insecticides on a scale of 1 to 4 as follows: (Both oral and dermal toxicity is considered)

1 = most dangerous, 2 = dangerous, 3 = less dangerous,
4 = least dangerous

It also gives the chemical group to which each insecticide belongs as follows:

CH = chlorinated hydrocarbon, OP = organic phosphate,
C = carbamate, M = miscellaneous

As you'll see, the antidote for poisoning varies with the chemical group. Aside from this difference, it's hard to make meaningful distinctions between these chemical groups. For example, Aldrin, DDT, Endrin, Heptachlor, Lindane, and Kelthane (dicofol) have long residual lives and are all CH's; however, in terms of their immediate toxicity, they vary greatly-DDT is a Class 4 (least dangerous), while Endrin is a Class 1 (most dangerous). Other CH's like Methoxychlor have relatively short residual lives. The OP's and C's break down fairly quickly but, like the CH's, also vary greatly in toxicity.

Insecticide Names: Note that each insecticide may be marketed under several or more different trade names. Many extension bulletins refer to insecticides by their non-commercial chemical names (i.e. carbaryl is the chemical name for Sevin). This can create much confusion in identifying insecticides.

Common Name	Other Trade or Chemical Names	Chem. Group	Mammalian Toxicity
Aldrin[1]	Aldrite, Drinox, Aldrosol, Seedrin, Octalene	CH	2
Asuntol	Co-ral, coumaphos, Baymix, Meldane, Resistox	OP	3
Azodrin	Nuvacron, Monocron, monocrotophos	OP	2
Actellic	pirimiphos-methyl, Blex, Silosan	OP	4
Baygon	propoxur	C	3

1. Long residue life (3-10 years).

Common Name	Other Trade or Chemical Names	Chem. Group	Mammalian Toxicity
BHC	benzene hexachloride, Hexachlor, Benzahex, Benzel, Soproxide, Dol, Dolmix, Hexafor, HCH	CH	3
Bidrin	Ektafos, Carbicron, dicrotophos	OP	2
Birlane	Supona, Sapecron, chlorfenvinphos	OP	2
Bux	Bufenkarb, metalkamate	C	3
Chlordane	Chlorkill, Orthochlor, Belt, Aspon	CH	3
Ciodrin	crotoxyphos	OP	3
DDT[1]	Anofex, Genitox, Gesarol, Neocid Zerdane, many others	CH	4
Dasanit	Terracur, fensulfothion	OP	1
Diazinon	Basudin, Spectracide, Diazol, Sarolex, Gardentox	OP	3
Dibrom	Bromex, naled	OP	3
Dieldrin[1]	Octalox, Alvit, Dieldrite	CH	2
Dimecron	phosphamidon	OP	2
Di-syston	disulfoton, Fruminal, oxydisulfoton	OP	1
Dimethoate	Cygon, Rogor, Perfekthion, Roxion, De-Fend, Trimetion	OP	3
Dipterex	Dylox, Klofon, Danex, trichlorfon Neguvon, Anthon, Bovinox, Proxol Tugor, Trinex	OP	3
Dyfonate	fonofos	OP	1
Ekatin	Morphothion, thiometon	OP	3
Endrin[1]	Hexadrin	CH	1
Folidol	(see methyl & ethyl parathion)		
Folimat	omethoate	OP	3
Folithion	Nuval, Agrothion, fenitrothion	OP	3
Furadan[2]	carbofuran, Curaterr	C	2
Galecron	Fundal, chlordimeform, chlorphenamadine	OP	3-4
Gardona	Rabon, Appex	OP	4

1. Long residue life (3-10 years).
2. High oral, low dermal (skin) toxicity.
3. Moderately long residue life (1-3 years).

Common Name	Other Trade or Chemical Names	Chem. Group	Mammalian Toxicity
Gusathion	Guthion, Carfene, azinphosmethyl	OP	2
Heptachlor[1]	Drinox H-34, Heptamul	CH	3
Hostathion	triazaphos	OP	3
Kelthane[3]	dicofol, Acarin, Mitig n	CH	3
Lannate	methomyl, Nudrin	C	2
Lebaycid	fenthion	OP	3
Lindane[3]	Gamma BHC, Gammexane, Isotox, OKO, Benesan, Lindagam, Lintox, Novigam, Silvanol	CH	3
Malathion	Cythion, Unithion, Emmatos, Fyfanon, Malaspray, Malamar, Zithiol	OP	4
Metasystox	demetonmethyl	OP	2-3
Metasystox R	oxydemetonmethyl	OP	2-3
Methoxychlor	Marlate, Moxie	CH	3
Methyl parathion	Folidol M, Parathion M, Nitrox, Metron, Parapest, Dalf, Partron, Phospherno	OP	2
Mirex[2]	dechlorane	CH	3
Monitor	Tama , methamidophos	OP	2
Orthene	acephate, Ortran	OP	4
Parathion	Niran, Bladan, E-605, ethyl parathion, Folidol E-605, Phoskil, Orthophos, Ekatox, etc.	OP	1
Perfekthion	Cygon, Rogor, dimethoate, De-Fend, Roxion, Trimethion, Daphene, Recelate	OP	3
Phosdrin	mevinphos, Phosfene, Menite	OP	1
Pyrethrin	Pibutrin	M	4
Pounce	Ambush, permethrin, Ectiban, Kafil, Eksmin	M	4
Pirimor	pirimicarb	C	3
Rotenone	Derrin, Derris, Extrax, Mexide, Cubor	M	3

1. Long residue life (3-10 years).
2. A suspected carcinogen; now banned in the U.S.
3. Moderately long residue life (1-3 years).

Common Name	Other Trade or Chemical Names	Chem. Group	Mammalian Toxicity
Sevin	carbaryl, Vetox, Ravyon, tricarnam	C	4
Systox	demeton, Demox, Systemox, Solvirex	OP	1
Tamaron	Monitor, methamidophos	OP	2
TEPP	Tetron, Vapotone, Kilmite 40	OP	1
Tedion	tetradiphon, Duphar	CH	4
Telodrin	isobenzan	CH	1
Temik	aldicarb	C	1
Thimet	phorate, Rampart	OP	1
Thiodan	Endosulfan	CH	2
Thuricide	Bacillus thuringiensis, Dipel, Biotrol	M	Non-Toxic
Toxaphene[1]	Motox, Strobane T, Toxakill, Magnum 44	CH	3
Trithion	carbophenothion, Garrathion	OP	2
Unden	Baygon, Senoran, Suncide, Blattanex, PHC, propoxur	C	3
Vapona	DDVP, dichlorvos, Nuvan, Phosvit	OP	3
Volaton	Valexon, phoxim, Baythion	OP	3
Thiodan	endosulfan, Cyclodan, Malix, Thiml, Thiodex	CH	2
Mocap	Jolt, Brophos, ethoprop	OP	2
Dursban	Lorsban, chlorpyrifos	OP	2-3

LD_{50} RATINGS OF COMMON INSECTICIDES

The LD_{50} (LD = lethal dose) rating measures the amount of 100% strength chemical (i.e., active ingredient) that is needed to kill 50% of the test animals (rats or rabbits) when given orally and dermally (placed on the skin); this amount is measured in terms of milligrams of pure chemical per kilogram of animal body weight. One milligram = 1/1000th gram or about 1/28000th of an ounce. The LD_{50} rating gives a good indication of the relative toxicity of pesticides to humans and other mammals. The lower the LD_{50} rating, the higher the pesticide's toxicity.

Before looking at the LD_{50} ratings below, keep the following in mind:

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1 Moderately long residue life (1-3 years).

1. The LD_{50} ratings are based on the amounts of 100% strength chemical. However, insecticides as marketed vary in strength from 1% up to 95%. After dilution with water for spraying, actual strength may only be about 0.1-0.2%.

2. The LD_{50} ratings give little information on the cumulative effect of repeated exposure.

3. If spilled on the skin, liquid insecticides are more readily absorbed than wettable powders or dusts.

4. Note that some inecticides like TEPP and Phosdrin are about as toxic dermally as they are orally.

5. Even Class 4 (least dangerous) insecticides like Malathion can cause severe poisoning if enough were ingested or spilled on the skin, especially in the concentrated form.

6. The LD_{50} rating has no relation to an insecticide's effectiveness against insects.

CLASS 1
Most Dangerous

Common Name	Other Trade or Chemical Names	LD_{50} Oral	(mg/kg) Dermal
Dasanit	Terracur, fensulfothion	2-10	3-30
Disyston	Disulfoton, Fruminal, oxydisulfoton	7	15
Dyfonate	fonofos	8	25
Endrin	Hexadrin	1	18
Parathion	Ethyl parathion, Bladan, Niran, E-605, Polidol E-605, Phoskill Orthophos, Ekatox, Parathene, Panthion, Thiophos, Alkron	13	21
Phosdrin	mevinphos, Phosphene, Menite	6	5
Systox	demeton, Solvirex, Systemox, Demox	6	14
Telodrin	isobenzan	5-30	5-30
TEPP	Tetron, Vapotone, Kilmite 40	1	2
Thimet	phorate, Rampart	2	6
Temik	aldicarb	1	below 5

CLASS 2
Dangerous

Common Name	Other Trade or Chemical Names	LD50 rating Oral	Dermal
Aldrin	Aldrite, Aldrosol, Drinox, Seedrin, Octalene	39	98
Azodrin	Nuvacron, Monocron, monocrotophos	17	126
Bidrin	Ekafos, Carbicron	21	43
Birlane	chlorfenvinphos, Supona, Sapecron	10-155	108
Dieldrin	Alvit, Octalox, Dieldrite	46	90
Furadan	carbofuran, Curaterr	11	10,000
Gusathion	Guthion, Carfene, azinphosmethyl	12	220
Methyl parathion	Folidol M, Parathion M, Nitrox, Metron, Parapest, Dalf, Bartron, Phospherno	14	67
Lannate	Methomyl, Nudrin	17-24	1000
Monitor	Tamaron, methamidophos	21	118
Mocap	Jolt, Prophos, ethoprop	61	26
Thiodan	endosulfan, Cyclodan, Malix, Thimul, Thiodex	43	130
Trithion	carbophenothion, Garrathion	30	54
Nemacur	phenamiphos, fenamiphos	8	72

CLASS 3
Less Dangerous

Common Name	Other Trade or Chemical Names	LD50 rating Oral	Dermal
Baygon	propoxur	95	1000
BHC	benzene hexachloride, Hexachlor, Benzahex, Benzel, Soprocide, Dol, Dolmix, Hexafor, HCH	600	---
Bux	Bufenkarb, metalkamate	87	400
Chlordane	Chlorkill, Orthochlor, Belt, Aspon	335	840
Ciodrin	crotoxyphos	125	385
Diazinon	Basudin, Spectracide, Diazol, Sarolex, Gardentox	180	900
Dibrom	naled, Bromex	250	800
Dimethoate	Cygon, Rogor, Perfekthion, Roxion, De-Fend	215	400

CLASS 3 (continued)
Less Dangerous

Common Name	Other Trade or Chemical Names	LD50 Oral	rating Dermal
Dursban	chlorpyrifos, Lorsban	97-276	---
Dipterex	Dylox, Klorfon, Danex, trichlorfon, Neguvon, Anthon, Bovinox, Proxol, Tugon, Trinex	180	2000
Folimat	mmethoate	50	700
Folithion	Nuval, Agrothion, fenitrothion	500	1300
Hostathion	triazaphos	80	1100
Heptachlor	Drinox H-34, Heptamul	100	195
Lebaycid	Fenthion	200	1300
Lindane	Gamma BHC, Gammexane, Isotox, OKO Benesan, Lindagam, Lintox, Novigam, Silvanol	80	1000
Metasystox	oxydemetonmethyl	47	173
Mirex	dechlorane	300	800
Toxaphene	Motox, Strobane T, Toxakil, Magnum 44	90	1075
Unden	Baygon, Suncide, Senoran, Blattanex PHC, propoxur	100	1000
Vapona	DDVP, dichlorvos, Nuvan, Phosvit	90	107

CLASS 4
Least Dangerous

Common Name	Other Trade or Chemical Names	LD50 Oral	rating Dermal
DDT	Anofex, Genitox, Gesarol, Neocid, etc.	113	2510
Galecron	chlordimeform, Fundal	127-132	3000
Gardona	Appex, Rabon	4000	5000
Kelthane	dicofol, Acarin, Mitigan	1100	1230
Malathion	Cythion, Unithion, Emmatos, Fyfanon Malaspray, Malamar, Zithiol	1375	4444
Methoxychlor	Marlate	5000	6000
Morestan	Forstan	1800	2000+
Orthene	Acephate, Ortran	866	---
Sevin	carbaryl, Vetox, Ravyon, Tricarnam	850	4000
Tedion	Tetradifon	14,700	10,000
Volaton	phoxim, Valexon	1845	1000+
Actellic	pirimiphos-methyl, Blex, Silosan	2080	2000+

DISEASE CONTROL

I. TYPES OF DISEASES AND THEIR IDENTIFICATION

Parasitic vs. Non-parasitic Diseases

Parasitic diseases are caused by certain types of fungi, bacteria, and viruses that invade plants and multiply within their tissues. Nematodes and parasitic weeds like Striga (witchweed) can also be included in this category, but we'll deal with them separately below.

Non-parasitic (non-infectious) diseases are caused by unfavorable growing conditions or other non-parasitic factors such as:

a. Excesses, deficiencies, or imbalances of soil nutrients.

b. Excessive soil acidity or alkalinity.

c. Temperature extremes.

d. Poor drainage or drought.

e. Mechanical, fertilizer, or pesticide injury.

f. Air pollutants like ozone and sulfur dioxide.

Some of these non-parasitic conditions produce symptoms easily confused with those of parasitic diseases.

Fungal Diseases

Fungi are actually tiny parasitic plants without roots, leaves, or chlorophyll which feed on living or decaying organic matter; they reproduce and spread by means of microscopic seeds called spores. Some fungi are beneficial such as those that help break down crop residues into humus; others can penetrate directly into seed, leaf, or root tissue or can enter through wounds or nature openings.

General types of fungal diseases: Leaf spots leading to possible defoliation; rotting of seeds, stems, stalks, roots, grain heads, pods, and ears; storage molds; wilts.

Diseases caused by fungi are by far the most common, because the spores are highly resistant to unfavorable conditions. They are easily spread by wind, water, soil, and farm implements, but some types can also be carried by the crop seeds themselves. Most fungal diseases develop and spread much more readily under high humidity and moisture. An important characteristic of fungal diseases is their ability to mutate to produce new races that are resistant to certain fungicides; this is not common, however.

Bacterial Diseases

Bacteria are microscopic single cell organisms that multiply by cell division. Like the fungi, some bacteria are beneficial and perform essential functions like converting unavailable organic forms of soil nutrients to available inorganic (mineral) forms. Others invade plants and cause diseases that produce leaf spots, wilts, galls, and fruit and stem rots. For several reasons, bacterial diseases are generally much less prevalent than fungal diseases.

a. Bacteria lack a resistant spore stage and are very dependent on favorable temperature and moisture conditions.

b. Unlike the fungi, bacteria can't forcibly penetrate into plant tissue but must enter through natural openings or wounds.

c. Although bacterial diseases can be spread by wind driven rain, field equipment, and certain types of insects (mainly some beetles), they are much less readily transmitted than fungal diseases.

Viral Diseases

Viruses are microscopic particles consisting of a core of nucleic acid (genetic material) surrounded by a protein coat. Viruses can multiply by diverting living host cells into the production of more virus particles and can also mutate to produce different strains. They are largely spread by sucking insects (aphids, leafhoppers, thrips); the relationship between these insect vectors and the viruses is sometimes very specific; for example, peanut rosette virus is transmitted by only one species of aphid. Some species of weeds are susceptible to certain viruses and serve as alternate hosts to provide sucking insects with a steady source of innoculum.

Viruses usually don't kill plants but can greately reduce yields and quality. A wide variety of symptoms are produced such as leaf mottling (blotching), leaf curling, chlorotic (yellow) or necrotic (dead) spots on the leaves, leaf ma rmation, leaf striping, and excessive branching.

How to Identify Plant Diseases

Some plant diseases can be readily identified by non-professionals right in the field; in other cases, however, accurate diagnosis requires a good deal of field experience or even the expertise of a trained plant pathologist and lab facilities.

Troubleshooting Disease Problems

Helpful items: Magnifying glass, pocket knife for slitting stems, pictorial disease identification guides (see below).

1. Symptoms of some fungal, bacterial, and viral diseases can be easily confused with each other or with those caused by nematodes, non-parasitic diseases, or insects. Use the troubleshooting guide on pp. 158-162 to help narrow the problem down.

2. Examine the plants closely. If root, stem, or stalk rots are suspected, carefully remove some plants from the soil along with part of the root system; look for signs of damage such as soil insects,

root feeding, root discoloration. Slit stems and stalks lengthwise and check for rotting, discoloration or borers.

Disease Identification Guides For the Reference Crops

This section gives verbal descriptions of common reference crop diseases, but pictures are definitely worth a thousand words when it comes to identification. Ag field workers will find the following pictorial disease guides invaluable:

Maize

"Maize Diseases: A Guide for Field Identification", Information Bulletin No. 11, CIMMYT, Londres 40, Apartado Postal 6-641, Mexico 6, D.F. Available in English and Spanish.

"A Compendium of Corn Diseases", American Phytopathological Society, 3340 Pilot Knob Rd., St. Paul, Minnesota, U.S.A. 55121. More complete than the CIMMYT bulletin and also gives some control measures.

Sorghum and Millet

"Sorghum and Pearl Millet Disease Identification Handbook", Information Bulletin No. 2, ICRISAT, P.O. Patancheru 502 324, Andhra Pradesh, INDIA or Texas Agricultural Experiment Station, Texas A & M Univ., College Station, Texas, U.S.A. 77843. Available in English, French, Spanish.

"Sorghum Diseases", Bulletin 1085, Texas Agricultural Extension Service, Texas A & M Univ., College Station, Texas, U.S.A. 77843. Also gives some control measures.

Beans

"Field Problems of Beans in Latin America", CIAT, Apartado Aereo 6713, Cali, COLOMBIA, S.A. $5.60 (U.S.) plus postage. Includes diseases, insects, and hunger signs. Available in English and Spanish. Also gives some control measures.

"Bean Diseases: How to Control Them", Agriculture Handbook No. 225, Agric. Research Service, U.S.D.A. Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. Not as complete as the CIAT bulletin.

Soybeans

"Soybean Diseases Atlas", Cooperative Extension Service, Clemson University, Clemson, South Carolina, U.S.A. 29631.

"Soybean Insects, Nematodes, and Diseases", Circular 504, Cooperative Ext. Service, Clemson Univ., Clemson, South Carolina, U.S.A. 29631.

II. METHODS OF DISEASE CONTROL AND THEIR EFFECTIVENESS

Prevention vs. Cure

Most diseases such as viruses and the bacterial and fungal rots of seeds, seedlings, roots, stalks, and stems can't be controlled once they enter plant tissue. Fair to good control of fungal leafspots* can be achieved with foliar fungicides but this is usually uneconomical with low value crops like maize, millet, and sorghum. Disease control methods are therefore geared much more toward prevention rather than cure. Let's look at the principal non-chemical and chemical control practices.

Non-Chemical Disease Control Methods

1. Resistant varieties: Plant breeders have located genetic sources of resistance to some of the more serious diseases, especially viruses and other types that lack effective or economical chemical control measures. However, resistance does not mean 100% immunity, and the ability of viruses and fungi to mutate into new races has posed some problems. Disease resistance is a top priority among plant breeders.

2. Sanitation and Cultural Practices

   a. Disease free seed: Some diseases like bacterial blight and common mosaic virus of beans can be carried by the seeds. The use of certified seed (see Section C) that is disease free is an important management practice in many bean growing areas where these problems exist.

   b. Controlling host plants and insect vectors: This is especially important for controlling certain viral diseases and involves the removal of host weeds and other natural vegetation that serve as sources of innoculum. In some cases, non-susceptible barrier crops are planted around a field in a 15-20 meter wide strip to "decontaminate" sucking insects before they reach the susceptible crop (this is usually not practical). Also included is the roguing (removal) of diseased crop plants attacked by viruses; roguing is not effective for most fungal and bacterial diseases.

   c. Crop residue management: The burning or plowing under of crop residues is an effective prevention method for a few diseases like peanut Southern (Sclerotium) stem rot.

   d. The following practices may help minimize certain disease problems: not cultivating plants while they are wet; avoiding crop injury at or before harvest; irrigating in the morning when sprinklers or hand watering are used so that crop leaves

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* Fair control of most bacterial leaf spots can be obtained using copper base fungicides.

are dry at night; using raised beds to improve drainage; disinfecting tools.

e. Crop rotation can reduce the incidence of many fungal and bacterial diseases,* especially those that are soil borne, but will have little effect on viruses. There is nothing wrong monculture from a disease standpoint as long as resistant varieties are being continually developed and introduced in response to new problems; however, this is unlikely in the LDC's.

f. Intercropping may reduce or intensify disease problems, depending on the crop mixtures involved and whether they share some diseases in common.

Chemical Disease Control Methods

1. Fungicides can be applied to planting seeds, the soil, and crop leaves and will provide fair to good control of certain fungal diseases. They are mainly applied as protectants.

   a. Seed treatment with a fungicide dust or liquid will effectively prevent seed rots (pre-emergence "damping off") caused by soil fungi and will also kill any fungal diseases borne on the seedcoat surface such as loose smut and covered smut which attack adult sorphum plants.

      Since seed treatments mainly protect the seed, they are not as effective at preventing seedling blights (rots) and seedling root rots. A systemic seed treatment fungicide called Vitamax (Carboxin) gives somewhat better control.

      Seed treatments will not control any soil-borne or airborne fungal diseases that attack older plants such as leaf spots, stalk rots, stem rots, and root rots.

   b. Fungicide applications to the soil: Some fungicides like PCNB (Terrachlor), Vitavax (Carboxin), and Benlate (benomyl) can be applied as sprays or dusts to the seed furrow or to the row soil during crop growth to control certain fungal stem and root rots.

      Such soil applications are seldom necessary or economical for maize, sorghum, and millet but are usually profitable on high yielding peanut and bean crops if such disease problems exist.

   c. Foliar fungicides can be applied as dusts or sprays to crop foliage to control fungal leaf spot diseases. Most foliar fungicides act as protectants to help prevent the occurence or spread of leaf spots. Some of the recently developed systemic

* Especially soil-borne ones.

fungicides like Benlate (benomyl) and Mertect (Thiabendazole) also have erradicant properties.

Most foliar fungicides have little or no activity against bacterial leaf spots, but copper base fungicides provide fair to good control.

Foliar fungicides are usually not economical for field crops like maize, sorghum, and millet but are often essential for control of Cercospora leaf spot in peanuts and can be very profitable in this case. Their use on beans may be justified where yields are in the medium to high range and fungal leaf spots become serious. The use of foliar fungicides on high value vegetable crops such as tomatoes, squash, and potatoes is usually very cost effective where foliar fungus diseases are a problem.

2. Soil sterilants like methyl bromide, formaldehyde, Basamid, and Vapam will control soil fungi, bacteria, insects, weeds, and nematodes. They are applied in advance of planting and allowed to dissipate before the seeds are sown. Soil sterilants are frequently used on seedbeds for growing tobacco and vegetable transplants but are too expensive for use with the reference field crops.

3. Antibiotics like Streptomycin and Terramycin are bactericides used as foliar sprays or transplant dips to control certain bacterial diseases. Other antibiotics like Kasumin (Kasugamycin) and Blasticidin are effective against certain fungal diseases such as rice blast and are widely used in Japan. Their high cost makes them uneconomical for use on the reference crops. There are several problems associated with antibiotics, namely residues, the development of resistant races of fungi and bacteria, and occasional phytotoxicity (plant injury).

4. Use of insecticides to control insect vectors: This is seldom completely effective since 100% control is impossible.

Integrated Disease Control

Integrated disease control involves the combined use of non-chemical and chemical methods. Except for the mercury base fungicides sometimes used as seed dressings, the fungicides pose few toxic or environmental threats, unlike some insecticides. The main impetus for integrated disease control is based on economics and the fact that many diseases cannot be adequately controlled with chemicals.

RECOMMENDATIONS FOR FOLIAR FUNGICIDES

Protectant vs. Erradicant Fungicides

Most fungicides like Maneb, Zineb, Difolatan, and Manzate act as protectants: by remaining on the leaf surface to prevent fungal spores from germinating and penetrating the plant; they have little or no erradicant ability to stop the progress of an existing infection. However, a few fungicides like Benlate (benomyl) and Thiabendazole (Mertect) are actually absorbed into the leaf tissue and translocated outwards toward the margins; these systemic fungicides act as erradicants as well as protectants and also have other advantages:

1. They are not vulnerable to being washed off the foliage by rainfall or sprinkler irrigation.

2. Since they are translocated within the leaf, uniform foliage coverage isn't as important as with the non-systemic protectant fungicides.

The main disadvantage of the systemic fungicides is that they are effective against a narrower range of fungal diseases than most of the protectant fungicides, so more care must be taken to match the product to the disease. Another problem is that a few fungal diseases have developed resistance to some of the systemics (this hasn't occurred with the non-systemics).

Guidelines for Applying Foliar Fungicides

Type of Crop: Foliar fungicides are seldom economical for maize, sorghum, and millet; they will give the best benefit/cost ratio (cost-effectiveness) when used on well managed peanuts and beans under conditions where fungal leaf diseases are a limiting factor and on high value vegetable crops.

When to apply: Ideally, applications should be started slightly before the onset of infection or at least before the disease signs have become very evident. This is especially important when non-systemic protectant fungicides are used. In most growing areas, the major fungal leaf diseases are often rather predictable as to their date of first appearance, so that preventative applications can be begun in advance. Fungicides are too expensive to be used on a routine basis from the time the plants emerge; besides, most fungal diseases don't infect plants until around flowering time or after.

Frequency of application: This depends on disease severity, rainfall, and type of fungicide. The non-systemic protectant fungicides can be washed off the foliage by rainfall (or sprinkler irrigation), but the systemics remain safely within the plant once they've been absorbed. Under frequent rainfall, the protectants may have to be applied as often as every 4-7 days. Under less wet conditions, intervals of 10-14 days regardless of rainfall frequency. Disease severity also affects application frequency but is usually closely related to rainfall and humidity (as well as varietal resistance).

Uniform and thorough coverage of crop foliage is very important when applying fungicides. This is especially true for the protectant products which are effective only on those portions of the leaf surface they actually cover. An attempt should be made to cover both sides of the leaves when using protectants. Stickers and spreaders (see pp 233-234) are recommended for nearly all fungicide sprays to enhance coverage and adhesion; Duter is one exception, since these additives increase the likelihood of crop injury from that particular product. Some fungicides already contain stickers and spreader, so be sure to read the label.

Dusts vs. Sprays: See pp. 225-226.

Amount of water needed for adequate foliage coverage: This varies with plant size, crop density, and type of sprayer. When using backpack (knapsack) sprayers on full size plants, at least 700 liters/ha (75 gals./acre) of water is needed. Excessive water volume increases runoff which carries away spray droplets.

Nozzle selection and sprayer operation: See insecticide section.

Dosage Recommendations

Always follow label instructions and the recommendations of your country's extension service if the latter are based on sound adaptive research. The following recommendations are meant to serve as general guidelines.

Peanut Cercospora Leafspot: Benlate and Duter have generally proved the most effective although most other products such as Dithane M-45, Antracol, Bravo (Daconil), Difolatan, copper-sulfur dusts, and copper base sprays also give satisfactory control. The following recommendations come from North Carolina State University (U.S.A.) and Australia.

Duter 47% WP, 425 grams actual formulation per hectare (6 ounces/acre); don't use a sticker or a spreader.

Benlate 50% WP, 285 grams actual formulation/ha (4 oz./acre) plus sticker-spreader. Control is enhanced by combining 285 grams Benlate + 1.7 kg Dithane M-45 or Manzate 200 + 2.3 liters non-phytotoxic crop oil per hectare; the oil improves penetration.

COMMON FOLIAR FUNGICIDES

They are of relatively low toxicity (compared to insecticides) and have minimal dermal absorption (the dermal LD_{50} for Captan is over 10,000).

ANTRACOL (Propineb): Not registered in the U.S., but widely used overseas. A zinc base product by Bayer. Especially effective against early and late blight. Compatible with most other pesticides. Use at 75-125 cc per 15 liters (5-8 tablespoons per 4 gallons) and apply at 4-10 intervals depending on weather and disease severity.

BENLATE (Benomyl): One of the few systemic fungicides; has an erradicant effect as well as a protective effect but it is not broad spectrum; mainly for powdery mildews, Cercospora leafspot (peanuts), Botrytis (Gray mold) of tomatoes and lettuce, and brown rot of fruit trees. For small areas use 1-2 teaspoonfuls per gallon (5-10 cc/gal.). Also prevents mite eggs from hatching. Repeat at 10-21 day intervals. Use a sticker-spreader.

BORDEAUX (Copper sulfate + hydrated lime + water): One of the first original manmade fungicides. Has a protectant effect and also repels some insects. Don't let the solution stand in the sprayer for long periods. You can make it yourself. Two common formulas are 8-8-100 and 10-10-100 (first 2 numbers refer to lbs. of copper sulfate and hydrated lime; the last number refers to gallons of water). Each lb. of copper sulfate in 100 gals. of water equals 1/3 tablespoon (5 cc) per gallon. Each lb. of hydrated lime (slaked lime or calcium hydroxide) per 100 gals. equals 1 tablespoon (15 cc)/gal. To make 1 gallon of the 8-6-100 formula, dissolve 40 cc copper sulfate in 1/2 gal. of water; then dissolve 120 cc of hydrated lime in the other 1/2 gal; then mix both together. May cause leaf burn if made too strong.

CAPTAN (Orthocide, Merpan): Very safe broad-spectrum fungicide (also for seed treatment). Use the 50% WP at 3.5-5 tablespoons per gallon (13-20 cc/liter). As a seedbed drench for damping off prevention, mix up 2-3 cc/liter of water and apply with a sprinkling can at the rate of 2-3 liters/sq. meter immediately after planting vegies (if seed is not treated) or as soon as the seedling emerge.

COPPER COMPOUNDS (Aside from Bordeaux): For broad-spectrum foliar fungal control, but also more effective than other types for bacterial leafspots. Don't mix these with Diazinon insecticide. Copper oxyxhloride and Cupravit Blue are two examples and are used at 400-600 grams/100 liters water.

DACONIL (Bravo W-75, Termil): Broad-spectrum foliar fungal control; toxic to fish. Compatible with most other fungicides. Don't apply within 5 days of harvest. Use at 2.5-3 tablespoons per gallon (10-12 cc/liter).

DUTER (fentin hydroxide): An organic tin compound used on potatoes for its unusually good control of early and late blights. Also widely used for Cercospora leafspot on peanuts. Has some insect anti-feeding properties. Do not use a sticker-spreader or leaf burn may result.

MANEB (Dithane M-22, Manzate 200, Lonocol M): Manganese base broad-spectrum fungicide available as an 80% WP. Used at 1.5-2.5 tablespoons/gal. (6-8 g/l) or 1.5-2.5 lbs./100 gals. Don't apply within 5 days of harvest.

MANZATE (Dithane M-45, Mancozeb, Fore): A manganese-zinc combination. Manufacturers claim it's better than Maneb on tomatoes. Use same dosage as for Maneb. Don't apply within 5 days of harvest. Also used as a seed piece dip on potatoes to control seed piece decay.

ZINEB (Dithane Z-78, Lonocol Z, Polyram Z): A zinc base product. May injure squash and cucumber and tobacco. Don't apply within 5 days of harvest. Use same dosage as for Maneb.

PCNB (Terrachlor, Brassicol): A soil fungicide usually applied pre-plant either broadcast or in a band; also used as a soil drench at transplant time. Mainly for damping-off, Sclerotinia, and Rhizoctonia. For cabbage family crops, it's used as a seedbed drench right after planting. Use 1 tablespoon Terrachlor 75W + 2 tablespoons Captan 50W per gal. of water and apply it over 50 sq. ft.

FUNGICIDES FOR SEED TREATMENT

Remember that treating seed with a fungicide inhibits surface-borne fungi on the seed coat and protects against soil-borne ones. Most fungicide seed treatments offer no protection to the seedling. However, some of the newer systemic fungicides for seed treatment such as Vitavax (carboxin) can offer some protection during the early stages of seedling growth. Seed treatment will not control any soil-borne or air-borne fungal diseases that attack older plants like leaf spots, stalk rots, root rots, etc.

ARASAN (Thiram, Tersan): A low toxicity compound usually available as a 50% or 75% dust.

BENLATE T (Thiram + Benlate): For control of soil-borne Pythium, Fusarium, Rhizoctonia damping off and early root rots of beans and peas. Benlate (benomyl) is a systemic. Low toxicity.

CAPTAN (Orthocide, Merpan): Another low toxicity seed treatment fungicide that's also used as a foliar fungicide.

FERNASAN: A combination of Arasan and Lindane (an insecticide) that comes in several formulations. Fernasan 75W contains 75% Arasan and 1% Lindane--only enough insecticide to protect seeds during storage, not once in the ground. Fernasan 60/15 contains 60% Arasan and 15% Lindane for better control of seed eating insects in the soil. Both formulations are used at rates of 100-150 grams per 100 kg of seed. Smaller seeds require the higher dosage (more surface area).

MERCURY COMPOUNDS: Mercury compounds have been virtually banned in the U.S. as seed treatments. The problem wasn't a build-up of mercury in the soil but the accidental (or unwitting) ingestion of mercury treated seed by livestock or even people. Mercury is very effective and even has a penetrating effect into the seed, but avoid using it whenever possible. Common mercury-base seed treatment compounds are Ceresan and Semesan. Agallol is a mercury base dip for potato seed pieces, but Zineb or Manzate can be substituted. Skin absorption of organic mercury compounds (Ceresan, Semesan, Agallol) is minor but not so with inorganic like bichloride of mercury. Avoid breathing the vapors of any mercury product.

APPLYING SEED TREATMENTS: Arasan, Captan, and Fernasan can be applied as dusts to the seed at the rate of about 2-3.5 grams per kg of seed (smaller seeds need the higher rate). A baby food size jar works perfect for small quantities of vegie seeds and you can "eyeball" the rate (it takes much less than you think); seed should look uniformly covered but not "buried" in the fungicide. Wash hands afterwards. Always store treated seed out of reach of children and NEVER feed leftovers to humans or animals (i.e. treated maize, sorghum, bean seed, etc.)

NEMATODES AND THEIR CONTROL

I. BASIC FACTS ON NEMATODES

What are nematodes?: They are tiny, colorless, threadlike, unsegmented roundworms; they are not related to earthworms. Some types of nematodes like hookworms, roundworms, and pinworms attack man as well as animals. There are several dozen species that attack plant roots, as well as a few that injure stems and leaves. These plant feeding nematodes live in the soil, and most are too small (0.2 - 0.4 mm) to be easily seen with the naked eye.

How do they damage plants?: The root feeding nematodes are the most common types attacking plants. They feed on or inside plant roots using needle-like mouthparts (called stylets) for piercing and sucking. The root knot nematode causes portions of the roots to swell into galls or knots, while root lesion nematodes produce dark colored lesions on the roots. Sting nematodes and stubby root nematodes prune the root system, making it appear stubby and sparse. Affected plants have trouble absorbing enough water and nutrient and become much more vulnerable to soil-borne fungal and bacterial diseases. In fact, those tomato varieties resistant to Fusarium wilt lost that resistance when attacked by nematodes.

How serious is the damage?: Heavy infestations can lower crop yields by 30-80%.

Where are nematodes found?: Nematodes can be found in virtually any soil but are most prevalent and active where soil temperatures are warm; they seem to prefer sandier soils or those portions where moisture and soil fertility are low.

How do nematodes spread?: Nematodes reproduce by eggs, and life cycles of some types can be as short as 18-21 days in warm soils. Although a typical nematode will move less than half a meter during its life, they are easily spread by soil carried on tools, feet, and transplants or by water runoff from a field.

What crops are most affected?: Nearly all crops are susceptible to some type of nematode but vegies and pulse crops are generally more vulnerable than cereal crops.

Some crops especially susceptible to root knot nematode damage: Squash, cucumber, watermelon, cantaloupe, tomato, pepper, beans, peas, okra, lettuce, carrots, and strawberries.

Some crops especially susceptible to root lesion nematodes: Okra, pepper, potato, sweetpotato, strawberries, cowpeas, peanuts, soybeans.

Varieties within a crop vary greatly in their resistance to different types of nematodes.

II. HOW TO DIAGNOSE NEMATODE PROBLEMS

Nematode damage is not often obvious or easily differentiated from other problems. In fact, a lab analysis is usually needed to confirm nematode damage and the type of nematode, except in obvious cases of root knot nematode infestation.

Above Ground Symptoms

Above ground symptoms aren't distinctive enough to make a conclusive diagnosis without also examining the root system, but the following are possible indications of nematode damage.

1. Plant stunting and lack of vigor is the most common but can also be caused by other problems such as low soil fertility, lack of moisture, diseases, insects, etc.

2. Yellowing of the leaves, although diseases, some hunger signs, insects, moisture stress, etc. can cause similar symptoms.

3. Wilting, even when soil moisture appears adequate and heat isn't excessive; soil insects, stem borers, and diseases can also cause wilting.

4. A distinguishing feature of nematode damage is that it almost always occurs in scattered patches in the field and is rarely uniform.

Root Symptoms

Carefully dig up the roots and look for the following:

1. Galls or knots on roots indicate root knot nematode damage. Don't confuse them with Rhizobia bacteria nodules attached to legume roots. Nematode galls are swellings of the actual root itself and have a white, granular appearance inside. Rhizobia nodules are pink to red inside and can be easily detached from the roots.

2. Root damage by other species is less obvious and takes the form of dark colored lesions (wounds), stubby roots, and general stunting of the root system. Don't confuse these symptoms with those caused by rootworms, white grubs, or other soil insects.

Laboratory Diagnosis

Plant pathology labs in most countries can test soil and root samples for nematodes. Take 5-10 random sub-samples within the field right next to plants, using a shovel. Dig down about 20-25 cm (8-10") and discard the soil from the top 5 cm and from the sides of the shovel. Place the remaining 15-20 cm deep strip in a pail, and be sure to include some roots. Mix the sub-samples together and place about a half-liter (pint) of the soil into a plastic bag. Protect the sample from sunlight and exposure to excessive heat. Fill out the lab's information form completely.

III. HOW TO CONTROL NEMATODES

Successrul nematode control requires an integrated approach that combines several non-chemical methods and the likely need for chemical nematocides. The use of nematocides alone is unlikely to provide satisfactory control.

Non-chemical Controls

1. Avoid spreading nematodes into uninfested areas: Clean off soil from tools and equipment; avoid using transplants of unknown origin that might harbor nematodes. Some types of trees introduced for shade or windbreaks such as Prosapis species harbor nematodes.

2. Crop rotation: Designing an effective rotation requires a nematode lab analysis to determine the types of nematodes present; given the many types of nematodes and susceptible crops, a nematologist should be consulted. A farmer's cropping options may not allow for an ideal rotation.

3. Resistant varieties: Nematode resistance varies greatly among varieties of a particular crop, although complete immunity isn't possible. Furthermore, even a resistant variety may still be susceptible to several types of nematodes. Vegetable varieties with the letter "N" following their names have some resistance to nematodes (usually certain types of root knot nematodes).

4. Plowing up crop roots and exposing them to sun and drying winds: This will significantly reduce nematode populations.

5. Flooding: One month of flooding, one month of drying, and another month of flooding will reduce nematode problems but isn't often practical.

6. Good soil fertility and high soil organic matter levels help reduce the severity of nematode damage.

7. Antagonistic plants: Many garden books recommend interplanting marigolds among susceptible crops to control nematodes. However, research has shown that marigold varieties vary in their effectiveness which is also limited to certain types of nematodes (root knot and/or root lesion, depending on the authority). Furthermore, marigolds don't kill nematodes but starve them out; this means that interplanting isn't effective, since the nematodes would still have a food source. Marigolds should be planted solid (about 15-20 cm apart) and allowed to mature. Keep the area completely weed and crop free where the marigolds are growing. Collect the mature heads before they shatter (drop their seeds). Where root knot nematodes are a problem, marigolds should be planted every other year. French dwarf types such as "Tangerine", "Petite Gold", and "Harmony" are known to be effective.

Two legume green manure or cover crops, Crotalaria spectabilis (showy crotalaria or rattlebox) and Indigofera hirsuta (hairy indigo) can reduce populations of most types of nematodes.

8. Heat sterilization of soil using clear plastic: A good method for hot, sunny areas, Cover the soil with plastic and bury the edges. Leave it on for 3-4 weeks which should heat up the soil to 130-140°F several inches down. Th' will also kill harmful fungi and bacteria as well as weed seec

9. Heat sterilization of nursery seedbox soil with boiling water, steam, or baking.

10. Deep setting of tomato plants helps assure a larger root system more capable of withstanding nematode damage.

Chemical Controls

Soil fumigants like methyl bromide, Vapam, Basamid, and EDB are often used on vegetables or transplant beds but are either too expensive or require specialized application equipment. Some are very dangerous.

Non-fumigant nematocides like Mocap (ethoprop), Furadan, and Dasanit can be applied as granules to the crop row and are also effective against some insects. Under small farmer conditions, their use on maize and other cereals for nematodes only would be uneconomical except in cases of heavy infestations and high potential yields. There may be some cases where their use is justified on the pulses, especially peanuts. Here are some product use guidelines for some of the more common nematocides:

NEMAGON (DBCP, Frumazone): Comes as a liquid or granules but has been virtually banned in the U.S. as a possible carcinogen; prolonged exposure over the years has caused testicular atrophy in males. Stay away from this one.

FURADAN (Carbofuran): See description on pp. 240-241. Has a very low dermal but very high oral toxicity. Nematode application guidelines are shown below:

Peanuts: Apply in a band 30-35 cm wide over the row before planting; use 2.2-4.5 kg of active ingredient/ha. Needs to be worked into the soil 5.5-15 cm deep.

Maize: Apply in a band 18-36 cm wide over the row before planting and work into the top 5-10 cm of soil. Use 1.7-2.25 kg of active ingredient/ha.

MOCAP (Ethoprop, Prophos): Kills nematodes and soil insects but is very toxic both orally and dermally; applied like Furadan at the rate of 1.7-2.25 kg active ingredient/ha. Not recommended for most small farmers. Non-systemic.

TEMIK (Aldicarb): A systemic insecticide/nematocide with extremely high oral and dermal toxicity. Avoid it.

DASANIT (Terracur, fensulfothion): A non-systemic product for soil insects and nematodes. Very high oral and dermal toxicity. Avoid using.

NEMACUR (Phenamiphos, Fenamiphos): A systemic product for nematodes, soil insects, above-ground sucking insects. Class 2 toxicity. Applied to ; anuts like Furadan at 1.7-2.85 kg active ingredient/ha. Handle with care. Use Furadan instead if possible due to its much lower dermal toxicity.

Root knot nematode galls on bean roots. Note how they differ from nodules by actually being part of the root.

NEMATOCIDES & SOIL STERILANTS

Soil sterilant is a vague term. Some products kill just about everything (nematodes, insects, fungus, bacteria, weeds) while others are less comprehensive. Some nematocides control only nematodes (i.e. like Nemagon) while others are really soil sterilants in the broad sense.

Do soil sterilants also hurt the "good guys" like beneficial bacteria, fungi, and earthworms? You bet, but it's only temporary and confined to the top 6-8". Where disease problems (soil borne ones) are severe, some form of sterilization may be the only answer.

Non-Chemical Soil Sterilization

1. Applying boiling water to seedbox soil is very effective if the soil is thoroughly soaked.

2. Heating the soil in an oven or over a fire works great too; partly wet soil heats up better and the formation of steam helps. Soil can be placed on a piece of zinc roofing supported over a fire or use half of a 55 gal, drum split the long way. About one hour at 180°F does the trick; don't overcook the soil as it may release toxic (for plants) amounts of certain elements. One way of checking is to place a potato or sweetpotato midway down in the soil; when it's cooked, the soil is ready.

Be careful not to recontaminate the soil by further additions or by adding compost or manure afterwards.

Chemical Soil Sterilants and Nematocides

BASAMID Granules (DMTT)

A multi-purpose soil sterilant for nematodes, insects, fungi, bacteria, and weeds; has a fumigant (gaseous) action. Moderate toxicity for humans. Applied broadcast or band. Soil should be clod-free, loose, and semi-wet, and free of undecomposed plant residues. In sandy and loamy soils, use 35-40 grams per sq. meter (11 sq. ft.) broadcast and immediately worked into the top 6-9" of soil. Uniform mixing is important for good control. Prevent escape of the fumes by watering lightly after application (1/4" of water or about 2 gals. per sq. meter) and then once again 3-4 days later or covering with plastic for a few days (sounds better). Wait 10-14 days before planting in warm climates (soil temp. above 68°F). Stir soil thoroughly 7 days after application. Can also be applied 20 cms. (8") wide centered over the row and incorporated 8" deep for tobacco and tomato transplants; wait 4 weeks before transplanting.

FORMALDEHYDE (Formalin)

Controls everything but nematodes and weed seeds. There are various recipes but here's a couple of old standby's:

1. 1 gal. of commercial formaldehyde (about 37% strength) mixed with 30 gals. water. Drench soil at 1 quart per sq. ft. (10 liters/sq. meter). Water heavily afterwards and apply plastic. Remove plastic after 48 hours and work up the soil as soon as it's dry. Wait 10-14 days before planting (make a small test planting first).

2. Quickie Method for small amounts of soil: 1 part formaldehyde in 5 parts water. Apply at 1 tablespoon per 2-1/2 sq. feet (0.25 sq. meters) of seedbox soil and thoroughly mix or stir. Plant after 24 hours but water right after planting.

Formaldehyde funes are irritating to the eyes and nose and poisonous to nearby growing plants.

FURADAN (Carbofuran)

A systemic nematocide-insecticide available as a 3% and 5% granular formulation and a 75% WP. The pure material has a high oral but very low dermal toxicity. Usually applied as a band treatment centered over the row. It's absorbed by the roots and then translocated throughout the plant. Controls soil nematodes, soil insects, plus many chewing and sucking foliage pests like flea beetles, aphids, leafhoppers, and leaf miners.

On vegetables, the rate of Furadan 5% granules is 30-40 grams per 10 meters of row length applied at transplant or seeding time. There are 4 recommended methods of application:

1. Placing it in a 15-25 cm. (6-10") wide band centered over the row.

2. In a circle around each transplant or seed.

3. Mixing with the row fertilizer and applying it in the bottom of the furrow, covering with a couple inches of soil and then seeding. Make the furrow a couple inches off to the side to avoid fertilizer burn.

4. For nursery seedbeds, use 10-15 grams per sq. met. (5% granules) and work into the top 4-6" of soil.

NEMAGON (Fumazone, DBCP)

For nematodes only. Unfortunately, Nemagon has been found to be a possible carcinogen and is being phased out in the U.S. on some crops. Of moderate oral and dermal toxicity. Frumazone is a liquid; Nemagon comes as both a liquid and granules. Never use repackaged Nemagon granules or those that have been exposed to the air for several days--all the vapor leaves the granules in 7-10 days when exposed to air. Not for tobacco, sweetpotatoes, potatoes, beets, onions, or garlic. When transplanting tomatoes and peppers, it's best to wait 8-10 days after treatment. Both liquid and granules need to be applied 6-8" deep and then covered (make a furrow for each crop row). Plant seed or transplant over the furrow. A quart size jar with 2 holes in the lid (opposite each other) makes a good liquid applicator. See label for dosage as there are several different formulations. Has a fumigant action.

METHYL BROMIDE (Dowfume MC-2)

A general soil sterilant sold in a can as a liquid under pressure which volatilizes into a gas when opened. Highly poisonous to all living things. The gas will severly burn the skin and inhalation can be fatal. Most formulations are spiked with tear gas (chloropicrin) as a warning agent. Don't use on onions, garlic or celery.

Must be applied under a sealed plastic tarp to loose, semi-wet soil tilled to at least 8". Soil should be free of crop residues. 1-2 lbs. needed per 100 sq. ft (comes in can). Keep plastic on for at least 48 hours after application, then stir up the soil to help dissipate the chemical (no danger of human toxicity after 48 hours). Planting can be done 3-7 days after the plastic is taken off. Usually used only for nursery seedbed soil (i.e. for starting out seeds for transplants).

MOCAP (Ethoprop, Jolt, Prophos)

A non-systemic insecticide-nematocide for controlling soil insects and nematodes. Highly toxic both orally and dermally. Readily absorbed through the skin. Has a residual activity of about 8 weeks in the soil. Requires only light incorporation (1-2" deep) as it moves downward rather than upward (no fumigant action). Rubber gloves are a must when handling. It's too dangerous a chemical for most farmers.

VAPAM (VPM)

A liquid broad-spectrum soil fumigant effective against insects, nematodes, bacteria, weeds, and fungi. For treating small areas, it can be mixed with water and applied with a sprinkling can. Cover the soil with plastic for a couple days after application or drench with plain water to move the chemical downward. Allow at least 21 days before planting; dosage is usually 1-2 quarts per 100 sq. ft. in 15-20 gals. water. READ THE LABEL. Vapam has low oral and moderate dermal toxicity.

When using a soil sterilant, don't recontaminate the soil by making additions of compost and manure (do it first). Unclean tools or boots can track in disease and nematodes too.

Some agronomists recommend that any N fertilizer applied after sterilization should contain about half its N in the mobile and more available nitrate form. Sterilized soil won't have enough good guy bacteria to convert ammonium N (doesn't move much and is less available) to nitrate N.

WEED CONTROL

I. HOW WEEDS LOWER CROP YEILDS

1. They compete with the crop for water, sunlight, and nutrients.

2. They harbor insects, and some weeds are hosts for crop diseases (especially viruses).

3. Heavy infestations can seriously interfere with machine harvesting.

4. A few weeds like Striga (witchweed) are parasitic and cause yellowing, wilting, and loss of crop vigor.

Extent of Yield Losses

Numerous trials in the U.S. have shown maize yield losses ranging from 41-86% when weeds weren't controlled. One trial in Kenya yield only 370 kg/ha of maize with no weed control compared to 3000 kg/ha for clean weeded plots. A CIAT trial with beans in Colombia a yield drop of 83% with no weeding.

Of course, all farmers weed their fields to some extent, but most of them could significantly increase their crop yields if they did a more thorough and timely job. A University of Illinois (U.S.) trial showed that just one pigweed every meter (40") along the row reduced maize yields by 440 kg/ha (390 lbs./acre). By the time weeds are only a few inches tall, they have already affected crop yields.

Relative competitive ability of the reference crops: Slow starters like peanuts, millet, and sorghum compete poorly with weeds during the first few weeks of growth. Low growing crops like peanuts, bush beans, and bush cowpeas are fairly effective at suppressing further weed growth once they are big enough to fully shade the inter-row spaces. However, tall growing weeds that were not adequately controlled earlier can easily overtake these "short" crops.

II. SOME IMPORTANT FACTS ON WEEDS

Broadleaf vs. Grassy Weeds

Broadleaf weeds have wide (broad or oval shaped) leaves with veins that form a feather-like pattern. Grassy weeds are true grasses and have long, narrow leaves with veins that run up and down in a parallel pattern. A few weeds like nutsedge (nutgrass) belong to neither category but are sedges, all of which have triangular stems. Some chemical herbicides are more effective on broadleaf weeds, while others give better control of grassy types.

How Weeds Reproduce and Spread: nuals vs. Perennials

Annual weeds live only a year or so and reproduce by seed: they are the most common weeds in may fields. In the tropics, annuals may live more than a year if rainfall is sufficient. Most annuals produce tremendous amounts of seed, some of which may not germinate for years. When you stir the soil with a hoe, harrow, or cultivator to kill weeds, you destroy one crop of them but encourage another by moving more weed seeds closer to the surface where they can sprout.

You can help lower a field's population of annual weeds by controlling them before they produce seed. Permanent eradication of annual weeds isn't possible because most fields contain millions of weed seeds waiting to germinate, and the supply is continually replenished by more seeds brought in by wind, water, animals, animal manure, and by contaminated crop seeds.

Perennial weeds live more than 2 years. Most produce seed but many also propogate by means of creeping above-ground stems (stolons) and creeping underground stems (rhizomes). Johnsongrass, Bermudagrass, quackgrass, and nutsedge are some of the more agressive perennial weeds. Hoeing or mechanical cultivation may actually aid in spreading them around the field. Most herbicides will kill only the topgrowth, and there is enough food in the underground parts to continue propagation.

Identifying Weeds

Where weeds are being controlled by hoeing or mechanical cultivation, their specific identification is usually not important. However, where chemical weed control is used, you and the farmer should have a good idea of which specific weeds are present, because most herbicides do not give broad-spectrum control. The following extension publication is an excellent identification guide and has pictures and descriptions of some 150 common weeds found throughout the tropics and sub-tropics:

"Weeds of the Southern United States, available from the Cooperative Extension Service of Clemson University, Clemson, South Carolina, U.S.A. 29631

III. A LOOK AT DIFFERENT WEED CONTROL METHODS

Let's look at the pros and cons of the following weed control methods:

1. Burning
2. Mulching
3. Shading (the row crop principle)
4. Hoe and machete cultivation
5. Animal and tractor-drawn cultivation
6. Herbicides

1. Burning

When land is cleared by burning, standing annual weeds are killed along with weed seeds very near the soil surface. However, burning will not kill weed seeds or reproductive underground parts of perennial weeds if they are deeper than 4-5 cm (2"). Furthermore, as the brush is often placed in windrows or piles before burning, much of the soil may not be affected by the fire. Some perennial tropical grasses such as Guinea (Panicum maximum) and speargrass (Imperata cylindrica) are actually stimulated into dense regrowth by burning. On the other hand, weeds may be less of a problem under slash and burn farming, because the soil is usually not turned by plowing or cultivation to bring up more weed seeds.

2. Mulching

Mulching the soil surface with a 10-15 cm (4-6") layer of crop residues, dead weeds, or grass can give very effective weed control and provide a number of other benefits:

a. Erosion is greatly reduced on sloping soils.

b. Soil water loss by evaporation and runoff is greatly reduced.

c. In very hot areas, soil temperatures are reduced to a more beneficial level for crop growth.

d. Organic matter is eventually added to the soil.

In trials conducted by IITA in Nigeria, mulching increased maize yields by 23-45% and greatly reduced the heavy labor requirement for hand weeding which accounts for a 50-70% of the hours needed to grow maize in that area.

3. The Row Crop Principle

Arranging crops in rows facilitates hand weeding but also makes possible mechnical cultivation (weeding) with tractor or animal-drawn equipment. The rows also permit the crop to exert better shade competition against the weeds.

4. Hoe and Machete Cultivation

Weeding with hand tools is an effective method if sufficient labor is available. However, small farmers who rely on this method commonly fall behind in weeding, and crop yields often suffer.

5. Animal and Tractor-drawn Cultivation

Disk harrow , field cultivators, and spike tooth harrows can provide excellent pre-planting weed control. The spike tooth harrow can also be used to control emerging weeds up until the crop is about 7.5-10 cm (3-4") tall without serious damage.

Animal and tractor-drawn row cultivators can be used from the time the crop is a few inches tall; they do a much more rapid job than hand weeding, and a one-row animal drawn model can easily cover 3-4 hectares/day (7.5-10 acres) unless the rows are very narrow. They can be adjusted to throw soil into the row itself to kill small weeds by burying them. If operated too deeply or too close to the row, serious root pruning may result.

6. Herbicides

Herbicides can greatly reduce labor requirements and permit a farmer to grow a larger acreage; they also avoid root pruning damage, soil compaction, and stand reduction which are caused by hand tools or mechanical equipent. In a number of cases, herbicides like Gesaprim (atrazine, see herbicide section) and 2,4-D have proven competitive with hand labor in maize production in the LDC's. IITA is working on improved methods for small farmer application of herbicides such as granular forms and ultra low volume sprayers.

Herbicides do have some very definite disadvantages that must be considered when working with small farmers:

1. They are less reliable than hand tool or mechanical weeding and most require careful and accurate application. This can be achieved by small farmers using backpack sprayers, but it requires some training.

2. Weed control is seldom complete; most herbicides are not broad-spectrum, and it's important to analyze the type of local weed species present before choosing a product.

3. Most soil applied herbicides require a certain amount of rain within a week after application in order to move the chemical into the zone of weed seed germination. Others need immediate incorporation into the soil with a disk harrow or rototiller.

4. Improper application may damage the crop.

5. Nearly all herbicides are unsuited for use in intercropping involving cereals and legumes due to crop injury; these products are crop-specific as well as weed-specific.

BIBLIOGRAPHY

USEFUL CROP PRODUCTION

REFERENCES FOR TRAINEES AND TRAINERS

Aside from the crops tech reference package (see Printed Materials Section), which should be given each crops trainee and trainer, the following additional references are very useful:

I. Suggested vegetable related references to be ordered for each trainee:

Insect Pests, Geo. Fitcher, a Golden Guide, Western Pub. Co., 1220 Mound Ave., Racine, Wisconsin 53404, Tel. 494-633-2431 or to order, $2.95. Very useful pocket Guide with drawings and descriptions of many common vegetable, field crop, livestock, and human pests found worldwide.

Soils, Crops, and Fertilizer Use, 1980, ed., PC/ICE Reprint R8, 160 pp. A how-to guide on essential hands-on and tech skills needed for trouble-shooting soils, soil conservation, and maximizing returns from the appropriate use of organic can chemical fertilizers under small farmer conditions.

"Tomato Diseases and their Control", USDA Agric. Handbook No. 203, 109 pp., $1.00. Sometimes available free through PC/ICE. Complete pictorial and descriptive guide to tomato diseases and their control methods. A much shorter (10 pp.) USDA bulletin, "Controlling Tomato Diseases in the Home Garden" is usually available through PC/ICE.

Intensive Vegetable Gardening for Profit and Self-sufficiency, PC/ICE Reprint R-25, 160 pp. Contains some very practical information on small scale gardening, particularly tool selection, home fabrication of tools and water lifts, garden planning, and basic production practices. However, the manual is based on Jamaican conditions and tends to oversimplify important areas like soil fertility and fertilizer use, watering, and pest and disease control.

II. Suggested vegetable and field crop related references for inclusion in a training center ag library: (In some cases, such as the field crop pocket disease guides, they may be worth ordering for each trainee.)

VEGETABLE PRODUCTION

Vegetable Growing Handbook, W. Splittstoesser, AVI Pub. Co., Westport, CN, 1979. An unusually practical textbook.

Producing Vegetable Crops, Ware and McCollum, 3rd ed., 1980, Thompson Publications, Box 9335, Fresno, CA 93791, $18.00. Geared to commercial production but still useful.

The Self-Sufficient Vegetable Gardener, J. Seymour, Dolphin Books, Garden City, N.Y. 1980, $9.95. Probably the most reliable and complete of the home gardening books. Covers land preparation through harvest practices plus drying, canning, and more. Like most such books, it is based on temperate zone conditions. Well illustrated.

Handbook for Vegetable Growers, J. Knott, John Wiley and Sons, N.Y. 1962. Despite its age, it contains many useful tables on irrigation, crop adaptation, time to maturity, fertilizers, etc.

All About Vegetables, Ortho Book Series, Chevron Chemical Company, 575 Market Street, San Francisco, California 94105, $4.98. Often available in garden and book stores. Another useful supplemental vegetable gardening guide; well illustrated; based on temperate zone conditions. A good beginner's guide for home gardening. Tends to oversimplify.

Down to Earth Vegetable Gardening Know-How, D. Raymond, Garden Way Publications, Charlotte, Vermont, 05445, $5.95. Very useful guidelines for selecting, processing, and saving seed, but does not address the problem of seed-borne diseases.

How to Grow More Vegetables, J. Jeavons, Ten Speed Press, Box 7123, Berkley, California 94707, 115 pp., $5.95. This popular book on the biodynamic/French intensive method of organic gardening offers some useful advice on double-digging, deep bed preparation, and hexagonal planting. However, it oversimplifies watering (i.e. the "shiny" method), and gets bogged down in unproven statements and doubtful practices such as planting by the moon, relying on portable soil test kits, the "poisoning" effect of chemical fertilizers. The benefits of companion planting are overstated.

INSECTS, DISEASES, WEEDS, NEMATODES

General

North Carolina Agricultural Chemicals Handbook, Division of Continuing Education, Box 5125, Raleigh, North Carolina 27650, $5.00. Revised yearly. Gives dosages, application rates, and safety precautions for insecticides, fungicides, herbicides, nematocides.

Insect Pests of Farm, Garden, and Orchard, 7th ed., R. Davidson and W. Lyon, 1979, John Wiley and Sons, N.Y. Good for identification and life cycles.

Complete Guide to Pest Control, George Ware, Thompson Publications, Box 9335, Fresno, California 93791, $19.00. Cover organic and chemical insect, disease, weed, nematode, rodent, and bird controls. Very helpful.

Thompson Guides. Book I: Insecticides; Book II: Herbicides; Book IV: Fungicides, Thompson Publications (see address above). $13.50 each. Lists and describes the most widely used pesticides including common names, uses, rates (per acre), pests controlled, toxicity (oral only), and precautions.

Plant Disease Control, E. Sharvelle, AVI Pub. Co., Westport, CN, 1979. One of the most practical te. s available.

Color Handbook of Garden Insects, A. Carr, Rodale Press, Emmaus, PA, $12.95. Contains 300 full color pictures of common harmful and beneficial insects (including eggs in some cases). An especially good insect guide.

"Handbook on Biological Control of Plant Pests", Brooklyn Botanic Gardens, 1000 Washington Avenue, Brooklyn, New York 11225, $2.55, 1960, 97 pp. Covers predator insects, microbial insecticides, other non-chemical controls. Good pictures of lace bugs, lady bugs, aphid lions, etc.

"Nematode Control", Bul. 652, Coop. Extension Service, Univ. of Georgia, College of Agriculture, Athens, Georgia 30602. Covers diagnosis and control of nematodes. Well illustrated, very helpful.

Agricultural Pests of the Tropics, 1975, D. Hill, Cambridge University Press, London, 1975.

Maize Diseases

"Maize Diseases: A Guide for Field Identification", Information Bulletin No. 11, CIMMYT, Apartado Postal 6-641, Mexico 6, D.F., $2.50. Available in English and Spanish. Pocket pictorial guide for diagnosis but does not give control measures.

"A Compendium of Corn Diseases", 2nd edition, 1980, American Phytopathological Society, 3340 Pilot Knob Road, St. Paul, Minnesota 55121, $11.00. Well illustrated and complete descriptions and control measures for diseases and nematodes; also includes hunger signs and environmental problems.

Sorghum and Millet Diseases

"Sorghum and Pearl Millet Disease Identification Handbook", Information Bulletin No. 2, ICRISAT, P.O. Patancheru 502 324, Andhra Pradesh, INDIA or Texas Agricultural Experimental Station, Texas A & M, College Station, Texas 77843. Pocket guide, illustrated, but does not give control measures.

"Sorghum Diseases", Bul. 1085, Texas Agricultural Extension Service, Texas A & M University, College Station, Texas 77843. Pictorial guide that also discuss controls.

Rice Diseases, Insects

"Field Problems of Tropical Rice", IRRI, 1970, available from Unipub, 345 Park Avenue South, New York, New York 10010, $5.00. Pocket pictorial guide that also covers hunger signs.

Peanuts Disease

"Peanut Disease Guide", #AG224, North Carolina Agricultural Extension Service, 1980, 23 pp. Great pictures but does not discuss controls.

Bean Diseases, Insects

"Field Problems of Beans in Latin America", 1978, CIAT, Apdo. Aereo 6713, California, Columbia, $5.60 plus air postage ($3.00 for U.S., $2.50 for Latin America, $6.00 for Asia and Africa). Available in English and Spanish; includes diseases, insects, and hunger signs; 136 pp., pictures.

Bean Production Problems: Disease, Insect, Soil, and Climatic Constraints of Phaseolus Vulgaris, ed. by H. Schwarz and G. Galvez, 1980, CIAT (see address above), $15.00 plus air postage; 424 pp.

Soybean-Diseases

"Soybean Diseases Atlas", Cooperative Extension Service, Clemson University, Clemson, South Carolina 29631.

Potato Diseases

"The Potato: Major Diseases and Nematodes", *1 International Potato Center, Apartado 5959, Lima, Peru or Box 25171, Nairobi, Kenya or Box 1237, Islamabad, Pakistan or c/o PCARR, Los Banos, Laguna, Philippines; one copy free, others $3.00 each. Pocket pictorial guide; does not give control measures.

Compendium of Potato Diseases, 1981, American Phytopathological Society, 3340 Pilot Knob Road, St. Paul, Minnesota 55121, $11.00, 142 pp, 192 illustrations. The best available; also gives control measures.

SOIL MANAGEMENT, FERTILIZER USE

Southern Gardener's Soil Handbook, W. Peavy, Pacesetter Press, Box 2608, Houston, Texas 77001, $4.95, 81 pp. Down to earth tech and hands-on coverage of improving clayey soils, composting, organic and chemical fertilizers, mulching, and watering by an extension horticulturist.

The Nature and Properties of Soils, Nort Brady, 8th ed., 1974, MacMillan Publishing Company, 866 3rd Avenue, New York, New York 10022. A dry but excellent text covering the tech side of plant nutrition, fertilizer use, soil classification, liming, and soil salinity.

Hunger Signs in Crops, H. Sprague, David McKay Company, New York, N.Y. 455 pp., 193 illustrations. Covers field crops, vegetables, citrus, tobacco, pasture legumes and grasses, grapes, deciduous tree fruits.

*1. Available in English, French or Spanish.

IRRIGATION

Irrigation Principles and Practices, 1969, PC/ICE Reprint R5, 112 pp. Useful reference on water measurement, irrigation planning, crop water needs.

"Irrigation: When? How much? Why", Bul. A-20, Cooperative Extension Service, University of Arizona, Tucson, Arizona 85721. Very helpful guide on furrow irrigation.

FIELD CROP PRODUCTION

Traditional Field Crops, 1981, PC/ICE. Covers maize, sorghum, millet, beans, peanuts, and cowpea production under small farmer conditions. Detailed information on characteristics, adaptation, cropping systems, land preparation, planting, pest control, fertilizer use, liming, harvesting, drying, and storage.

Small Farm Grain Storage, PC/ICE, 1976, 500 pp. Must reading for anyone contemplating work in grain storage. This well written and detailed manual covers principles and practices of drying, storage, and rodent-insect control. Includes designs for grain dryers, cribs, silos, and bins.

Manual on Improved Farm and Village Level Grain Storage Methods, D. Dichter (co-author of the manual above), German Agency for Technical Cooperation (GTZ), Dag-Hammarskjold-Weg 1, D-6236 Eschborn 1, Federal Republic of Germany, 243 pp. Less complete than the Small Farm Grain Storage manual but considerably less bulky. Contains some design improvements for the mud brick silo.

Crop Production Handbook, PC/ICE Reprint R6, 1969, 147 pp. Too academic an overview to be of much use.

Guide for Field Crops in the Tropicals and Sub-tropics, PC/ICE Reprint R10, 1976, 321 pp. An AID publication covering cereals, legumes, oil crops, bananas, fiber crops, and tuber crops. Not very field-oriented.

Principles of Field Crop Production. Martin & Leonard, MacMillan Publishing Company, New York, 1976 1100 pp. Good general reference but oriented to temperate zone production.

aize Production

Modern Corn Production, Aldrich & Leng, 2nd, ed., 1978, Thompson Publications, Box 9335, Fresno, California 93791, 360 pp., $21.75. The best in-depth yet practical guide to maize growing available. Well illustrated and geared toward the field.

On Farm Maize Drying and Storage in the Humid Tropics, FAO Agricultural Services Bulletin No. 40, 1979, 60 pp. Available from Unipub, 345 Park Avenue, South, New York, N.Y. 10010, $7.50. Results of work at the African Rural Storage Center Project in West Africa.

Millet Production

Pearl Millet, Rachie & Majmudar, Penn State University Park and London, 1980, 307 pp.

Rice Production

Training Manual for Rice Production, 1976, IRRI, 140 pp., Unipub, 345 Park Avenue South, New York, New York 10010, $12.00 plus $1.00 postage. Step-by-step lesson plans on flooded rice production growing practices.

A Farmer's Primer on Growing Rice, IRRI, 1979, 221 pp., Unipub, (see address above), $14.50 plus postage. Covers basic growing practices for flooded rice.

Peanut Production

"Growing Peanuts in Georgia," Bulletin 640, 1979, Cooperative Extension Service, University of Georgia, College of Agriculture, Athens, Georgia 30602. Geared to mechanized production but contains much useful information on peanut characteristics, adaptation, crop rotations, pests and diseases, growing practices. 47 pp.

Soybean Production

Modern Soybean Production, Scott & Aldrich, Thompson Publications, Box 9335, Fresno, California 93791, 192 pp., $18.50. The best overall reference on soybean production. Well illustrated.

ROOT AND TUBER CROPS

"Tropical Horticulture for Secondary Schools - Teacher's Manual", Book 2, Edward Soucie, PATS Educational Foundation of Micronesia, P.O. Box 39, Ponape, Caroline Islands 96941. An excellent practical manual covering tropical yams, taro, sweetpotato, cassava, as well as banana, breadfruit, and coconut. Contains a useful bibliography.

"Growing and Marketing Quality Sweetpotatoes", North Carolina Agricultural Extension Service, Circular 563, 1976.

IITA (International Institute of Tropical Agriculture) has an extensive ressearch program in tropical yam (Dioscorea spp.) production. CIAT (International Center for Tropical Agriculture) does work with cassava (Manioc). Both institutes have useful publications available on these crops which can be obtained by requesting a catalog from the addresses below:

IITA, PMB 5320, Ibadan, Nigeria, West Africa

CIAT, Apartado Aereo 6713, Cali, Columbia, South America

TROPICAL AGRICULTURE - General

An Introduction to the Botany of Tropical Crops, Cobley and Steele, 3rd edition, 1977, Longman, London and New York.

AGRICULTURAL EXTENSION

"Agricultural Extension: The Training and Visit System", D. Benor and J. Harrison, 1977, 55 pp., World Bank, 1818 H Street, N.W. Washington, D.C. 20433. Explains the operation and advantages of using a systematic program of continual in-service training for village extension workers, combined with fixed schedule visits by them to the fields of "contact" farmers who play an important role in extending new practices to others. Many of the suggestions are suited to PC agricultural programs.

Agricultural extension manual to be published by PC/ICE in 1982.

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