NATIONAL JUNIOR HORTICULTURAL ASSOCIATION

STUDY MANUAL

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PLANT NOMENCLATURE

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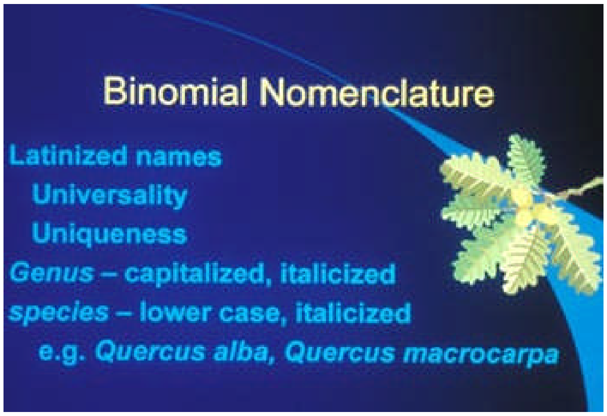

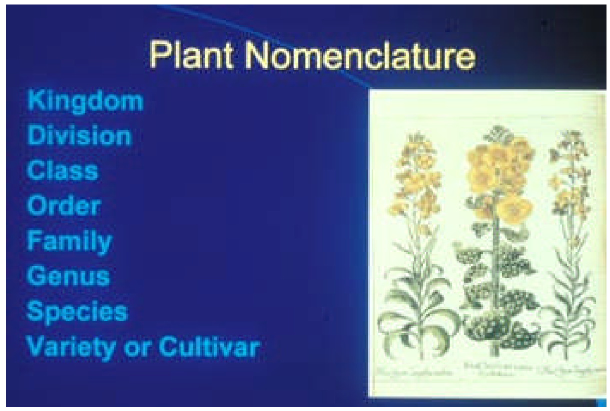

Botanical nomenclature is a relatively young science when compared to other sciences. It arose out of the need for a universal system of naming plants and other organisms. To the laymen Latinized names may seem trivial or burdensome. But, with over 200,000 types of plants described, the potential for confusion becomes immediately evident. Some very different plants share the same common name. Other plants have many different common names for the same type plant. Common names like pineapple do not indicate a true relationship. Pineapples are not related to either pines or apples.

Since the beginning of spoken language, people have attached names to things important to them. A name is nothing more than a handle by which we pass along a mental image. Plants were important to early peoples for food, fiber, lumber and other products. As long as the number of objects in ones surroundings are relatively limited, there is little trouble in mastering knowledge of them. As one's range of vision increases, the need to group items becomes necessary. Names for plants changed between people of different geographical areas and languages. Being able to accurately communicate plant names between different cultures became more important as commerce increased.

Plato (427-347 B.C.) and his student Aristotle (384-322 B.C.) developed the first known procedure for systematically naming plants and animals. Their system and others were based on visual characteristics such as leaf shape and plant form. Other systems developed for naming plants relied on long, detailed descriptions. These descriptive names, generally in Latin were too long for practical use. Early botanists contributed to the base level of knowledge but failed to develop a system for naming plants that worked well. Nevertheless, these systems remained functional until the late 1600s when European explorers began to discover large numbers of new organisms that defied classification with European specimens.

The study and classification of plants remained in a confused state until **Carl von Linné** (1707-1778). It was the custom at that time for all scholars to write in Latin. Linné was so intrigued by

Latinized names that he modified his own name to reflect this trait. This is why he is now best known by his Latinized name, **Carolus Linnaeus**.

Linnaeus was born in southern Sweden and educated as a medical doctor. Pharmacies were unheard of in those days so physicians had to become adept at recognizing and preserving plants with medicinal value. Linnaeus became more interested in the botanical side of medicine and specifically in the distribution of plants.

The system that Linnaeus developed used **floral characteristics to put plants into groups**. While the system has been modified greatly, it is the basis of the **binomial** (two name) system used for naming all living organisms. The study of identification, nomenclature (naming) and classification of objects is called **taxonomy**. When it deals with plants it is often called **systematic botany** and is considered to be the mother of all biological sciences.

The classification and naming of plants now operates under a system of rules called the International Code of Botanical Nomenclature. The largest unit, called the kingdom, is divided and subdivided into successively smaller units.

These units and some examples are as follows:

Unit	**Example**
Kingdom	Plant
Division	Tracheophyta (vascular plants)
Subdivision	Pteropsida (ferns & seed bearing plants)
Class	Angiosperms (flowering plants)
Subclass	Dicotyledoneae
Order	Rosales
Family	Rosaceae
Genus	Rosa
Species	rugosa
Variety/cultivar	'Alba'
Form	---
Clone	---

The class called **Angiosperms** are plants that produce true flowers. Many plants used in the horticultural trade fall into this group. **Gymnosperms** produce seeds differently than Angiosperms and are represented by cycads, ginkgo and conifers.

The class called Angiosperm is divided into two groups or **subclasses: monocotyledons** (e.g. grass, corn, dracaena) and **dicotyledons** (e.g. beans, rose, oaks) based upon number of cotyledons in the seed (1 or 2). A subclass is divided into **orders**. Only rarely are references made to orders of plants, although it quite common among animals.

The next major division is called a **family**. It is at this point that we really begin to see distinct differences in plant habitat and appearance. Almost all family names end in **-aceae**.

When we talk about the binomial system of nomenclature it is the **genus** and **species** that we are referring to. It was Linnaeus who pioneered the use of these two scientific or Latinized names that distinguish a plant from all others.

Genus is the singular form of the word, **genera** is the plural form of genus (i.e. one genus, two genera). Species is both singular and plural (i.e. one species, two species). The word specie refers to coins. The genus is always capitalized and the species is always in lower case letters. Both of these words are either italicized or underlined (i.e. *Acer rubrum* or <u>Acer rubrum</u>). Italicization is preferred.

It was Linnaeus's idea for the genus to show relationship just as your last name does. The species identifies the individual like your first name does. Latin was chosen as the language of science because it is a dead language (no longer changes) rather than a language such as English that is still changing by adding words, phrases, meanings, etc. The genus is always singular, has gender (masculine, feminine, or neuter) and acts like a noun. The species generally reflects the gender of the genus and acts like an adjective to describe "which one." In Latin all nouns have gender. The gender of a noun does not reflect any attribute of a plant but is just a characteristic of the language.

Sometimes we find an individual plant in a species like *Acer rubrum* (red maple) that is unique. This individual might be more valuable because of a characteristic such as form, ultimate size, leaf color, flowering characteristics, or resistance to diseases and insects. Because of these unique characteristic(s) this plant deserves to be propagated so other people can enjoy it. To make this designation a unqiue plant is given it a unique name so it can be distinguished from other members of the species with different traits. The solution is to make it a named **cultivar**.

The word cultivar results from the combination of two words, **cultivated** and **variety**. Varieties are always naturally occurring while cultivars are propagated and grown by horticulturists and others who appreciate their unique traits. A cultivar name is always capitalized and enclosed in single quotation marks or preceded by the word cultivar or the abbreviation Cv. An example of a cultivar is 'October Glory' red maple that has better red fall color than a typical plant of the species. This name may be written in any of the following ways (in order of preference from greatest to least):

Acer rubrum 'October Glory'
Acer rubrum Cv. October Glory
Acer rubrum Cultivar October Glory

Cultivars are almost always propagated **asexually**. This means that they will all be **genetically identical**. Seedlings of a species always have some genetic variability. Cultivars grafted onto seedlings have much less variability in shape and form than a seedling. The only variability seen in cultivars grown from rooted cuttings is from environmental and cultural differences. This is very important when a uniform grouping of plants is desired. Landscape architects, landscape designers and horticulturists frequently specify a certain cultivar because of the unique traits that this plant offers. Making the decision to use cultivars in the landscape gives predictability. We know how big they will grow, what they will look like and what problems they may or may not have.

Plants that are genetically identical are called **clones**. Many plants such as spring bulbs naturally reproduce asexually forming clumps of plants that are all the same clone.

Forms are naturally occurring groups of plants that differ from other members of the same species. We often are not able to see these differences. Examples are winter hardiness, tolerance to different soils or other environmental adaptations. The flowering dogwood is a good example of a plant with different environmental adaptations. It grows naturally from central Florida to Michigan. They are all the same species but have become adapted to entirely different climates. A flowering dogwood that evolved in Florida would not survive a Michigan winter. Likewise, a plant from Michigan may not grow well in Florida.

PLANT NUTRITION

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In early agricultural societies, it was observed that crop yields could be increased by adding animal manures or plant debris to soil. We continue this practice today with regular additions of organic matter. We have also learned that this simple practice provides a steady source of nutrients for plants, improves soil structure and tilth or looseness. Chemical sources through fertilizers have also been used to supply nutrients needed for plant growth and development.

Elements Required By Plants

Research has shown that 17 elements are necessary for most plants to grow and develop properly. Nine elements are used in relatively large quantities and they are referred to as major elements or **macronutrients**. The nine major elements are:

Carbon (C)
Hydrogen (H)
Oxygen (O)
Nitrogen (N)
Phosphorus (P)
Potassium (K)
Calcium (C)
Magnesium (Mg)
Sulfur (S)

The eight remaining elements are used by plants in small quantities and are called **trace elements**, **minor elements**, or **micronutrients**. Even though these minor elements are needed in small quantities, they are equally essential to plant growth and development. The micronutrients are:

Boron (B)
Zinc (Zn)
Manganese (Mn)
Copper (Cu)
Molybdenum (Mo)
Chlorine (Cl)
Iron (Fe)
Cobalt (Co)

Carbon, hydrogen and oxygen are the three elements used in the largest amounts and are the building blocks for plant growth, forming carbohydrates (sugars and starches) and oxygen forming carbon dioxide and water. Carbon, hydrogen and oxygen are obtained mainly from the air and water. Nitrogen, phosphorus and potassium are considered the **primary macronutrients**. Calcium, magnesium and sulfur are classified as **secondary macronutrients**.

Nitrogen gives plants their dark green color and increases leaf and stem growth. The crispness and quality of leafy vegetables such as lettuce and spinach is influenced by nitrogen levels. Plants deficient in nitrogen have light green to yellow leaves and appear stunted.

Phosphorus encourages root growth and establishment. Phosphorus is also crucial for plant flowering and fruiting, especially seed production. Most of the internal plant chemical reactions are dependent on phosphorus. Poor flowering and fruiting may be signs of the lack of phosphorus. Some plants, including corn and tomatoes, may exhibit red or purple leaves. Cold soils can prevent phosphorus uptake, even though the element is present.

Potassium or potash increases the plant's vigor, winter hardiness and resistance to diseases. Stems and stalks are stiffer. Plant seed or fruit yield is improved. Reduced vigor, susceptibility to diseases and thin skinned or small fruit may be signs of potassium deficiency.

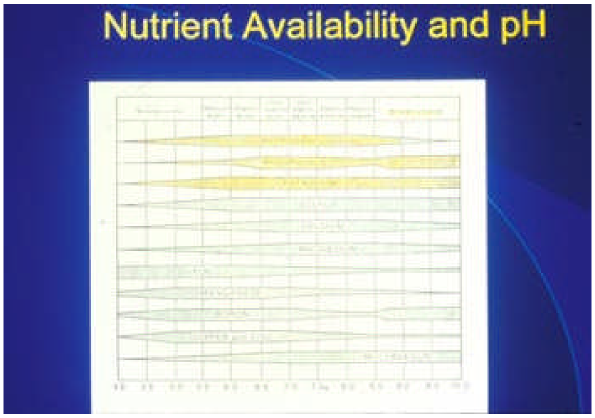
Any material, organic or chemical, that provides any one or more of the 17 essential elements could be called a fertilizer. The definition of a fertilizer is a legal one. Even though a substance like compost provides most of the essential nutrients a plant needs, it cannot legally be sold as a fertilizer in most parts of this country. It is however the only source of nutrients in some third world countries.

While organic fertilizers usually release their nutrients more slowly than chemical sources, once the elements are released they are available for uptake by the roots. Nutrients are not absorbed directly into the roots, but absorbed in a water solution. Therefore, there is no preference of organic fertilizers over chemical fertilizers on the basis of ability of plants to use released elements. However, inorganic sources usually provide a faster plant growth response.

Fertilizers can be purchased as **slow-release** or **conventional**. Slow-release fertilizers require fewer applications and have less of a chance to burn the plant. Release rates can vary depending on the particular type. However, slow-release fertilizers usually cost more and are harder to find. The nutrient release rate is usually dependent on environmental conditions and not on plant need.

Burning occurs to plant roots and other plant parts that may come in contact with conventional fertilizers. Fertilizer elements are often in the form of salts. Like sugar and table salt, these materials are **hygroscopic**. This means that they will absorb moisture. This is why a salt shaker will clump up on a rainy day. If the level of salts, regardless of whether it is deicing salt or fertilizer salts, becomes too high in the soil, water is unable to enter the root. If the amount of salts in the soil continues to increase water is pulled out of the plant into the soil. Even though the soil feels moist, water is unable to enter the plant.

Conventional fertilizers are fast acting and relatively inexpensive. The nitrogen leaches more readily. The fertilizer can form clumps in the bag, making application tougher.



Organic sources of fertilizer such as manure, cottonseed or soybean meal, dried blood or bone meal, are slower acting and have a relatively low plant burn potential. These sources usually have some micronutrients available. Organic sources (manures and compost) can condition the soil as they break down further. On the other hand, many organic sources are bulky, expensive and can have an unpleasant odor.

When we discuss the need to apply elements, generally we refer to major elements because they are used in greater quantity and may need to be replaced more frequently. Nitrogen, phosphorus and potassium, for example, are applied to lawns and gardens one or more times each season. When sources for nitrogen, phosphorus and potassium are packaged together to be applied in a single application, the fertilizer is called a **complete fertilizer**. An **incomplete fertilizer** lacks one or two of the primary micronutrients. Examples include ammonium nitrate (33-0-0), urea (46-0-0), triple superphosphate (0-45-0) or muriate of potash (0-0-60).

In most areas of the U.S., minor elements are present in native soils in quantities sufficient for most plants. Applications of trace elements is usually not necessary.

SOIL pH

Soil pH refers to the acidity or alkalinity of a soil. **pH is the logarithm of the negative hydrogen ion concentration**. A 14-point scale is used to measure pH. 1.0 is as acid as something can get, 7.0 is neutral. Anything below 7 is classified as **acidic** and anything above 7 is **basic** or **alkaline**. Sometimes people will refer to acid soils as "sour" and basic soils as "sweet."

Most plants grow best in a slightly acid soil. At pH 6.5, the 17 essential elements can be taken up by plants if they are present in the soil. If the pH rises (becomes more basic) or lowers (becomes more acid), some elements become less available for plant uptake. Other elements become so readily available that they become toxic to plants. Therefore, it is possible for plant nutrients to be present in the soil, but unavailable for plant use because of an improper soil pH. Low pH soils are neutralized or brought up to 6.5 range by adding **limestone** (calcium carbonate) to the soil. Some limestone, such as **dolomitic limestone**, also contains magnesium (Mg). For all horticultural uses, agricultural ground limestone or ground dolomitic limestone is recommended.

High pH soils can be neutralized by adding an acid forming material such as finely ground **sulfur** (S), peat moss, or by using an acid forming fertilizer to the soil. When correcting soil pH, it is important to remember that pH is measured on a logarithmic scale. On a logarithmic scale everything moves in multiples of 10. For example, if it takes a pound of sulfur to lower the pH of a "pile" of soil from 7.0 to 6.0, then, in theory it will take 11 pounds to lower it from 7.0 to 5.0 (1 pound to get it to 6.0 plus 10 pounds to get it from 6.0 to 5.0). If we lower the pH from 7.0 to 4.0 it theoretically will take 111 pounds (1 pound plus 10 pounds plus 100 pounds). In reality, it is

difficult or impossible to correct soil pH more than one unit (i.e. 7.0 to 6.0). Many soils are well buffered making them more difficult to adjust than other soils.

It is not possible to look at a soil and determine the pH. Soil test kits are available to get at least an approximate pH reading. For a reliable test, soils should be sent to a commercial or university testing laboratory. Not only will the laboratory give you the pH of the soil, the report will probably also include information on the amounts of other elements in the soil and how much fertilizer, limestone, etc. should be applied to the soil.

It is certainly worthwhile to invest the time and small amount of money to have a soil test made at least every three years. Basic soil testing usually gives pH, phosphorus and potassium levels. Nitrogen readings are seldom accurate due to the potential for leaching during testing.

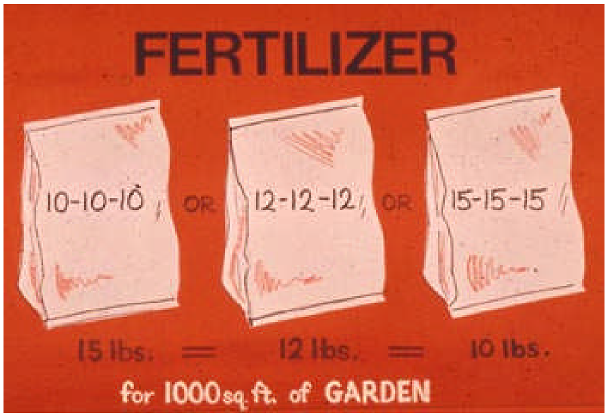
In recent years, leaf analysis, petiole analysis and tissue analysis has been used to detect nutrient deficiencies. These tests are particularly helpful in detecting micronutrient deficiencies. The tissue should be collected in midseason and representative leaves and/or petioles should be taken from the midshoot region. The laboratory doing the tests will provide specific sampling procedures. This test is commonly used on fruit crops since a nutrient imbalance can prevent maximum flowering and/or fruit development.

Nutrient Holding Capacity of Soils

Soil particles, even sand, can attract small quantities of elements and hold them by surface attraction; however, elements or nutrients are held tighter and in much larger quantities by clay particles and **humus**. Humus is well broken down organic matter. Soils with moderate to large quantities of clay and soils rich in organic matter have higher nutrient holding capacities.

Benefits of Organic Matter

Organic matter provides some nutrients for plants as it decomposes, increasing the **nutrient holding capacity** of the soil significantly. After it completely decomposes, it "glues" soil particles together. This **aggregation of particles** results in a soil with improved **soil structure**, one that is loose, crumbly and not compacted. A soil with good structure allows water and air to move more freely through the root zone resulting in improved root and plant growth.



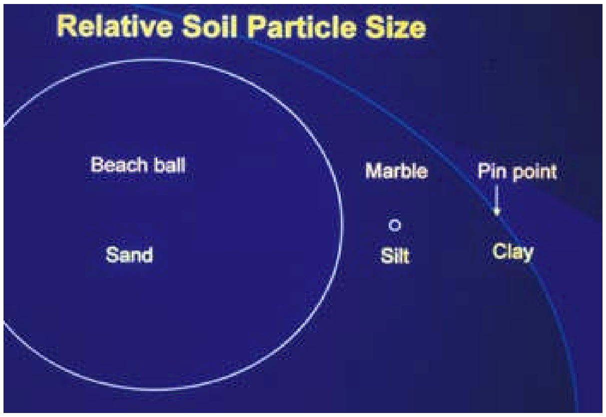
What Is in the Fertilizer Bag?

You have seen many different brands and kinds of fertilizers at garden centers, nurseries and other retail stores. By law they all have three numbers boldly listed on the front of the fertilizer bag (e.g. 10-6-4, 5-10-5, 38-0-0). These numbers represent the percentage by weight of nitrogen, phosphorus (as P2O5) and potassium (as K2O) in a bag. The order (N, P and K) is always the same. So with a 50 pound bag of 10-6-4, we know that 5 pounds (10% of 50 pounds) is N, 3 pounds is P2O5 and 2 pounds is K2O. So there is a total of 10 pounds of plant nutrients in this 50 pound bag (5 lbs N + 3 lbs P2O5 + 2 lbs K2O). The remaining 40 pounds is filler such as ground corn cobs, sawdust, talc, vermiculite, or clay which makes it easier for you to apply the product evenly over your lawn or garden.

In most instances, fertilizer applications are made on the basis of the nitrogen required. Frequently, it is one pound of actual nitrogen per 1000 sq feet (square feet) or 43 pounds of N per acre. (There are 43,560 sq feet in an acre) How much of the following fertilizers are required to place one pound of nitrogen on a garden that is 1000 sq feet?

- 10-6-4 (10%N)
  to calculate divide 1 pound nitrogen by the percent nitrogen in the fertilizer: 1/.10 = 10 lbs of 10-6-4 per 1000 sq feet
- 5-10-5 (5% N)
  1/.05 = 20 lbs of 5-10-5 per 1000 sq feet
- 20-10-10 (20% N)
  1/.20 = 5 lbs of 20-10-10 per 1000 sq feet

Application rates of fertilizers are important. Excessive amounts may damage plants by burning roots or foliage or may prevent another element from being absorbed from the soil. Insufficient amounts may lower the potential crop yield or cause the plant not to grow or develop and complete its life cycle properly. It is especially important to be careful when applying micronutrients since they are applied in relatively small quantities. How would you apply one teaspoon per 1000 sq feet? Perhaps you could mix the nutrient thoroughly in a bucket of soil or sand and then apply the material evenly over the 1000 sq feet. In this case, the bucket of soil becomes the filler to allow for easier, more accurate application.

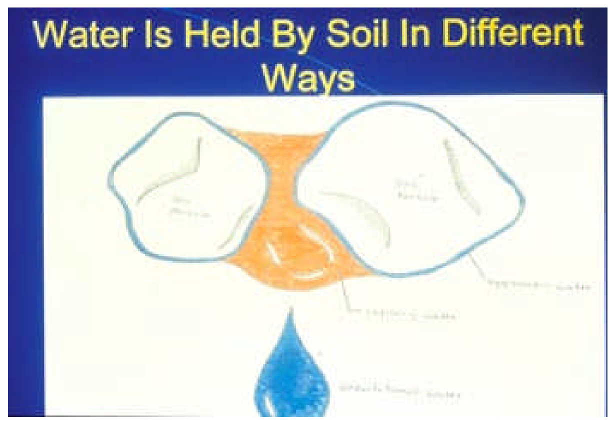


Soil Particle Size Comparison

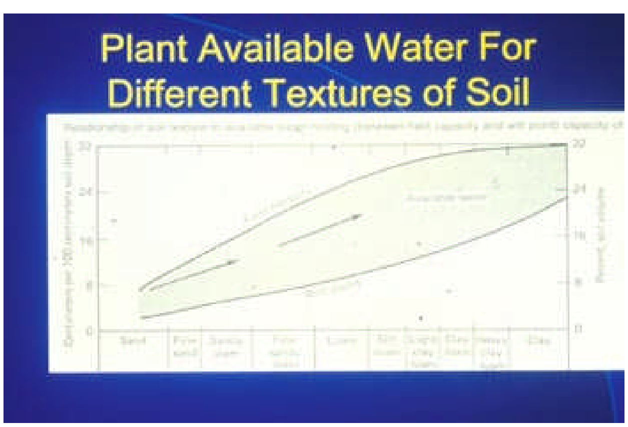
Soil is a natural body composed of organic and mineral materials. Every soil is made up of mineral matter, organic materials, air and water. The mineral portion is made up of various particle sizes called **sand**, **silt** and **clay** . Sand and silt particles are the result of breakdown of larger rocks, a process known as weathering. During this **weathering** process, the elements which make up the larger materials are released and made available for plant uptake. Clay particles have been synthesized or put together by physical and chemical processes over a long period of time. These clay particles are in plate-like layers and have internal spaces between the layers that allows the clay particles to hold more nutrients.

Heavy clay soil structures can be modified by the addition of organic matter that increases the soil tilth or looseness. Gypsum is sometimes used to break apart the clay structure; however, soil chemistry is usually altered negatively. Organic matter such as compost, leaf mold, or peat moss added to sandy soils helps retain water.

Approximately 50% of a soil is made up of solids (45% mineral and 5% organic matter) and the other 50 percent is pore space. The pore space is made up of the spaces between particles. If the soil particles are aggregated or glued together with broken down organic matter, about 50% of the soil volume will be **pore space**. On the average, half of the space should be occupied by water and half by air. In order to achieve this balance between air and water, the water level will fluctuate from a saturated level to a fairly dry level.



When all of the pore space is filled with water, the soil is saturated and a poor environment for plant growth results because of insufficient air in the root zone. Roots rot, nutrients are not absorbed due to a lack of oxygen and loss of nitrogen into the air can occur. After several hours, gravity will carry excess water down through the soil; this water is referred to as **gravitational water**. Plant nutrients such as nitrogen are water soluble and carried away or **leached** with this gravitational water. Gravitational water also carries away excess fertilizers that may damage plants. This flushing is one way to minimize winter salt damage to plants. Not all elements are carried off easily with gravitational water. Calcium and phosphorus, for example, are quite immobile in the soil.



The amount of water remaining in the pore space after the force of gravity has drawn off the excess is called **field capacity**. At this point, considerably more than 25 percent of the pore space is occupied by water. As water is used by plants and evaporates from the soil surface, the pore space has less and less water until it gets so dry that plants cannot absorb any more water from it. At this point, most of the pore space is occupied by air. At this point moisture in the soil is referred to as being at the **wilting point**.

Between field capacity and the wilting point, the water available for plant use is referred to as available or capillary water. Research shows that moisture within this available range is equally available to plants, so there is no advantage to keeping the water level in the soil high. In fact this would be detrimental to plants since too little air would be in the pore space.

On many hot summer afternoons, plants wilt. However, this condition is not usually related to low soil moisture (wilting point) but rather to a situation where the plant is using (losing) water more rapidly than the roots can absorb it and transport it to the leaves.

If soils dry below the wilting point, a level is reached called hygroscopic water. **Hygroscopic water** is not available to plants and is held so tightly by soil particles (especially clay) that it can only be removed by heating.

VEGETABLES

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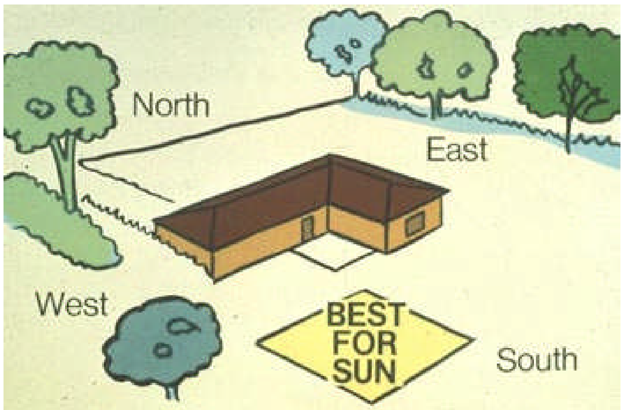


According to a survey conducted by the Gallup Organization in 1996-1997, about 26 percent of U.S. households have a vegetable garden. Vegetables are grown to provide nutritious food and for many, vegetable gardening is a relaxing, therapeutic hobby.

Technically, **vegetables are foods we obtain from the leaves, stems, roots, or tubers while fruits are the product of a ripened ovary**. This strict botanical definition of a fruit makes tomatoes, peppers, okra, and even pumpkins fruits. A better definition of a vegetable is a part of a plant eaten cooked or raw, usually with the main part of the meal. Fruits are generally consumed as dessert. Even this definition has some gray areas, however, as a few vegetables, such as rhubarb and pumpkins, are used as fruits in dishes such as rhubarb crisp and pumpkin pie.

Fresh vegetables are an important part of our diets. They provide vitamins, minerals and complex carbohydrates for energy. Members of the onion and cabbage families contain important anti-cancer compounds that are being researched. Vegetables provide bulk (fiber) to our diets; yet tend to be lower in calories than other food groups since they are low in fat. Many people, especially children are inspired to eat more fresh vegetables when they grow their own.

Site Selection

A successful garden takes more than just buying a few seeds and transplants at the local garden store. First, a site must be chosen for the garden. Properties with small yards may be limited to where a garden can be located. If there is no space for a separate vegetable garden, plant vegetables among ornamental plants since many are attractive plants. Some people call this edible landscaping. When selecting a site consider the amount of sunlight that reaches it, the type of soil, availability of water, wind protection and slope. The soil should be fertile, deep, loose and well drained. Avoid heavy shade, heavy clay or excessively sandy soils, soils with hardpans, or hard shale layers that make growing a garden difficult. Most soils benefit from the addition of organic matter such as sphagnum peat moss, compost, composted manure, leaves, and grass clippings.

Plants need light to grow and make food through photosynthesis. Select a site that gets at least six hours of sunlight each day. If the site is shaded, it is better for plants to receive morning sun so the foliage dries quickly, reducing the chance of disease. Try to set your vegetable garden beyond the drip line of trees and shrubs. Generally, leafy vegetables and root crops grow better in partial shade than those that produce fruit.

Soil

A well-drained, fertile soil is best for growing vegetables. Plant roots absorb water and nutrients from the soil and anchor and support the plant. Plant roots also need oxygen in the soil. When a soil becomes waterlogged all of the oxygen in the soil has been replaced by water and plants will not grow well.

This can be a major problem with heavy clay soils. In contrast, sandy soils drain quickly and do not hold water well. Organic matter helps improve both sandy and clay soils. Soil organic matter consists of plant, insect and animal remains. These materials continuously decay, improving soil structure and adding nutrients to the soil.

Organic matter incorporated into a sandy soil helps hold moisture and nutrients. In clay soils, organic matter aids drainage by breaking apart clay particles so air and water can move through the soil. Adding organic matter to any soil makes it easier to work the soil.

Although good drainage is important, access to water is important as well. Most locations need a source of water to irrigate the plants. When selecting a garden site, make sure it is close enough to an outside faucet to make irrigating easy. Vegetables need consistent water throughout the growing season. One to 1-1/2 inches of water per week is a general recommendation, unless rain is received. However, the amount of water required in your garden depends on the temperature, soil type, crops grown and whether mulches are used to reduce evaporation.

Unless the soil is very sandy and drains fast, it is better to apply water in larger quantities at less frequent intervals as plant roots will grow deeper into the soil as they seek water. Light frequent sprinkling tends to form cause roots to grow shallowly near the soil surface if the watering is not deep, and plants may become stressed during periods of drought. Shallow watering also allows soil salts to build up where soil salts are present, particularly the western US, and most vegetables do not grow well when soil salts are prevalent.

In some areas of the country, hot, dry winds blow all summer. The wind can stress plants, tear, and damage them. Summer winds usually come from the west or southwest. A hedgerow, fence or building on the west side of the garden will help break the wind. Choose a site where the windbreak does not shade the garden until late afternoon as vegetables need sunshine for growth. A temporary windbreak such as a strip of rye or wheat, or borders of tall sunflowers can be planted to reduce/divert winds blowing across gardens.

A level or gently sloping site is easiest to garden. If a hillside is used for planting, make sure rows across the hill, not up and down. If rows run up and down the hill, rain and irrigation water may cause soil erosion.

Do not make the seeded totally smooth and fine. Very fine textured soils (as well as those high in salt content) tend to form a crust at the soil surface after watering, that makes it difficult for seedlings, especially those of dicot plants, to emerge. To prevent crusting, apply a very light layer (1/2 inch) of grass clippings or other mulch material after planting. Planting fast germinating seeds, such as radishes, with slower germinating seeds to help break up any crust that might form.

Tools

For a small garden, a basic set of well built tools should last many years. You will need a spade (shovel) or spading fork for turning over the soil. A rototiller or plow is useful for large gardens. Use a hoe to break up the soil after it is turned and to hoe weeds. A garden rake is handy for smoothing the seed bed and for very shallow cultivation. A trowel or a hand cultivator will help you transplant small plants. Finally, a yardstick or measuring tape, stakes, string and labels help you make straight and properly spaced rows, ensuring that individual plants have room to grow.

Planning the Garden

Make a garden plan before ordering seeds or planting. The size of the garden and amounts of specific vegetables depends on many factors, including the amount of space available, the number of people in your family, the kind of vegetables they want to eat and previous gardening experience. If the plans for the produce include canning, freezing, or drying vegetables, look for cultivars which preserve well.

Variety and cultivar are two words gardeners often hear. A variety is a subdivision within a species. They are a group of individuals within a species that are distinct in form or function from other similar arrays of individuals. For example, there are three different kinds of peas - English peas, field peas and sugar peas. Each is a different variety and is used for a different purpose.

A second kind of variety is the cultivated variety or cultivar. These varieties are developed for a specific plant type or use. The names on pea seed packages, such as `Little Marvel,' `Snow Bird,' or `Sugar Snap' pea, are cultivar names. The names often are informative of the cultivar such as its suitability for freezing, or whether it grows up a pole or is a bush. There are hundreds of cultivars of many vegetables.

Many discount, garden and grocery stores sell flower and vegetable seeds each spring, but carry only a few cultivars of most plants. There are many mail order companies that carry a wide selection of seeds.

In choosing vegetable cultivars for the home garden, consider:

- **Disease resistance** - Plants tolerant or resistant to common diseases will require fewer fungicide applications.
- **Plant type** - Determinate (bush) or indeterminate (vining). Bush type plants take less space and still yield well.
- **Shape, color, flavor**
- **Use** - Fresh, frozen, canned or dried. Some cultivars preserve better than others.
- **Those recommended for your area**. Ask at the local Cooperative Extension office for a current list of suggested vegetable cultivars for your state. Friends and neighbors might offer their experiences and suggestions as well.

Buy or order seed well in advance of the planting date. Some people like to save seed from year to year. Depending on the crop this can be good or bad. Do not save seed from hybrid plants, they do not produce true-to-type plants. Some crops, such as cucurbits (cucumbers, winter and summer squash and melons), are highly cross pollinated. Seed from these plants should not be saved unless the flowers have been hand pollinated. Members of the bean family, tomatoes and peppers are often self-pollinated. Cultivars that are not hybrids can often be saved successfully.

Once a decision had been made on what to plant, one must determine when to plant. This depends on whether the vegetables are cool season or warm season crops. Cool season crops need to grow and mature before temperatures get too hot. The first vegetables to be planted in a garden will be hardy cool season crops that can be planted early in the spring as soon as the ground can be worked. Broccoli, cabbage and radishes are a few of the vegetables that can withstand freezing temperatures, hence the name hardy.

The second group to be planted include the less hardy or half hardy cool season crop such as carrots, spinach and beets. Plant these two to four weeks before the final spring frost is expected. The plants in this group do best if planted after the soil has begun to warm, but they can tolerate some freezing without injury.

Warm season crops are planted last and include tender and very tender plants. Tender plants, such as sweet corn and snap beans, should not be planted until after the last spring frost. These plants grow best during warm weather and are easily injured by frost. Even if you plant them early and they escape frost injury, they do not grow well until the soil warms in the spring. Wait least one week after the last expected frost to plant very tender crops. These plants (such as peppers, pumpkins, melons, and okra) love the heat and need hot weather to grow well.

Many people like to plant tender vegetables earlier than recommended. These plants must be protected from frost. Milk jugs and cartons can be used to protect the plants. Remove the cap, cut the bottom off and set the plastic milk jug over the young plant. There are other products, such as Wall O' Water® and floating fabric row covers, which can be used to gain time at the beginning or end of the gardening season.

Rotate your crops. If there was a garden previously on your site, try to determine what vegetables were planted where. Plant diseases and insects often stay in the soil and can infect future crops. Often plants in the same family are susceptible to the same diseases. Some major plant families include:

- Solanaceae (Nightshade family) - tomato, potato, pepper, eggplant
- Leguminosae (Pea family) - snap bean, pea, peanut, dry bean
- Cucurbitaceae (Squash family) - summer squash, winter squash, cucumbers, melons, pumpkins, gourds, chayote
- Cruciferae (Mustard family) - broccoli, cabbage, brussels sprouts, cauliflower, kale, Chinese cabbage

Planting Tips - Getting the Most Garden for the Space Available

Even if the garden space available is very small, there are several planting methods you can use to squeeze more plants into the garden. Planting in single rows is the most common method of planting. Mark the rows by stretching a string or piece of twine between two stakes. Straight rows make the garden neat, permit better spacing of plants, and make it easier to maintain. Use a hoe handle to make shallow trenches for small seeds or use the blade of the hoe for larger seeds. Plant seeds evenly spaced in the row and cover two to four times their diameter. While single row planting is the most common planting method, it does not use space efficiently.

Wide Row Planting

This method uses space more efficiently than single row planting. Seeds are broadcast in rows 10 or more inches wide, separated by normal pathways. To use this method, prepare a smooth seeded and mark off rows using a garden rake. A garden rake works well because it is usually 10-12 inches wide. The seeds are then thinly broadcast seeded in the row so the seeds have 1 to 2-inches of space between each. Cover the seed or lightly rake it into the soil. When seedlings emerge, thin them so they are the recommended distance apart. Wide rows allow more intensive cropping. Plants growing close together shade the ground, restricting the growth of weeds and conserving moisture. Crops easily grown in wide rows are beets, carrots, chard, dill, lettuce, onions, peas, spinach and turnips.

Companion Planting

Some crops can be planted together in the same row to save space or mark the rows. Radishes, for example, can be planted thinly in rows of carrots, lettuce and beets. The radishes germinate quickly to mark the rows before other vegetables come up. They grow fast and are ready to harvest before the other vegetables need the space.

Companion planting is also the term for planting different plants close together to benefit each other. Some people believe certain plants repel insects and help other plants to grow better. In many cases scientific research has shown that companion planting does not work well and may reduce yields due to crowding and other problems. However, there are some experimental findings where specific combinations of plants have shown positive results.

Interplanting

Slow starting or late maturing plants can be planted between or within rows of early spring vegetables. For example, lettuce, spinach, radishes and peas can all be interplanted with tomatoes, peppers, summer squash and corn. By the time hot weather arrives, the early crops are ready to harvest and remove, leaving plenty of room for the long season plants.

Stagger Planting

Most gardens are capable of producing vegetables for a long period of time. Some planting practices result in the gardener being swamped with lettuce and radishes for a few days and then not have any. To provide a long term steady production of several types of vegetables, consider staggering the plantings. By planting very short rows of early spring vegetables, you can spread the harvest over several weeks. Simply plant a few seeds every 7-10 days for a continuous harvest.

Succession Planting

As early season vegetables are harvested the space can be used to grow another crop of vegetables. When short season crops finish bearing, remove them and put a new planting in their place. For example, green beans can follow lettuce, or summer squash can follow spinach.

Minimum Soil Temperatures for Vegetale Seed Germination

32°F Cool Season	40°F Half Hardy	50°F Warm Season	60°F Warm Season
Endive	Beet	Asparagus	Beans
Lettuce	Broccoli	Sweet Corn	Cucumber
Onion	Cabbage	Tomato	Eggplant
Parsnip	Carrot		Melons
Spinach	Cauliflower		Okra
	Celery		Pepper
	Parsley		Pumpkins
	Pea		Squash
	Radish		
	Swiss Chard		
	Turnip		
	Seed Potato		

Optimum Soil Temperatures and Days for Germination at Optimal Teperatures

70°F	75°F	80°F	85°F	95°F
Celery (10-14)	**Asparagus** (21)	**Bean, Lima** (7-10)	**Bean, Snap** (7)	**Cantaloupe** (4- 10)
Parsnip (14-21)	**Endive** (10-14)	**Carrot** (12-14)	**Beet** (7-14)	**Cucumber** (7- 10)
Spinach (7-14)	**Lettuce** (7-10)	**Cauliflower** (5-10)	**Broccoli** (5-10)	**Muskmelon** (4-10)
	Pea (7-14)	**Onion** (10-14)	**Cabbage** (5-10)	**Okra** (7-14)
		Parsley (11-28)	**Eggplant** (10)	**Pumpkin** (7- 10)
			Pepper (10)	**Squash** (7-14)
			Radish (5-7)	**Watermelon** (4-10)
			Sweet Corn (7-10)	
			Swiss Chard (7-14)	
			Tomato (7-14)	
			Turnip (7-14)	

Numbers in parentheses are days for germination.

Vertical Supports

Growing plants vertically using stakes, cages, or trellises will help you fit even more plants in your garden. Staked or caged tomatoes require about 1/4 to 1/2 the space as those grown on the ground. Supporting plants off the ground can reduce some disease and insect problems.

It is a good idea to plot your garden on paper before planting. Remember the space saving ideas such as companion cropping, wide rows, intercropping, succession planting and plant supports. Tracing paper can be used to plan successive plantings over the entire season. Draw your garden outlines first on graph paper and note which way is north. It is a good idea to plant the rows going east and west so the sun reaches all plants equally.

Check seed packets, catalogs, or gardening books to determine the garden area space each type of vegetable needs. Many vegetables are similar in size from cultivar to cultivar. Others may vary, such as bush pumpkins and regular vining pumpkins, or bush and vine type tomatoes.

Any permanent (perennial) plantings already in the garden, such as rhubarb and asparagus, should be at one side of the garden so they are not in the way when preparing the soil. Long season crops, such as parsnips, should be planted near the perennial crops so they are not in the way when planting succeeding crops.

Plan to plant tall crops such as corn, asparagus, sunflowers, staked or caged tomatoes and pole beans on the north side of the garden so they do not shade the short plants. An exception is on exposed sites where a windbreak is needed. Sunflowers or corn planted on the south or west side can provide a windbreak. Be sure to plant shade tolerant crops next to tall crops. Note: Since corn is wind pollinated, it is best to plant it in three or more short rows side by side. If planted in one or two long rows, pollination and therefore kernel set may be poor.

Your finished garden plan should indicate:

- What crops you are going to grow
- Approximate planting dates
- Where each row will be
- The distance between crop rows

All planned plantings can be drawn on one sheet, or a separate plan can be made for a fall garden. As the days grow cooler in the fall, the same vegetables you planted in early spring can be planted again. See your local Cooperative Extension office for more information on planting a fall garden.

Improving the Soil

For optimum plant growth, the soil must supply nutrients and allow for the penetration of water and oxygen to the roots. Depending on the soil type or location, the garden may be prepared at different times of the year. In the northern US, heavy soils often benefit from fall plowing, tilling or spading, which exposes the soil surface to freezing and thawing during the winter months.

Cover cropping in the fall helps control erosion especially on sandy soils. Cover crops should be plowed or tilled early in the spring to work the vegetation uniformly into the soil. Cover cropping adds organic matter to the soil and protects exposed soils from winter wind and water erosion.

Another alternative is to add fertilizer and organic matter, just as compost, to the soil before spading or rototilling the garden. Some nutrients are leached out of the soil by rain or irrigation water; others are lost each time a crop is harvested. There are many different types of fertilizers you can use in your garden.

Granular fertilizers are the most commonly used types of fertilizers in home gardens. They can be spread on the soil and worked in with a spade. A complete fertilizer contains nitrogen, phosphorus and potassium (the nutrients most commonly needed in a garden). An analysis, or percentage of the nutrients in the fertilizer, will always be on the container. The analysis will be three numbers such as 5-10-5, 20-20-20, or 4-10-6 (sometimes there will be a fourth number if the fertilizer contains a special nutrient.) The numbers on the bag indicate in order, the percent of nitrogen, phosphorus as phosphorus pentoxide (P2O5) and potassium as potash (K2O). In 100 pounds of 5-10-5, there are 5 pounds of nitrogen (N), 10 pounds of P2O5 and 5 pounds of K2O. This totals 20 pounds of nutrients. The other 80 pounds represent filler material. Use the fertilizer that comes nearest to the needs of all crops such as 10- 10-10, 18-46-0 or 5-10-5. Before purchasing, use the percentages to figure the actual cost of the nutrients to get the best buy. Since nitrogen is the most expensive ingredient, it is used to compare costs.

The amount and type of fertilizer added to the garden depends on many factors such as past fertilizer use, previous crops and soil type. To find out which nutrients and how much will be needed to add to the soil, the soil in your garden tested. A soil test determines the level of nutrients in the soil and the amount of fertilizer that needs to be applied for good plant growth. A soil test also determines the pH of your soil. pH is a measure of the hydrogen (potential Hydrogen) content in soil, with pH of 7.0 considered neutral.

A slightly acid soil with a pH from 6.0 to 6.7 is ideal for most vegetables. A pH above 7.0 is considered alkaline and sulfur may be recommended to lower it. In the eastern U.S., soils tend to be acid, while many dry western soils are alkaline. A low pH of 4.5 to 5.5 causes vegetables to grow poorly. Dolomitic lime is usually recommended to raise the pH of the soil. Lime should be applied three to six months prior to planting. Elemental sulfur can be applied to lower the pH of the soil. It should also be applied a few months to a year prior to planting for best results.

Organic matter such as animal manure, compost, grass clippings and tree leaves also can add nutrients to the soil. Organic matter can:

- Improve soil structure
- Improve drainage
- Help hold nutrients in the soil so they are not leached away

Cow, sheep, horse, pig and chicken manures all can be used to add organic matter and nutrients to the soil. Do not use cat or dog manure, because they may harbor parasites that can be transmitted to humans. If you are planting immediately after applying manure, use composted manure. Composted manure will not burn the plant roots with excess nitrogen and does not smell as much as fresh manure. Apply uncomposted manure and organic material and incorporate into the soil several months before planting so these types of manures will decompose prior to planting.

Compost is partially decomposed organic material such as yard and food waste. Many home gardeners start a compost pile where microorganisms, such as bacteria and fungi, break down lawn clippings, leaves, kitchen scraps, etc. into humus. As compost decomposes in the soil, nutrients are released slowly. Compost generally will not supply all the nutrients required for optimum growth, but usually supplies most of the plant micronutrients. To make sure your plants get all the nutrients they need, use a combination of organic (manure, compost) and inorganic (fertilizer) sources.

Before spading or tilling the garden, spread compost, manure and/or fertilizer over the garden so it can be worked into the soil. The garden should be spaded or rototilled to a depth of 6-10 inches. Deeper cultivation is better because it loosens the soil so plant roots can become more extensive.

Avoid working wet soil, as it compacts and forms large clods when clay particles are present. The clods are hard to break up, and compacted soil can keep plant roots from growing well. To see if the soil is too wet, take a handful of soil and try to form a ball with it. If it forms a ball that does not crumble apart when pressed, it is too wet. If the ball crumbles when pressed, it is dry enough to work. Use a rake or hoe to break soil clumps into a relatively fine seedbed. Do not work the soil too fine or it will form a crust making it difficult for seeds to emerge.

Planting

For best results, plant vegetables at the recommended soil temperature. In most of the US, cool season vegetables are planted early in spring for an early crop, and in mid-to late summer for fall crops. In parts of the US where winters are mild and have little freezing, cool season crops are planted in the fall and winter months. Warm season vegetables should be planted after danger of frost has passed. With the garden plan in hand, measure and mark the rows so they are straight and the plants in each row have adequate space.

Direct seeded vegetables generally need to be thinned for optimum growth. Proper spacing within and between rows promotes faster growth and larger, better quality produce. Gently pull excess plants or snip them off with scissors so nearby plant roots are not damaged.

Some crops do best when started as transplants, slips, sets or tubers. In transplants are not purchased, start them inside under lights, in a bright sunny window, or outdoors in a cold frame or hot box. Adequate light is very important for good transplant production. Too little light results in weak, spindly plants that perform poorly in the garden. Another way to produce short, stocky plants is to brush them lightly with your hand or have an oscillating fan blow a gently across the plants for part of each day. Brushing or air movement helps simulate the wind the plants would be exposed to outdoors, helping the plants produce stronger, thicker cell walls that result in sturdier plants.

Transplants should be started early enough that they can be hardened off for a few weeks before the actual transplanting date. To harden plants, gradually expose them to full sunlight, cooler temperatures, and wind for a few hours each day. Gradually increase the exposure over a two week period until the plants can tolerate full sun and wind. Gradually decrease the frequency of watering and fertilizing, but do not allow the plants to wilt or become nutrient deficient.

When purchasing transplants, select short, stocky plants of recommended cultivars. Transplants should already have been hardened off and ready to plant. Plant transplants at recommended distances. Most plants should be planted at the same level they were growing in the pot. Tomatoes can be set deeper, since they root easily along the stem. If plants are in peat pots, tear off the top edges of the pots and remove the bottoms of the pots so the roots can grow. If exposed, the top edge of a peat pot acts as a wicks, drawing water out of the soil and killing the new transplants due to lack of water available for the roots. Remove all other pots before planting. Lightly firm the soil around the transplants and water them. A water-soluble starter fertilizer solution high in phosphorus helps seedlings become established and grow vigorously. Keep transplants watered, protected from harsh winds and shielded from bright sun until they are well established.

When plants are directly seeded in the garden, they should be properly spaced to reduce the amount of thinning needed later. Use space saving techniques to get the most from your garden. Vine crops and pole beans can be planted in rows or hills (a hill is a group of plants growing in a cluster). Thin to three plants per hill. Sometimes a mound of soil 3-6 inches high is formed for better drainage. Yields from hill planted crops are usually not as large as those planted in rows. Seeds must be kept moist to ensure proper germination. Once a seed has taken up water, it can not dry out or it will die.

Mulch

Mulching reduces the amount of water your garden needs. There are two types of mulch, organic and inorganic. Examples of inorganic mulches are clear and black plastic film. Commercial growers often use plastic mulches to conserve moisture, warm the soil and control weeds. Organic mulches include grass clippings, dry leaves, compost and newspapers. Home gardeners more commonly use organic mulches.

Many garden plants are subject to injury by herbicides used on lawns. When lawns have been treated with herbicides to control weeds, grass clippings from treated lawns should be not applied to gardens unless they have been collected and composted. After two subsequent cuttings, lawn clippings may again be immediately utilized in gardens.

In addition conserving water, mulches help smother weeds, lessen soil compaction, reduce soil erosion, help keep fruit (tomatoes, cucumbers) and leafy crops (lettuce, spinach) clean and increase yields. Organic mulches insulate the soil from heat and cold and, when incorporated, increase the organic matter content of the soil.

Organic mulches should be applied at the correct soil temperatures (which in turn affect the growth of different crops) because of the insulating ability of mulches. If the soil is cool when mulch is applied, the soil remains cool. Apply mulch to cool season crops before the soil gets too warm. Warm season crops, such as tomatoes, peppers and squash, like warm soil. Mulch after the soil has warmed to avoid stunting these plants.

Controlling Weeds

Weed control should begin soon after the garden is planted. Weeds are easiest to control as weed seedlings. At this stage, scraping the soil with a hoe cuts the weeds off so they dry out and die. Once weeds get a foothold, they are hard to control. Allowing weeds to grow can result in crowding and shading of vegetables, reducing vegetable yields.

Shallow hoeing a day or two after watering or a rain is a good time to stop weeds. Hoe in the morning before it gets hot. The afternoon sun will dry out and kill the uprooted weeds. Controlling weeds also prevents disease and insect infestations, as some weeds harbor pests that attack garden plants. A small, weed-free garden can out-produce a large, unkempt one, both in quality and quantity of vegetables.

Controlling Insects and Diseases

Insect pests can be a nuisance in the garden because damaged plants produce fewer vegetables. Careful monitoring of plants is necessary to keep ahead of insect problems. Prevention or reduction of insect damage is often necessary to raise high quality vegetables. Many gardeners deal with insects through a pest management program. Pest management is different from pest eradication. Over the years, scientific research coupled with observations has shown that a war against insect pests is never completely won. Insect pests can be dealt with or managed for a short time to enable a garden to be highly productive.

Cultural practices can help reduce the number of insect pests in the garden. Healthy, vigorously growing plants usually are less subject to attack by insects. However, certain vegetables are naturally more vulnerable than others. Use these methods to prevent insect damage in your garden.

- Use plant "collars" around transplants to prevent cutworm damage. Recycle juice cans, milk cartons or other similar containers and place them around the stem of plants to prevent insect attack. Be sure the container is large enough to allow the stem to grow. Cutworms like to hide in the soil around the base of plants during the day. Check the soil next to the plants before placing collars to be certain a cutworm is not hidden inside the perimeter of the collar.
- Rotate vegetable crops. Many insects overwinter in the soil. Do not grow the same family of vegetables in the same place as the year before.
- Remove or turn under all garden plants at the end of the growing season. Plants left in the garden can serve as infestations sources of insects and diseases for subsequent plantings. Remove heavily infested plants and put them in the trash or compost pile. A properly constructed compost pile should heat up enough to kill insects and diseases.
- Purchase transplants free of insects and diseases.
- Use floating row covers to protect against some insect pests.

Insect pests have natural enemies such as predators, parasites and insect diseases. Cabbage loopers and imported cabbageworms attack cole crops such as broccoli, cabbage and cauliflower. These pests are easily controlled, however, with a naturally occurring bacteria, *Bacillus thuringiensis*, commonly referred to as Bt. As an insecticide, Bt kills the larval (caterpillar) stages of many butterflies and moths after the caterpillars have eaten Bt, but Bt is not equally effective against all species. Certain strains of the Bt bacteria are also used for control Colorado potato beetle and bean beetles.

Horticultural oils and insecticidal soaps are other materials that are not toxic to people, pets and wildlife yet are excellent for controlling insect pests in the garden. Most usage of the oils is for scales on fruit trees, but some have shown to be effective repellants on certain insect pests. Insecticidal soaps are effective against softbodied pests (aphids, spider mites).

Not all insects are harmful for vegetable production. Many insects are beneficial because they control other insects. Common beneficial insects that are predators of other insects include the ladybird beetles (lady bugs), preying mantids, dragonflies, predaceous flower bugs, big-eyed bugs, spined soldier bugs and damsel bugs. Certain very small wasps, such as Trichogramma spp., attack insect eggs. A number of fly and wasp species are common parasites that live on or in other insects. Insects can also be infected and die from diseases caused by viruses, bacteria and fungi.

The **honeybee is probably the most beneficial of all insects**. Without honeybees to pollinate many of our crops there would be very little fruit to eat or vegetable seeds to plant. Read the label before using any pesticide to learn how to lessen damage to bees and other beneficial insects.

Mechanical control refers to actions or devices used directly against insect pests. Mechanical control can be as simple as picking insects or their eggs off plants or hitting them with a flyswatter. Other examples of mechanical control include insect traps, barriers and screens that keep insects from reaching plants.

Lightweight floating row covers, such as Reemay®, can keep insects off plants. Air, water and sunlight pass through the fabric but insects cannot. The covers also help hold in heat so plants grow quickly. Row covers must be removed on insect pollinated crops, like squash and melons, at flowering for pollination to occur.

Chemical pesticides are sometimes necessary to control heavy infestations of pests. Check with your local Cooperative Extension office for current recommendations. Chemical control can be safe and efficient when applied properly and label directions are followed. When using any product for pest control, always read and follow the directions on the product label carefully. Do not use more than the label recommends. Your best approach with insect pests may differ with each and every pest problem. For a good pest management program, follow these steps:

- Check plants often. Look at them closely and try to identify any problems.
- If the problem is an insect, identify the insect.
- Determine the potential for damage caused by the pest.
- Determine your options for controlling the pest and the pros and cons of each.
- Use the "best" combination of control methods, follow label recommendations for chemicals and waiting periods until harvest.

The best pest management program will vary with each crop, season, gardener and soil type.

Diseases are caused by bacteria, fungi, viruses and other organisms too small to see with the naked eye. Cultural practices can help reduce diseases in your garden.

- Select disease resistant cultivars. Plant breeders work hard to develop plants that need fewer pesticides. Read descriptions in seed catalogs or on seed packages to find out which cultivars are tolerant of, or resistant to, the diseases which are expected to be problems. Water plants early in the morning so the foliage dries more rapidly. Increased humidity in the evenings means the foliage does not dry well and favors disease development.
- Water the soil at the base of the plant, not the foliage. Soil splashed on leaves can spread diseases.
- Use mulch to reduce diseases spread by soil splashing.
- Rotate your vegetable crops. Diseases can overwinter in the soil and attack plants.
- Remove all diseased plant parts before they can infect other plants in your garden. Do not put diseased plant material on the compost pile unless you know the compost pile will heat up enough to kill the disease organisms. Monitor the pile with a thermometer.
- Check with your local Cooperative Extension office for current information on fungicides.

Harvesting and Storing Garden Produce

If one hasn't grown a particular vegetable before and is unsure when the vegetable should be harvested, check the produce at a grocery store or check on-line at www.farmersalmanac.com. Commercial growers harvest their produce at its peak so comparing those vegetables with the garden specimen can assist in the decision.

Storing your vegetables properly will help to preserve the quality. For example, tomatoes and squash were originally grown in the tropics. They do not like cold temperatures and will exhibit symptoms of chilling injury when stored below their minimum recommended temperature. Symptoms of chilling injury are decay, pitting, discoloration, softening and poor flavor.

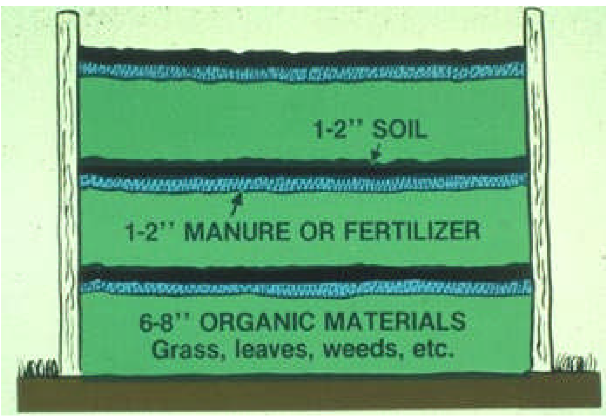
Fall Gardening

Fall gardening can extend the growing season by a few months for those located in northern states, and is the time period many people in southern states begin to plant their cool season vegetables that will be harvested during the winter months. During the summer, it may be difficult to think about more planting but a fall garden can produce premium cool-season crops. All debris from previous crops should

be removed and the soil reworked. Plant seeds slightly deeper than normal (2-4x of the seed diameter) and keep the soil moist. Use a very light mulch or a board over the row to retain moisture, but remove the board as soon as germination begins. Plant your fall garden to one side of the summer garden so the rest of the space can be cleaned up as soon as frost kills warm season crops or when the harvest season for these crops is completed.

Preparing for the Next Season

In northern states when the ground freezes, the ground can be prepared in the fall to get a head start on the garden next spring. By waiting until after several hard freezes, spade, rototill, or plow your garden. By waiting until after several hard freezes, many insects will be killed before tilling. Remove and throw away any severely infested or infected plants. Mowing the dead plants first will make it easier to incorporate them into the soil or put them in/on a compost pile. Rough soil will collect snow and rain for moisture next spring when final planting preparations are made in northern states.



Gardeners in southern states or in coastal areas often can grow vegetables year round because they do not have killing freezes. Plant sanitation/removal from the garden becomes even more important to limit diseases and insects, and should be done as quickly as possible.

Composting plant residue not heavily infected with diseases, insects, or weed seed provides a good source of mulch for the garden. Leaves, lawn clippings, straw, kitchen and garden refuse all are good additions to the compost pile. A nitrogen source (i.e. commercial fertilizer or manure) needs to be added if the pile is high in carbon refuse (wood chips, leaves, straw). The pile should be kept moist and turned regularly to hasten decay.

Compost can be made in a pile or bin. Fall is an excellent time to start a pile, as leaves are plentiful. Build the pile in 6-inches layers alternating green (high nitrogen) and brown (high carbon) materials. Sprinkle a small amount of soil or old compost between the layers to get a good start of beneficial micro-organisms that help create compost. If green materials are not available, use 1/2 pound (1 cup) of commercial fertilizer such as 10-10-10, 10-20-10, to each ten square feet of surface over the brown layers. Sprinkle each layer with water to moisten but not soak the pile. The minimum size for a compost pile is one cubic yard. There is no limit on how large it can be as long as it can be turned to keep it well oxygenated.

As the compost pile heats up, decomposition will occur faster if the pile is turned to incorporate air into the pile. Water may need to be added as the pile is turned so microorganisms can work effectively. If properly prepared, a compost pile heats to about 140°F and kills insects, diseases and weed seeds. 1. Allard, R. W. 1960. *Principles of Plant Breeding*. John Wiley and Sons, page 472.

GARDEN FLOWERS

Greg Stack
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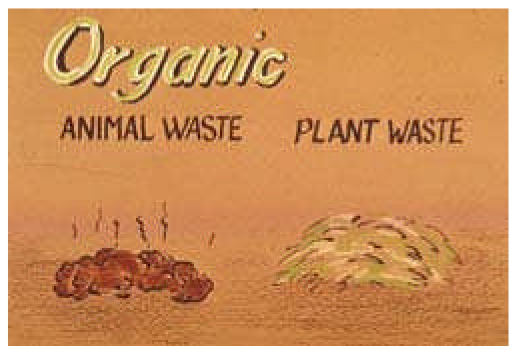
Flowers offer color and form that can fit into almost any landscape. They provide color to landscapes that would otherwise be drab. Flowering plants in containers add splashes of color to decks and patios. Many types can be brought inside for fresh or dry cut flower arrangements.

Garden flowers are classified into several groups. **Annuals** are grown from seed and flower, produce seed and die in one growing season. **Biennials** complete their life span in two years. The first year they produce only vegetative growth. The second year they flower, produce seeds and die. **Perennials** last for three or more years. While the stems and leaves generally die to the ground with the first frost, the root system remains alive and produces more growth the following year.

The ideal way to start a garden is with a plan. This will afford a chance to arrange plants by height, color and season of bloom. A plan can be developed in many ways. An easy way is to start with height designations (low, medium, high), whether the area is to be planted in annuals, biennials, or perennials. Finally determine the season of flowering (spring, summer, fall). After determining these factors, you will want to read books and catalogs to select plants hardy to your area that fit the areas on your plan.



Soil Preparation

Flower gardens should be located in well drained areas. If drainage is a problem, raised beds offer an excellent way to keep the root system from being in a saturated soil. While they may not do well, annuals can tolerate poorly prepared soil if enough fertilizer and water are provided. Perennials seldom survive more than one or two years in poor soil.

If the soil is poor you can improve it by adding organic matter such as compost or peat moss. The amount will depend on the exact type of soil. Three inches of organic matter spaded in to a depth of 8 inches is a good starting place. Fall is the best time to do this so that weeds and organic matter will have a chance to decay before planting time in the spring for the northern US. The soil moisture is generally better making soil easier to work.

Fertilization

Ideally fertilizer should be added to the garden based on soil test recommendations. When this is not possible you can follow some general recommendations. Add a complete fertilizer (i.e. 5-10-5, 10-6-4, or 5-10-10) to the soil surface after the soil has been spaded or tilled and raked level. The fertilizer should be spread uniformly at the rate of three pounds per 100 square feet. This fertilizer should then be raked into the upper 2 to 3-inches of soil. Liquid fertilizer can be added in mid-summer to continue strong plant growth.

Established perennials should be fertilized in the early spring or as soon as the ground can be worked. The same type and rate of complete fertilizer can be used. Try not to get fertilizer on young perennial shoots and crowns as burning can result. A shallow cultivation will help get the fertilizer into the soil.

Perennials generally require more fertilizer than annuals and will benefit from a second application of complete fertilizer in July. Rates are the same as spring application (for additional information see the chapter on Plant Nutrition).

Selecting Plants for the Garden

There is a wide range of annual flower types. Regardless of the part of the country there is always a selection of annual flowers for the garden. Modern plant breeding and improved selection have resulted in many new varieties of old favorites that flower earlier, last longer, are more compact and offer a wider selection of colors. New introductions of annual flowers worthy of trial are designated **All-America Selections (AAS)**. While there is no guarantee that these types of annuals will do well in your area they are worth trying.

Annuals

Annual flowers are sometimes referred to as hardy or tender annuals. Hardy annuals tolerate cool temperatures and some frost. Snapdragons and larkspur are examples. These plants can be seeded outdoors very early in the spring. Tender annuals require warm soil and air and should be planted outside only after the danger of frost has passed.

Perennials

Study which perennials do well in your area before purchasing plants. Make a note of

flowering season. While most perennials flower in the spring and summer, there is a great difference between different varieties of the same species. By careful selection you can have something in flower for most of the year. Select perennials hardy to your area and planting zone (see map in chapter on **Environment and Horticultural Plants**). Even perennials classified as hardy for your area will die if not cared for properly. Soil conditions are very important as is the need for mulch to provide winter protection. While we think of snow as being cold, it actually helps protect plants from extremely low temperatures.

Be careful in selecting rapidly multiplying perennials for small gardens. They may become undesirable additions as they rapidly take over the garden.

Biennials

A few garden flowers live for only two years. A true biennial dies after it flowers in the second growing season. Some perennials are grown as biennials because they flower poorly as they get older. Because of the short life span of these flowers, it is necessary to start some new plants every year. Examples of biennials include foxglove, hollyhock and canterbury bells.

Summer Flowering Bulbs

The term bulb is used for plants that produce a variety of underground storage organs. These fleshy, below ground plant parts are important for storing plant foods and water. Not all bulbous plants produce true bulbs. A true bulb is a compressed stem with a growing point surrounded by fleshy leaves. Lilies produce true bulbs. Other bulb-like structures are called corms, tubers, tuberous roots and rhizomes.

Corms are solid with a growing point in the center. Gladiolus is one example of a corm. Tubers are fleshy stems that grow below the soil surface. Like the Irish potato, they have buds called eyes. Tuberous roots like the sweet potato and dahlia are true roots and do not have buds. Rhizomes are horizontal stems growing parallel to and at or below the soil surface. Some irises have this type of root or reproductive structure.

Among the most popular summer flowering bulbs are tuberous rooted begonia, canna, gladiolus, dahlia, iris and lily. Of these only the lily is a true bulb. With the exception of the lily and iris, these plants are not winter hardy in cold climates and must be lifted in the fall and stored until the following spring.

Tuberous rooted begonias are started indoors in the early spring. They can be planted outdoors in beds or pots in semi-shaded areas. They should be fertilized with a liquid fertilizer every other week during the growing season. The leaves will turn yellow in the fall. This is the time when they must be dug and stored in dry peat in a cool place.

Canna vary in height from 1-1/2 to 5 feet. They prefer a sunny location and will grow in areas that are wet. In colder climates you must dig the rhizomes after the first light frost. Trim the tops and store with soil intact in a cool dry area.

Dahlia tubers grow best in sunny locations. Varieties range from one to six feet tall and produce a variety of flower colors from 2-8 inches in diameter. Tubers should be dug after the first frost. They should be cleaned and stored in dry peat moss in a cool location. Tubers can be sprouted indoors about a month before setting out.

Gladiolus corms are planted in the spring as soon as the soil can be worked. Corms are planted 4-7 inches deep. To speed growth you should cover the corm with only an inch of soil and slowly add soil as it grows. Planting every two weeks will assure a uniform supply of flowers throughout the summer. Dig the corms after the first frost and dry for several weeks. Clean and store in a cool, well ventilated area. Onion bags make good storage containers.

Most lilies are winter hardy. Bulbs are usually planted outdoors in the fall. Bulbs are usually planted three times as deep as the bulb is tall. There are a great variety of colors, heights and flower forms.

Purchasing bulbs early insures a better selection of variety and size. Select larger bulbs to insure larger flower sizes. Avoid bulbs with mold and mechanical damage.

Spring Flowering Bulbs

Spring flowering bulbs are often referred to as Dutch bulbs or hardy bulbs. These include daffodils, tulips, hyacinth, crocus and hyacinth. Spring flowering bulbs look best when planted in large masses or clumps of at least six to eight bulbs.

Spring bulbs should be planted in the fall so that they will become well rooted before the soil freezes. Bulbs should be planted at the depth suggested in planting charts. As a general rule, the growing tip should be below the soil surface four times the height of the bulb. When planting spring flowering bulbs, it is important that the bulb is not twisted and pushed into the soil. This grinds off the small roots on the basal plate. When these roots do not form, the plant is unable to take up sufficient water for the leaves and flowers. The plant becomes stunted and does not develop large flowers. Spring bulbs must be grown in well drained soil that has been worked deep. Many recommendations call for the addition of bone meal in the planting hole.

Gardeners in the deep south often have difficulty growing spring flowering bulbs because their soils do not become cold enough for plant to acquire enough chill units. Chill units are necessary for fruit trees as well as some bulbs to flower. Many distributors offer pre-cooled bulbs for markets in warmer climates. Pre-cooled bulbs should be planted as soon as possible and should not remain at room temperature for longer than five days. Gardeners can pre-cool their own bulbs by storing them for 45 to 60 days at 35-40°F. This practice will improve flower quality and length of stems. Gardeners in the deep south frequently grow spring flowering bulbs as annuals while northern growers treat them as perennials.

Growing Flowers from Seed

Both annuals and perennials can be grown from seed. Annual seed is fairly easy to germinate and offers the gardener a great diversity of types. Perennial seed can be more difficult to germinate. Some types of seed require special temperature treatment to insure good germination. Annual flower seeds are sown six to eight weeks prior to when they can be transplanted to the garden. As a result, timing is critical to insure that plants are in top quality. Consult seed catalogues and books for local seeding and transplanting dates.

Seed should be germinated in a prepared potting soil mix. The artificial mixes are excellent because they are well-drained, well-aerated and sterile. These qualities improve the percent germination.

Most seed should be covered with a very thin layer of the soil mix. The smaller the seed, the thinner the layer. Very fine seed like petunia is sown on the surface and lightly pressed into the soil. After sowing, the seed flat should be moistened and covered with plastic or newspaper to maintain uniform moisture. Keep the seed flat in a warm (65-70°F) location. Bottom heat is especially beneficial in promoting germination. As seeds begin to germinate, raise the cover and move the container to a bright, sunny window. Low light results in tall, spindly plants more likely to fail.

As soon as seedlings have developed their first set of true leaves they should be transplanted to individual pots or paks. As plants grow pay close attention to light, moisture and temperature. A light application of liquid fertilizer will encourage strong growth.

Annuals and perennials are kept in small pots before they are transplanted to the garden. The soil in the pot should be moist. Gently tap the plant out of the container and plant it in the loose friable soil. Do not bury the root system too deep or leave it exposed. Space between plants will

depend on the growth habit of the variety. As a general rule, the space between plants should be half of their anticipated height. Stagger the plants by setting ones in the second row alternating with those in the first row. Water the plants with a transplant fertilizer. Transplant fertilizers are high in phosphorus (i.e. 10-52-17), encourage root growth and help overcome transplant shock. Follow the label directions.

Dividing Perennials

Most perennials are easier and faster to propagate by dividing established plants rather than by growing from seed. Many perennials become overcrowded and should be divided every three to four years. Plants such as peonies and lilies should not be disturbed as often.

Generally spring is the best time to divide perennials. The exceptions are peonies, iris and lilies. Bearded iris are divided in midsummer after the new growth has hardened off. Peonies are divided in late summer or early fall after new buds have formed for next year's growth.

Perennials are easily divided by digging up the clump, shaking off enough soil to expose individual crowns and tearing or cutting apart the clump. Each division should have several vegetative shoots. It is important to keep the roots moist if not replanted immediately. Replant at the same depth that it was previously growing. This is especially critical with iris and peonies. Planting too deep is a common reason these plants fail to flower.

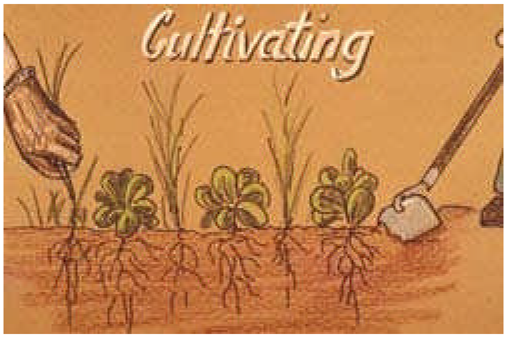
Flower Garden Care

Mulches are used extensively in flower gardens to retard weed growth, conserve moisture and moderate soil temperature. Mulches are usually applied to a depth of about 3-inches. Piling mulch too deep can smother roots.

In cold climates, winter mulches are applied only after the soil temperature has dropped, usually after several freezes. The purpose of the mulch is to keep the soil uniformly frozen. Alternate freezing and thawing will result in heaving of plants. Once this happens the roots will dry and die. If caught early enough the plant can be gently pushed back into the soil.

Mulch should be weed free, remain loose and be easy to remove. Good mulch materials include straw, pine needles, hardwood leaves, compost, bark chips and evergreen boughs. If the mulch covers the growing points it should be carefully removed after the soil thaws but before shoot growth begins.

Cultivation, Watering and Weekly Maintenance



Weed control is best handled by frequent, shallow cultivation. Flower gardens should receive about 1-inch of water per week. A weekly soaking is preferred to several light waterings. Inspect the garden at least once a week. Remove unsightly plants and prune plants crowding others. Pick seed heads from plants. Most annuals and many summer flowering perennials stop flowering when they begin
to set seed.

Inspect plants each week for diseases and harmful insects. Be prepared to prevent the spread of problems by removing and destroying the problem or applying recommended pesticides.

Roses

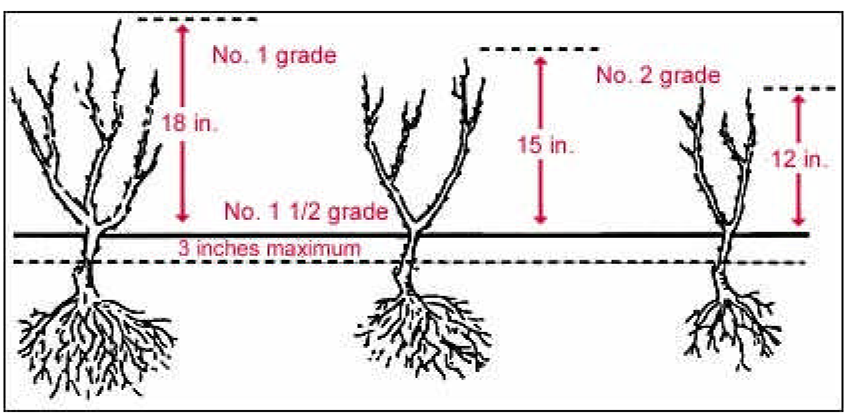
There are many types of roses available for the garden. Hybrid tea, floribunda and grandiflora are types most frequently planted. They require a vigorous disease and insect control program to keep them healthy. Shrub and species roses such as rugosa, damask, China, bourbon and Portland roses require much less attention.

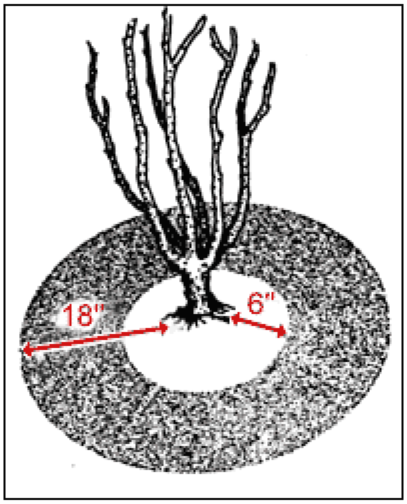
Growing Conditions

Roses grow best in full sunlight but it is possible to grow them in as little as 6 hours of bright light. Morning sun is better than afternoon sun. This allows the plants to dry off quicker and prevents some disease problems.

The soil should be friable and well drained. Rose roots do not compete well with tree and shrub roots. Rose beds should be in an area where there will not be competition with other woody plants.

Selecting Plants





Roses are usually sold as two year old plants. They are sold by grades (1, 1½ and 2). One is the largest (best) grade. Select the best grades rather than "bargain" grades. Roses are sold as packaged plants, container grown, or bare root. Packaged and bare root roses are best bought as early in the season as possible. Container grown plants can be bought and planted at almost any time.

Planting

The best time to plant roses is dependent on the type of winter weather in your area. Where winter temperatures do not drop below -10°F either fall or spring planting is satisfactory. Spring is preferred in areas where the temperature goes below this. Rose bushes should be spaced 2½ to 3 feet apart. In subtropical climates roses have a longer growing season and should be spaced farther apart.

Planting holes should be large enough to allow full spread of the roots. This will be approximately 12-16 inches deep and 18-20 inches wide.

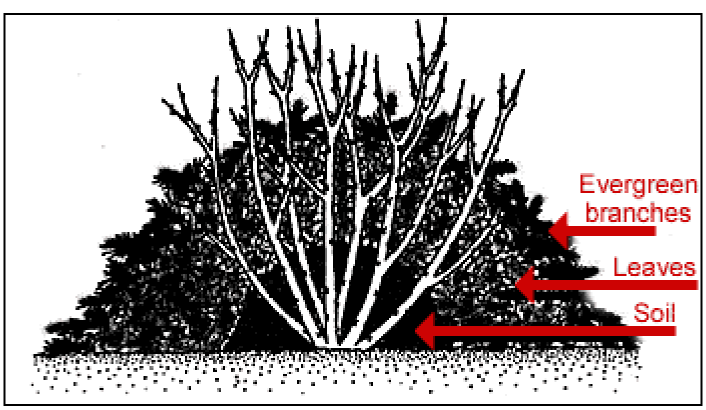
Almost all roses are budded onto a rootstock. The point where the scion (top) and stock (bottom) join is known as the bud union and forms a "knuckle." If this union is injured by cold weather the entire top may die and the roots will produce an undesirable plant. In areas where the winter temperatures are not severe, the plant is placed so that the bud union is about an inch above the soil line. In areas where winter temperatures are severe, the bud union should be about 2-inches below the soil line.

After Planting Care

Roses need water, fertilizer, winter protection and pest control. About an inch of water per week is preferred. Watering once is better than several shallow waterings. Fertilizer should be applied at the rate of three pounds of a complete fertilizer per 100 square feet. Apply as growth starts in the spring and repeat every six weeks until the end of July.

Winter Protection

Roses need protection from fluctuating winter temperatures. Proper summer care aids winter survival. A vigorous rose bush is more likely to survive cold weather than one in a weakened condition.



After several hard freezes, plants can be prepared for winter. A good way to protect the plant is to mound the soil 10-12 inches up around the canes. Bring

soil in rather than scraping soil up from around the base of the plant. Loose friable material such as straw, hardwood leaves, compost, bark, or evergreen boughs can be used in place of soil. Rose cones can also be used. Be sure to allow for good ventilation under cones so that the inside will not heat up on bright winter days. Coverings should be removed in spring after danger of severe frost has passed. Do not be too anxious as new shoots are tender and will be damaged by late freezes.

FRUIT AND NUT PRODUCTION

Bill Phillips, Bob Renner and Jeff Williamson
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Fruits and nuts comprise a wide variety of plants from small strawberry plants to various bushes, shrubs and vines to very large trees like the pecan. Some have a relatively short life span of only a few years while others may survive and produce for over a century. Most are edible right off the plant though some require some kind of processing or treatment. Avocado and pear, for example, mature on the tree but ripen after harvest, whereas the cashew nut requires a heat treatment to make it edible.

Climate

Climate is the major factor that determines the geographic areas in which certain fruits and nuts can be grown. Deciduous fruits are mainly limited to the temperate zone. They shed their leaves each fall and enter a winter dormancy that allows them to survive extended periods of sub-freezing temperatures. Many fruits such as grapes and blueberries can be grown throughout the United States. Deciduous fruits and nuts have a very difficult time producing fruit in locations with tropical climates such as that of extreme southern Florida where there are too few chilling hours during winter (see below for discussion of chilling requirements).

Tropical and subtropical fruits are mostly evergreen and can be severely damaged or killed outright by freezing temperatures. Consequently, fruits such as pineapple and papayas are limited to Hawaii, south Florida, extreme south Texas, and parts of southern California.

Climate will also influence the choice of fruit varieties for your area. Peaches, for example, can be grown in many parts of the country. Although the peach variety 'Alberta' are recommended for the northeastern US, this variety will not grow well in the southeastern US. Varieties such as ‘Flordacrest’ and ‘Flordaking’ are better suited for the milder winters in northern Florida and the southern Gulf Coast regions. Different varieties of deciduous fruits have different chilling requirements to break winter dormancy. A southern variety that is taken north will leaf out well before the last freeze. A northern variety planted in the deep south may never receive enough hours of cold temperature during the winter to resume normal growth in the spring.

Chilling requirements are commonly expressed as the number of hours below 42°F needed to break the dormancy requirements on buds. Only plants from the temperate zone have chilling requirements. Plants from the tropics do not have this characteristic. Many plants from near the Arctic Circle have not developed chilling requirements. When it finally does warm up in these frigid regions, these plants have to flower, ripen their seed, and go dormant as rapidly as possible.

Climate is more than temperature. Some fruits require a very dry or very moist climate to produce well. The climatic effect on insects and diseases is also significant. For example, a fungus called pecan scab grows well in humid weather. Since the southeastern part of this country is usually very humid, pecan growers use varieties resistant to this disease.

Soils

Fruits and nuts are grown on a wide variety of soil types. They generally prefer deep soils with good drainage and permeability to enable these plants to develop an extensive root system

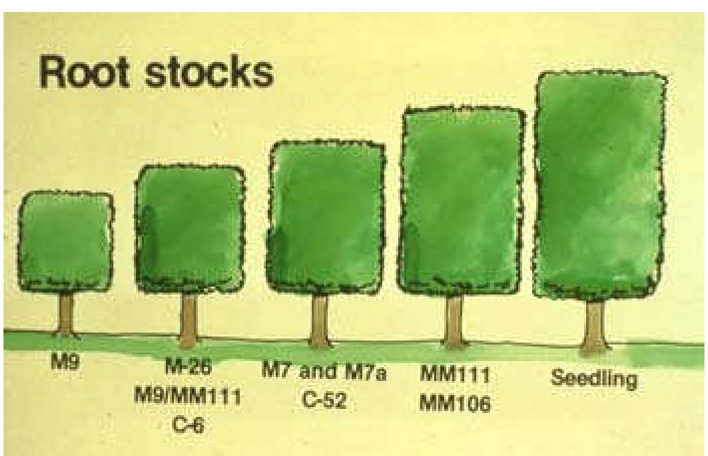
necessary for optimum growth. A poorly drained soil restricts growth by limiting oxygen to the roots. Since oxygen is necessary for the uptake of water and nutrients, soils low in oxygen will produce plants that have unthrifty growth, more disease and insect problems and fewer and smaller fruit. Even small fruits like strawberry and blueberry require deep, moist, fertile soils. Soils do not have to be as deep for these plants as for a large tree like a pecan however.

Soil pH is also very important to many fruits and nuts. While some will grow on either acid (pH<7.0) or alkaline soils (pH>7.0) others like the blueberry are limited to acid soils. The major effect of pH is on nutrient availability. Alkaline soils commonly tie-up (this means that these elements are in a chemical form that the roots cannot take up) necessary elements like iron, zinc, and manganese. Acidic soils tie-up potassium, magnesium and phosphate. Other elements like potassium and magnesium are tied-up in very acid soils. Soils which are too acid can be made useable by applying lime to raise the pH. Finely ground sulfur or acid forming fertilizers can be used to lower the pH. In order to be effective in a relatively short period of time these materials must be incorporated into the soil by cultivation. This is best done before planting.

Soil fertility is important, but natural fertility is not critical as nutrients necessary for good growth and development can be applied as fertilizer. Even infertile sandy soils can be fertilized to provide optimum plant nutrition.

Plant Propagation and Rootstocks

Fruits and nuts have some important and unique aspects of production which need to be considered. Most plants start from seeds. Each seedling is slightly different genetically from other seedlings. It is almost certain that a population of seedlings, even from the same plant will not bear fruit exactly like the parent plant. Other differences like size, rate of growth, time of



fruiting, insect and disease resistance, and hardiness would also be slighlty apparent.

Very few fruits are propagated from seed. Because of the genetic differences between seedlings, virtually all fruit plants are produced by some form of asexual propagation in order to obtain uniformity. Rootstocks for many fruits have been developed for certain soil problems, climatic differences, and pests such as nematodes (small microscopic non-segmented worms that are parasites) and soil-borne diseases. Virtually all peaches, apples, pecans, avocados, citrus, and many other fruits are propagated and grown on special rootstocks rather than on their own roots. For example, oranges are commonly grown on sour orange, rough lemon, trifoliate orange, Cleopatra mandarin, Carrizo citrange, or some other citrus rootstock based on the soil, climate, or other considerations. Apples are grown on standard or dwarfing (size controlling) rootstocks depending on the management plan for the orchard.

Dwarfing rootstocks have been a valuable addition to the production apples. Reduced tree size enables the producer to take advantage of simpler spraying, pruning, and harvesting techniques. Dwarfing is accomplished by using certain rootstocks. Apple rootstocks used in grafting are designated by the letters M or MM plus a number. The degree of dwarfing depends on the type of rootstock or interstem used. An interstem is just a piece of stem grafted onto a rootstock. The desired apple variety is then grafted onto a rootstock. The desired apple variety is then grafted onto the interstem.

The degree of dwarfing is determined by the length of the interstem (using less than 10 to 12 inches reduces the amount of dwarfing), soil fertility, variety size, pruning techniques, and crop size (trees grow more in years where the crop is lost because of a late frost). Some dwarfing rootstocks and interstems have the potential to keep a 40 foot tree from getting no more than 8-10 tall.

Although dwarf trees require extra care and attention, it is a practical cultural technique because dwarf trees produce earlier, require less space, produce higher yields, and have higher quality fruit that are easier to harvest.

Planting and Spacing

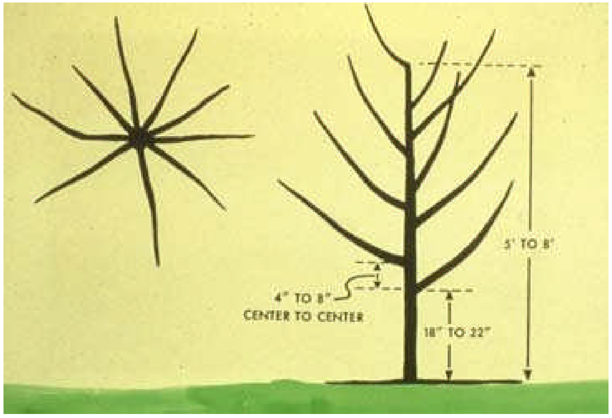
Fruit orchards are normally planted at a spacing compatible with the mature size of the plant. Strawberry fields may contain 30,000 plants per acre while pecans have as few as sixteen. Many traditional spacings are being changed to closer plantings to provide more trees per acre and thus higher yields. Dwarfing rootstocks and more intensive pruning and training are commonly used to maintain tree size and thereby permit even higher plant density. Because most fruit crops are long lived, the spacing chosen at planting will be there for years to come unless the grower removes alternate trees or rows when crowding occurs. Spacing must be wide enough to accommodate equipment used in cultivation and in harvesting the crop.

Fruit trees for planting are available as container grown or bare root plants. A few may be sold as balled and burlapped though this is a more expensive way of planting an orchard. Bare root trees are dug and sold when they are dormant and should be planted as soon as possible. Container grown trees are available year-round and may be planted at almost any time.

The planting hole should be dug larger than the longest root to allow for the entire root system. The plant should be set in the hole at the same depth or even slightly higher than it was growing at the nursery. Roots of bare root plants should be spread out in the hole. Work the soil around the roots and tamp soil lightly to remove air pockets. Water thoroughly at planting and anytime the soil dries out.

Roots of bare root plants should not be permitted to dry out at anytime from digging to planting. A good way to keep the roots moist is to place the root systems in a bucket of water during planting. It is important not to leave plants in this condition for more than a few hours, as lack of oxygen can kill roots. If plants are to be stored for several days, keep the root systems moist by covering them with moist saw-dust or mulch and keep them out of direct sunlight. Fertilization should be delayed until after new growth begins or after several rains or irrigations have settled the soil around the planting holes (several weeks).

Pruning and Training



While the majority of fruit crops are allowed to grow and develop naturally, a few require extensive training following planting in order to develop the desired size and shape of the plant. Once initial training has been accomplished, subsequent pruning is necessary to maintain the desired size and shape of the plant.

Central leader, **modified leader**, and **open-vase** are pruning/training systems used on certain fruit trees. Grapes are trained on wire trellis and there are several forms of trellis as well as pruning systems used in grape production.

Besides shape and size control, pruning is important in overall fruit production, fruit size and fruit quality. Once final plant size is attained and maintained, subsequent pruning to that size maintains fairly level fruit production from year to year. While pruning reduces the overall amount of fruit set, some crops such as peaches require additional fruit removal (thinning) in order for the remaining fruit to obtain the desired size and quality. Too many fruit on the tree can result in smaller fruit sizes and less value to the commercial grower.

Pruning is traditionally conducted during the dormant season, but more and more summer pruning is being practiced. Severe pruning of dwarf trees during the early life of the tree decreases the among of carbohydrates available to the tree. This delays fruiting and increases the size of the tree.

Sometimes **branch spreaders** are used to change the direction a branch is growing. A branch spreader is nothing more than a stick with a notch cut in each end. This stick is then wedged between two branches to increase the angle of growth. Spreaders are left in place until the branch no longer springs back. Bending branches down to a horizontal position in early summer for up to three weeks will increase flower bud formation. This can be important in getting trees to come into fruiting earlier.

Water

Most tree fruits need about 30-50 inches of water per year. This can be as rainfall or irrigation. Many areas have adequate rainfall for good growth and production. Relatively few areas have rainfall distribution patterns sufficient for optimum growth and production. Supplemental irrigation is often used even in high rainfall areas to supply water when it is needed. This reduces plant stress and increases vigor which is especially important for the development of a plant's natural defenses against insect and disease pests.

There are many irrigation systems. Each has its inherent advantages and disadvantages. The most critical issue is the capacity of a given system to apply as much water as is needed when it is needed. The crop, time of year, soil type, and climatic factors all influence the need for water. Some growers still wait for the plant to wilt before irrigating. Many growers use their years of experience to tell them when to irrigate. In many places water is too precious of a resource to be wasted.

Irrigation is also one of the major production expenses. Many growers are using computer programs that tell them when to water. The grower feeds data about the weather into the computer along with information on the condition of the crop and the amount of soil moisture. The goal is to apply water when it is needed and in the appropriate quantity, at a rate that will penetrate the soil without runoff.

Nutrition

Fruit crops are fertilized at least once and often two or more times a year. Consult local recommendations on the amount and timing of fertilizer. The rate of fertilization is based on the plant, soil, and cultural conditions. The types and quantities of nutrients is determined by soil testing and foliar tissue analysis. By the time visual symptoms of a nutrient deficiency appear, it is too late to correct the deficiency for that reason.

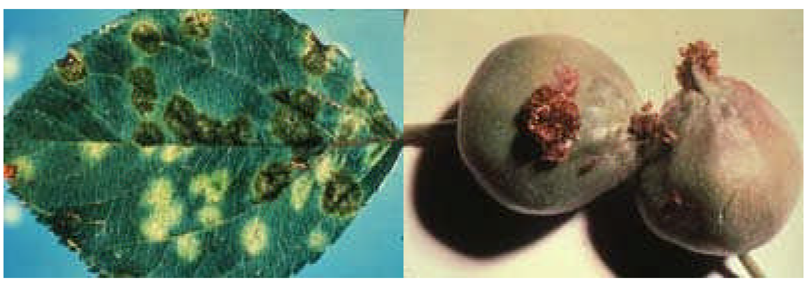
Fertilizer is applied in either liquid or dry (granular) forms. Liquid fertilizers are sometimes applied as foliar sprays, but most fertilizer (liquid and granular) is applied to the soil. Fertilizer can be incorporated into the soil by cultivation, rainfall, or irrigation.

Weed Control

Growers should maintain good weed control because weeds compete for water and nutrients. Mowing, cultivation, and herbicides are all used to reduce weed competition. Cultivation damages root systems and allows some evaporation of soil moisture. Mowing keeps the weeds down but leaves enough cover to prevent erosion by wind and water. Some crops and soils do better if herbicides are used to kill weeds under the trees and the middles are left in grass and mown.

Many orchards are under complete herbicide weed control to maintain a virtually weed-free condition. Competition for water and nutrients is eliminated and roots are not damaged by cultivation. A clean orchard floor provides more cold protection than a weedy situation. A clean orchard also helps in harvesting crops like almonds and pecans. These nuts are shaken from trees and then picked up mechanically.

Insect and Disease Problems



Insect and disease control are important for plant vigor, fruit quality, and yield. Most growers follow a regular spray schedule. Proper timing is as important as the material used. Air blast sprayers are generally used though hand held pressure guns are used on smaller acreages. Pesticide recommendations vary from crop to crop and from state to state. Some laws change each year. It is important to have up-to-date local information and to follow all label recommendations carefully for proper rates, frequency, and waiting time to harvest (preharvest intervals). Failure to do so can result in fines and/or prison sentences.

Insects may damage both fruit and trees. Fruit is damaged by both chewing and sucking insects. Even slight areas of damage may allow secondary fungal organisms to enter and cause rot and subsequent fruit drop. Damaged and scarred fruit is graded out at the packing house resulting in less income for the grower. Leaves are sometimes chewed by insects. If too much of the leaf is chewed or leaf drop occurs, the fruiting potential can be reduced. Diseases also attack the leaves, twigs, roots and fruit. Most sprays are directed toward the leaves or the fruit.

Diseases that attack the fruit are more serious because of the reduction in quality and the potential for the disease to increase in storage.

Additional Information

The diversity of fruit and nut crops grown in North America and the wide variety of soils, geography, and climate make it impossible to provide more specific information in this chapter. Your local Cooperative Extension Service office has information on varieties and cultural information for your area. They can also help you with soil samples, foliar analysis, and pest identification/control, as well as other pertinent information.

TURF

Bill Fountain
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A quality lawn adds more to a landscape than any other single element. Not only is it beautiful, but it is also functional. A quality lawn is also one of the best examples of our attempt to establish a monoculture (the growing of only one type of plant) while witnessing nature's attempt to return to diversity ("weeds"). The secret to satisfaction and success is to balance what you want with what you really need. Consider what you have to work with, how much work you are willing to do and how much you are willing to spend.

Imagine the perfect lawn. A thick, green carpet of turf makes an attractive setting for the house and is one of the first things that passers-by notice. A smooth, level lawn provides an area for recreational activities such as croquet, volleyball or a game of touch football. On the practical side, turf prevents erosion of soil by wind and water, keeping the home cleaner. Grasses, like other plants, give off water as one of their growth processes. This is called transpiration and will cool the air, making a home cooler.

Turfgrasses are divided into two groups **warm season** and **cool season grasses**, based on type of photosynthesis (C3 or C4). Plants with the C4 photosynthetic pathway are those that can grow in **hot summer conditions**, while those with C3 photosynthetic pathways are **not physiologically able to be as effective in hot summer conditions**.

Common warm season grasses (C4 photosynthesis) are:

- Bermudagrass
- Carpetgrass
- Centipedegrass
- St. Augustine
- Zoysia

Cool season grasses (C3 photosynthesis) are:

- Bentgrass
- Bluegrass
- Fescue
- Ryegrass


Zoysia


Bentgrass

Ryegrass

The type of grass selected depends on the climate. Each type has many varieties, some or all of which should not be grown in your area. Most lawns in the southern United States consist of only one type of grass while many lawns in the northern U.S. are a mixture of more than one type. Blends of different types of grass are sometimes recommended. It is important to check with your local Cooperative Extension office for the best varieties for your climate and soil type.

Establishment

There are three methods of getting a lawn started: solid sodding, seeding and planting small pieces called sprigs or plugs. Some types of grass are started by only one method while there may be a choice with others. Regardless of the method you choose, soil preparation is the same.

It is difficult if not impossible to get a lawn started on a site without topsoil. At the construction stage, it is beneficial to have the contractor push the upper 4-6 inches of soil to one side until building and subsoil grading operations are complete. Use fencing to protect existing trees from heavy equipment. Changing the grade (soil slope) within the drip line (edge of trees or buildings where water drips off) can be fatal. Use tree wells or retaining walls if grade changes are unavoidable. Remove all building materials such as paint cans, bricks, stone, concrete, boards, paper and wire. Do not bury these materials in the subsoil. If the subsoil is poorly drained it may be necessary to install tile drains.

Spread topsoil uniformly over the yard so that there are no low spots. Top soil should be tested and amended as necessary. If it is necessary to add lime, it should be tilled in before the final grade is established. Ground dolomitic limestone should be used when it is available since it contains magnesium in addition to calcium. A well-balanced inorganic fertilizer should be added and raked into the soil. Many soils are deficient in phosphorous, a nutrient important when grasses are being established.

Start with high quality seed or planting material (sprigs, plugs or sod) for best results. Examine the analysis tags on seed packages before you buy. State and federal laws require these tags to give percentages of each grass seed in the container, the percentage of noxious weeds, percent germination of the grass seed and date tested. **Amount of pure live seed can be calculated by multiplying the percent germination by the percent of grass seed**. It is important that seed be kept cool and dry prior to planting as high temperatures and humidity can lower germination.

Seed may be hand planted or with mechanical seeders. Regardless of the method, it is imperative that coverage be uniform. Divide the seed into two equal parts. Spread the first half evenly across the yard. Spread the second half evenly over the same area but at a right angle to the direction the first half was spread, insuring good coverage. Seed should be covered by raking lightly or by rolling.

Covering the lawn with clean straw (free of live seed) will help to keep young grass seedlings from drying out. Failure to use clean straw can result in years of fighting weeds. This layer of straw should be thin enough so that about 50 percent of the soil can be seen. One 60-80 pound bale of straw per 1,000 square feet gives this amount of coverage. It will not be necessary to remove this material before the grass is mowed.

Cheese-cloth, open-mesh sacking, or commercial mulching cloth helps keep soil moist while holding seed in place on terraced or sloping banks. Grass seedlings grow through these mulching materials and become established. This material can be left to rot.

Grass seedlings should be kept moist until established. This means watering at least once a day when it does not rain. In hot, dry weather it may be necessary to water as many as two or three times each day. Young plants are most vulnerable as seedlings. The lawn does not have to dry out for long to result in death. Avoid saturating the soil since excessive moisture is favorable for the development of a fungus disease called damping off. Keep people and pets off the lawn until it is established.

Starting a lawn from seed is not possible for grass varieties that do not come true from seed or when seed is not available in sufficient quantities. These grasses must be propagated asexually by solid sodding, strip sodding, plugging, sprigging, or stolonizing. Solid sodding is the most expensive method of getting a lawn established but gives that "instant" look. It is generally not used except where erosion will be a problem or results justify the cost. Sod should be 3/4 to one (1) inch thick. Thicker sod does not knit to the underlying soil as fast. Lay pieces of sod in a brick-like pattern and as close together as possible. Keep it moist until well established.

A less expensive method involves cutting up sod into smaller pieces. If sod is cut into long, 2-4 inch wide strips it is called **strip sodding**. If it is cut into 2-4 inch round plugs or squares it is called **plugging**. Generally strips, plugs, or squares are set about a foot apart. Sprigging and stolonizing involve planting individual plants, runners, or stolons. These are obtained by tearing apart or shredding solid pieces of established sod. Spacing is governed by how fast the grass spreads, how fast coverage is desired and amount of planting material available.

Table 1 gives the seeding rate and time of year for many common grasses and Table 2 gives the rate and time of planting for grasses that are established by asexual (vegetative) means in Kentucky. Because climates change and winters vary greatly across the United States which in turn affect growing conditions and seeding times, check with the local Cooperative Extension office regarding seeding information timings.

Table 1. Vegetative Grasses - Rate and Time of Planting

GRASS	AMT. PLANTING MATERIAL/1000 SQ FT	TIME OF PLANTING
Bermudagrass	10 sq. ft. nursery sod or 1 bushel of stolons	Spring-summer
Buffalograss	10 sq. ft. nursery sod or 1 bushel of stolons	Spring
Carpetgrass	8-10 sq. ft. of sod	Spring-summer
Centipedegrass	8-10 sq. ft. of sod	Spring-summer
Zoysia	30 sq. ft. of sod when plugging; 9 sq. ft. of sod when sprigging	Spring-summer

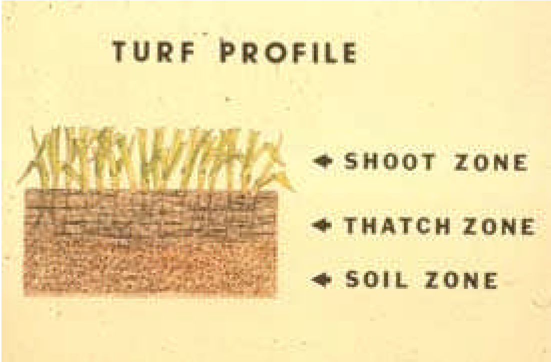
Table 2. Rate and Time for Seeding Grasses in Kentucky

GRASS	LBS OF SEED/ 1000 SQ.FT.	TIME OF PLANTING
Bahiagrass	2-3	Spring
Bentgrass	1-2	Fall
Bermudagrass	2-3	Spring
Buffalograss	1/2-1	Spring
Carpetgrass	3-4	Spring
Centipedegrass	2-3	Spring
Chewing fescue	3-5	Fall
Kentucky bluegrass	2-3	Fall
Red fescue	3-5	Fall
Rough bluegrass	3-5	Fall
Ryegrass (perennial)	4-6	Spring-Fall
Tall fescue	4-6	Fall

Maintenance

Establishing a lawn is only the beginning. A short period of neglect can cause a lawn to decline in quality. **Mowing the lawn properly is more important in maintaining quality than anything else**. Mowing frequency depends on how fast the grass grows. This varies according to the species of grass, season and soil conditions (water and nutrients). As a rule of thumb, no more than 1/3 to 1/2 of the leaf blade should be removed at any one time. Mowing grass at a height of about three (3) inches allows a more extensive root system to develop. This may be an important consideration where water is not available. It is not necessary to collect grass clippings unless they are so heavy that matting is a problem. Allowing clippings to remain will not result in thatch formation and adds additional nutrients as they break down. Keeping the mower blade sharp at all times insures that leaf blades are cut rather than torn off. Jagged, torn edges are a good entry site for diseases.

Lime is usually applied by itself. Nitrogen, phosphorus and potassium are applied together as complete fertilizers. Agricultural grade fertilizers are just as good as specialty and turf fertilizers. Care must be taken in applying agricultural fertilizers to turf to prevent burning and overfertilization. In order to have good growth, **potassium should be approximately half that of nitrogen and about twice that of phosphorus** (e.g. 4-1-2, 12-3-6, 20-5-10, etc.). To a large extent the amount of nitrogen will determine the quality of the lawn. A little nitrogen will green up a lawn faster than anything else but too much will cause grass to suffer from heat stress, disease and insect problems. Cool season grasses should be fertilized in the fall and warm season grasses should be fertilized in late spring or early summer. The amount of fertilizer applied should be based on results of a soil test and should be applied in the same manner as seed.



Thatch is mainly dead grass stems and roots that build up on the soil surface. If thatch gets too thick, grass will begin to form roots in this layer. Thatch will dry out before the soil and, once dry, is very difficult to rewet. Some thatch is an indication that the lawn is healthy but over a half inch can indicate that the lawn is headed for trouble. As more fertilizer is applied, the faster growing grass results in rapid thatch formation. Excess thatch is removed with a dethatching machine. This equipment has small blades or wires that dig down and pull a lot of the thatch up to the surface. It can then be raked up and disposed. It is impossible and undesirable to try to get it all. Spring and fall are best times for this operation.

Rust disease

Annual white grub

Turfgrasses, like other plants, are subject to attack by insects and diseases. The first job in controlling any problem is to identify it. Depending on the type of problem and its severity, chemical control may be necessary. Consult a professional for the best and safest control measure for your specific problem.

Cool season grasses turn brown and go dormant during hot, dry weather but may be kept green by watering. Regardless of the type of grass, it should be watered to a depth of 3 to 6-inches each time. This encourages a deeper root system. Watering can be done at any time of day if diseases are not a problem. If fungal diseases are a problem, watering should be done in the very early morning. Loss of water to evaporation is greater during the heat of the day and will be compounded by strong winds. This also allows leaf blades to dry and discourages fungal growth.

In the fall, rake leaves once a week. Do not wait until all leaves have fallen to remove them. A thick covering of leaves left on the lawn for several weeks may result in dead areas. If this happens, re-seed the area as previously described.

LANDSCAPING

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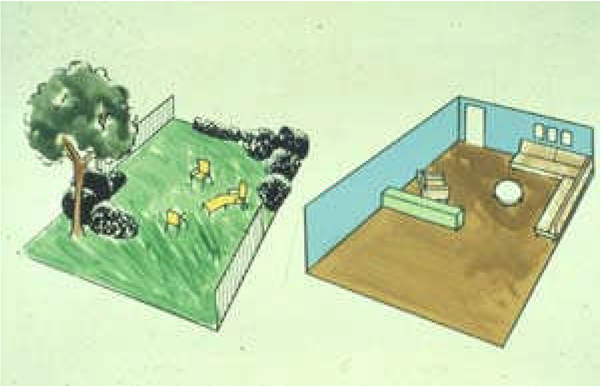
One definition of a weed is that it is a plant out of place. Such a definition is very appropriate for overgrown landscapes. This may occur only 5 to 10 years after installation. There are as many homes over-landscaped as there are homes which are under-landscaped or poorly landscaped. An attractive home without plants or hidden by a forest is undesirable. **Designing a landscape is the art of making the best use of available space in the most attractive manner**. Small areas require proper planning more than larger areas. The planning process requires anticipation of needs to be filled by plants and hardscape (statues, benches, walks, etc.). Selection, placement and culture of ornamental plants in the landscape requires a knowledge of plants and what can be expected from them.



A well planned landscape involves more than randomly placing a few trees for shade, a row of shrubs along the house foundation and a couple of taller bushes at each corner. Each landscape should mirror the needs and tastes of the principle user. For this reason there is a great deal of latitude in determining what is correct. However, there are many things that can be done to compliment the structure and natural terrain.

Use of trees, shrubs and turf in residential and commercial landscapes is important for more reasons than beautification of property. In addition to softening harsh lines of construction, plants can be used effectively to:

- Direct traffic
- Prevent erosion
- Divert cold winter winds away from heated structures
- Shade structures or outdoor areas from the blazing summer sun
- Create the feeling of depth in small areas, attract wildlife
- Screen unsightly areas

Before you begin the process of drawing a landscape plan, it is important that the area be considered in **three different ways**. First, think of the lot as a cube. Property lines are walls, trees or sky make up the ceiling and the ground is the floor. Next, think of the outdoor area as an extension of each room within the house. It is necessary to pay special attention to major living areas and keep in mind the multi-seasonal appeal of landscape plantings. Finally, consider the view of others onto your property and your view of other areas. There may be a need to screen areas for your privacy or to screen unsightly areas. Throughout this process it is necessary to keep in mind that the landscape plan should help the house blend with the remainder of the area.

Drawing a plan may seem like the first step. In order to know what to put into the plan **a list must first be made of all needs and wishes of the residents**. List them all. Some may be out of the question now due to cost; others limited due to lack of space. If there is a possibility they will be added in the future, now is the time to plan for them. Divide these up among use areas such as:

- Service area for garbage
- Play area for children
- Parking
- Outdoor living area (patio, deck, etc.)
- Tool/equipment storage
- Access routes

You may also want to include an area for:

- Sunning
- Reading
- Sports
- Gardening
- Formal entertaining

Some of these uses may be able to share the same space.

The design process necessitates having an accurate scale drawing of the property with all existing plant material above ground and buried utilities and septic systems located on the plan. Make a note of all grade changes and desirable or undesirable views. Arrows indicate views from areas where they will be seen.

Lay a piece of tracing paper over the drawing and begin making circles to indicate major use areas. Activities that require a separate area should be noted as well as those able to share the same area. As walk-ways and beds are laid out keep in mind three ways in which property should be viewed: a cube, an extension of indoor areas and views into or out of the property.

Once a satisfactory arrangement is worked out, it is time to begin placing plant forms into the plan. Specific plants should not be used at this point. Later, specific plants are matched to plant forms. Trees, shrubs and ground covers should emphasize desirable architectural lines and masses of the house. Pleasing vertical, horizontal and diagonal lines can be echoed by the form and branching pattern of certain trees and shrubs. Other plants can be used to soften harsh architectural angles, masses and materials. Plants can also be used to frame desirable views of the house. Sometimes the best view of a house is from the side. Selective framing allows the viewer to see only the best parts of the house and yard in a sequence that builds curiosity.

The human eye has a tendency to follow the outline of objects in the landscape. This affects the apparent size of a house. **Placing plants of increasing heights away from the house corners increases the apparent length of the house**. This is especially helpful with boxlike, two story structures. It is also useful on a smaller scale to emphasize and lead the eye to an entrance or window. Just the opposite effect occurs when large conical evergreens are placed on either side of an entrance giving it an uninviting, inhibiting appearance.

Foundation plantings became popular when it was necessary to hide exposed foundation walls made of less attractive materials such as concrete block. Foundations on newer homes are rarely exposed for more than 12 inches. This job is easily handled by a ground cover. Older homes often have attractive stone foundations that should be emphasized, not masked.

Plant material need not be limited to evergreens such as boxwood and *Taxus* (yew). Deciduous material can be used to unify the architecture through its branching pattern (i.e., horizontal house lines, horizontal branching pattern). These plants change throughout the seasons and add interest through an infinite variety of color and texture. They can do all of this without distracting from the main feature, the house.

Remember to consider growth habits and cultural requirements of plants you are considering. This is especially important for plants close to the house. Failure to consider the mature height and width of a tree can result in an overgrown, crowded appearance that dwarfs and hides the house. It is also important that soil, moisture, cultural requirements and disease and insect problems be recognized before the plant is purchased. Consult more than one source before making a final decision.

MANAGING TREES AND SHRUBS IN THE LANDSCAPE

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All plants are not created equal. The specific type of plant material selected for the landscape has the ability to make or break a quality design. Consult several references and talk with local gardeners and/or plant professionals before making a final decision on plants to be purchased. Free plants are often the most expensive choice in the long run if they are undesirable for the location. Facts about plants that should be known before purchase are: longevity; susceptibility to diseases and insects; ultimate size; hardiness; and cultural problems, such as litter and storm damage.

It is also undesirable to plant too many of the same species in a region. If a disease or insect were to become a problem, it could result in the destruction of most, if not all, of that type of plant. A good example of this is the American elm. Many of these stately, old trees were killed by a disease called Dutch elm disease in the mid-1900s. In the early 1900s another disease called chestnut blight killed almost all of the American chestnuts in North America. In many parts of the Appalachian Mountains, the American chestnut made up 40 percent of the forest.

Woody ornamental trees and shrubs purchased for a landscape come in one of four forms. These are **balled and burlapped** (often referred to as B&B), **container grown**, **bare root** and **packaged**. Each of these methods has distinct advantages and disadvantages and no one method is best for all plants.

Balled and Burlapped (B&B)

Most trees and shrubs can be purchased B&B. Some plants, such as evergreens (rhododendron, azalea, conifers, etc.), do not survive well unless they are transplanted this way or as container grown material. B&B plants are grown in a field and dug with a ball of soil around the roots. This ball of soil is wrapped with burlap and held in place with twine, nails (called pinning nails) or wire baskets. Burlap has been traditionally made of jute though synthetic fibers are now sometimes used. When planting, it is not necessary to remove pinning nails and jute burlap. Materials made of plastic or treated burlap must be removed.

Treated burlap has been saturated with chemicals to prevent it from rotting in the retail nursery before it is sold. Treated burlap is usually a bright green, orange, or blue color instead of the dull tan of natural burlap. Plastic or synthetic burlap (as well as that which has been treated) keeps roots from growing out into the planting hole. Plastic twine will girdle the trunk and must also be removed. These materials do not break down when buried. Remove all synthetic materials before planting. If you are in doubt, touch a burning match to the material. Plastic melts and jute smolders. If you are still in doubt, remove it.

Wire baskets are also used to hold the burlap and soil ball together. Baskets smaller than 24 inches in diameter should be removed. Larger wire baskets should have as much of the wire near the surface removed as possible once the soil ball is in the planting hole. If wire baskets are left on the root ball, root damage can result as the roots will increase in diameter through the years and the wires will start to constrict root growth which in turn effects plant growth and health.

Plants moved B&B generally experience the least amount of transplant shock of any of the four methods. Soil balls are very heavy, bulky and expensive to ship long distances so are often locally grown. This means they are already acclimated to the climate. This turns into a disadvantage when large soil balls become a problem for homeowners who wish to install their own landscape.

B&B plants must be handled properly during planting. In some areas of the country, winter is an excellent time for planting most types of trees and shrubs. The root system of a plant is less hardy than the above ground system of stems and leaves. As a result, it is important that the soil ball be protected from freezing. It is possible for roots to be killed while the top remains undamaged. When spring growth begins, there is no way for the plant to take up water and nutrients necessary for the continuation of growth. As a result, the entire plant dies.

When planting B&B material, it is important to get the aid of another person if the soil ball is heavy. Never pick up any plant by its trunk. This can result in damage to the root system. The thin roots are not capable of supporting the great weight of the soil ball. Roots can also be damaged severely if the soil ball is dropped or cracks. Heavy soil balls should be placed on a sling of canvas or burlap and moved by two people. While it is not necessary for untreated burlap to be removed, it is a good idea to loosen it from the top of the soil ball and lay it back so that water will be able to penetrate into the soil ball. The remainder of the burlap decays rapidly in the moist soil.

Bare Root

Deciduous fruit and shade trees, flowering shrubs, roses, brambles, strawberries and some annuals are commonly sold bare root. They are generally field grown and gently lifted out of the soil in late fall or early winter. Since plants are shipped without soil, they are 40-70 percent cheaper than the same plant shipped with a soil ball. Setting plants out bare root in fall or winter gives time for roots to regenerate before spring growth begins. The disadvantage of this method of transplanting is that roots exposed to the air dry out very rapidly. Plants must be kept in a cool humid area until planted.

Plant bare root plants within a day after they arrive. If this is not possible, protect roots with moist straw or paper towels and cover with plastic. Store plants in a cool area above 32°F. Roots must be fresh and plump, not dead, dry or withered. Soaking roots for an hour or two in water

before planting will help roots that are alive (but dried down) absorb enough water to cause them to swell up again. A sharp pair of clippers should be used to remove damaged roots before planting. Some plants may also require corrective pruning of the top though it is unnecessary to ever “balance” the top with the roots.

The planting hole should be large enough so roots are not cramped or bent. Spread all roots out in the planting hole. There must be soil around each root just as there was before digging. It will be necessary to stake most bare root trees and large shrubs to prevent wind damage. Never plant a tree or shrub deep to help it stand up.

Dormant plants need less water than those in active growth. If the soil is kept too wet, new roots will fail to form and kill existing roots. Bare root plants are often slower to leaf out in the spring than plants moved with soil.

Packaged

Plants are sometimes dug as if they were going to be sold bare root. Roots are then put into a plastic bag and packed with rotted sawdust or other light weight material. Selling plants this way has the advantage over bare root material that roots are less likely to dry out. However, these plants still need to be watered occasionally and protected from heat and cold. Watering can be difficult since the plastic bags are generally tied tightly at the base of the trunk.

All plastic, packing material and ties must be removed at the time of planting to prevent future problems. This necessitates care at planting to prevent drying out of the roots. Roots must also be carefully spread out in the planting hole as if this was a bare root plant. Packaged plant materials are more common with mass marketing outlets than retail nurseries. Be wary of plants stored on asphalt parking lots. It does not take long for the heat to kill the roots.

Container Grown

Plants grown in containers are popular for many reasons. They are lighter in weight than B&B material and can be shipped for longer distances. They are also cheaper because there is no labor in digging plants from the field. Since the root system is not damaged by a digging operation, plant species that do not regenerate roots efficiently often reestablish better as a container grown specimen than plants moved B&B or dug bare root. This is especially true of plants with tap roots. Container grown plants are available in all seasons for planting whenever installation is desired.

It is important that the plant not be **pot bound**. Pot bound means that roots are circling the inside of the container. Although it may be impossible to look at the root system, you can still tell if a plant has been in the container too long because the top is unusually large for the size of the container, growth is stunted, or dead twigs are present. Roots curling around inside the container often continue to go around in a circle even after planting. This results in loss of vigor as roots run out of soil or begin girdling the trunk choking the flow of nutrients.

Soil used in containers must drain well and be more porous than soil found in the garden. This light, loose medium also favors quick, uniform root development. Roots grow through the path of least resistance. Roots in a light, loose medium are often slow to become reestablished in the new location because of heavier soil they are now in. It is beneficial to unwind long roots and lay them out in the fill soil. A sharp pointed stick can be used to loosen roots or they can be cut at three of four points with a sharp knife.

There are several types of containers that are used for the production of plants. Plastic is the most common and has fewer problems than other systems. Fiber pots are sometimes used. While they are sometimes advertised as being suitable for planting, it is best to remove them before planting. If the rim of the pot is left above the soil surface it wicks water out of the soil ball and prevents moisture from moving into the soil ball from the surrounding soil. Metal containers are cheap but rust, and they must be cut with a can cutter. This leaves sharp edges that can cut hands.

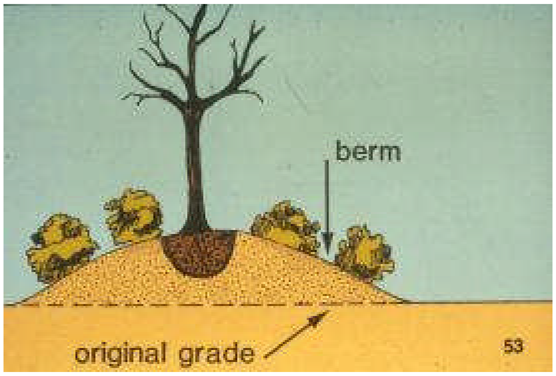
Planting Trees and Shrubs in the Landscape

Planting holes should never be dug when the soil is saturated with water. Side walls of a hole dug in a clay soil become glazed just like a ceramic pot. This smooth side wall prevents roots from going out of the planting hole. Eventually the plant becomes pot bound and declines.

The planting hole should be two to three times the diameter of the soil ball or spread of the roots in the case of bare root plants. The poorer the soil and the more difficult it is to dig the hole, the wider the planting hole should be. **The depth of the planting hole should be equal to the height of the soil ball**. Measure the depth of the hole carefully against the height of the soil ball. It is easier to double check the measurement than to lift a heavy plant out of the hole so that it can be dug deeper or filled.

The most important rule is that the root system should be the same depth as it was previously growing in the nursery. If the newly transplanted tree or shrub is too deep, feeder roots die because of lack of oxygen and the trunk begins to decay. If it is planted too high, the upper part of the root system will dry out and roots die. Decay also occurs when graft unions are buried. Decay organisms that attack the graft union or trunk result in a plant that is stunted, begins to decline and eventually dies.

Some soils do not drain well. If you suspect that the soil you are hoping to use to plant into has this characteristic, you can test prior to planting by filling the hole with water. If it takes more than a day for the hole to drain you will need to select another location or drain the excess water



from the bottom of the hole. This is more easily done on slopes than flat areas. In low areas, you will have to resort to using a raised mound called a **berm**.

Now that you have determined that the planting site will drain properly and the plant has been carefully placed into the hole, you are ready to fill the hole. This soil is called backfill. The only thing that should go back into the planting hole is the soil that came out of it. Rock and other foreign material should be removed but you should not add peat moss, sand, bark, compost or other material to the soil. This is especially true for heavy clay soils. The only exception is when the entire area where the root system will ultimately grow can be modified. The best example is raised beds for rhododendrons and azaleas. Amended soil in the planting hole can hold water like a sponge in a bucket making it too wet for roots.

Roots grow through the path of least resistance. We dig a large planting hole, so that there will be lots of loose soil for new roots to grow in. Amending the backfill can lead to a situation that is like growing a plant in a large container. Eventually the plant becomes pot bound and runs out of water and nutrients.

As soil is put into the planting hole, it should be firmed but never compacted. Firming removes air pockets and prevents settling. Compaction makes the soil so hard that roots will have difficulty growing through the compacted layers. After the hole has been filled about half way, it should be filled with water. This is especially important for large planting holes. After the water has soaked in, fill the remainder of the hole taking care to not compact the wet soil and thoroughly water again. This is easier if a small dike of soil is built around the planting hole so water stands long enough to soak into the soil.

Ericaceous plants (rhododendron, azalea, blueberry, pieris) should be planted in a soil amended with 50 percent sphagnum peat moss. This soil should be mounded up at least 18-inches above the natural grade of the soil and should be wide enough to handle the root system for the life of the plant. Using berms prevent soil from becoming waterlogged and allows oxygen to penetrate these soils. Insufficient oxygen in the soil increases fungal diseases attack roots of plants, and is prevalent in compacted and/or high clay soils.

Mulch

Mulching plants in the landscape can be very advantageous for the plant. After all, most trees and shrubs evolved in woodland areas where a carpet of leaves and small branches provide a year round layer of organic matter on top of the soil. This layer of organic matter decays recycling nutrients for reuse by plants. Over time mulch, regardless of whether it is natural or added by gardeners, improves the quality of the soil. Mulch also conserves moisture and moderates temperature, keeping the soil cooler in the summer and warmer in the winter. Mulching helps control weeds and protects trees from string trimmers and mowing equipment.

With all of these wonderful virtues, it seems that if some mulch is good, more would be even better. Unfortunately this practice is not only wasteful of time and materials but is very detrimental to plant health.

While mulch helps conserve soil moisture, too much mulch can prevent carbon dioxide from escaping from the soil and oxygen from moving into the soil. High levels of carbon dioxide is toxic to roots and oxygen in the soil is essential for roots to take up water and nutrients. When mulch excludes oxygen from the soil, roots die and the plant begins to die. It doesn't take too much excess mulch to damage roots. Generally anything over four inches will have detrimental effects.

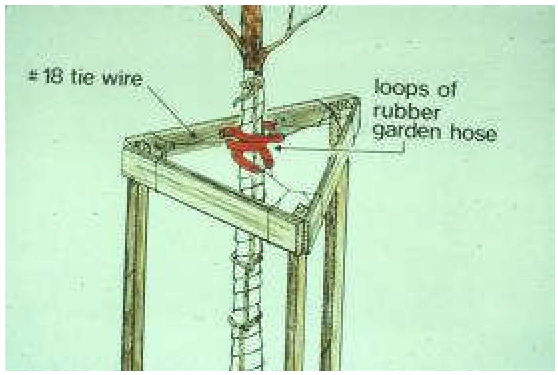
When mulch is too deep, the roots grow up into it. Removal of excess mulch then results in removal of feeder roots. Mulch layers also dry out in summer resulting in roots that are growing in an area that is too dry. Once dry, mulch becomes hydrophobic meaning that it sheds water making it very difficult to rewet. Like planting something too deep, mulch piled up on the trunk also causes decay. Mulch against the trunk is also a great shelter for insects, mice and other small mammals that will feed on the trunk.

Staking

Trees should be staked only when there is a real danger that they will blow over. If the plant was dug with a soil ball sized according to the *American Standard for Nursery Stock*, there should be little danger that it will blow over except in very windy sites. Very large plant material is often staked to keep it straight as it settles. Staking has also been shown to reduce vandalism.

The reasons not to stake trees are stronger than the reasons for staking. Trunk diameter of unstaked plants increases faster than tightly staked trees. Staked trees also grow taller more quickly than unstaked trees. This means that a tree that has been tightly staked may be more likely to blow over a year later than one allowed to sway in the wind.

If staking is deemed necessary, it is best to use three stakes rather than one (crossing the trunk) or two vertical stakes. Stakes must be driven far enough into the ground to prevent them from being pulled out. They should also be outside the planting hole where the soil is firm. Stakes may be short or long but in either case the securing lines should be attached approximately 1/2 of the way up the trunk. **Metal wires are sometimes used to guy the tree but must never go around the trunk**. A piece of rubber hose is sometimes used around the wire with the thought that it protects trees from being girdled. Unfortunately the rubber hose does almost as much damage as a piece of wire. Using a piece of cloth or broad nylon strap around the trunk is much better protection for the trunk.



Leave enough slack for the tree to sway gently in the wind. The purpose of staking is to protect the tree from blowing over in high winds. Never leave staking on trees for more than one year. Check the supporting straps frequently, especially in early spring. Excessively tight ties can girdle the trunk as it increases in diameter.

Pruning

Most plants show increased vigor and benefit aesthetically from pruning at some point in their life. Pruning is done to **improve the form of the plant**. Examples of this include removal of lower limbs so that attractive bark can be admired or to create a tree form from a large multistemmed shrub. Pruning is also necessary to **improve the health of the tree and improve safety to people and property**. This includes removal of diseased, dead and dying branches. The third major reason is for **correction of problems**. This includes shaping of hedges, removal of crossing branches, branches with narrow crotches, those that grow toward the center of the tree, multiple leaders and suckers, or those growing towards water sprouts. Pruning is a method of rejuvenating plants. Removal of old wood in flowering shrubs will cause the plant to produce young, vigorous shoots with an abundance of flowers.

On small stems, pruning cuts should be made back to a live bud when shearing and shaping shrubs (i.e. boxwood, juniper, holly and yew). Other plants like privet have the ability to produce an abundance of adventitious buds on older branches. Privets can be pruned as far back as is necessary to control their height. Doing this to a juniper will result in a dead plant.

Sometimes large branches must be removed. Removing the offending branch as soon as possible results in a smaller wound than if it is done later and it will seal over more quickly. Plants do not heal when they are injured. Healing is the repairing and replacing of damaged tissues, something only animals can do. Plants seal or close over wounds and develop chemical and/or physical barriers to wood rotting organisms (bacteria, fungi, etc.).

When a branch is removed, it should be cut at the point where it comes out of a larger branch or a smaller branch comes out of it. The smaller branch should be at least a third the diameter of the one being removed.

At the base of every branch is a **collar** (Fig.13) that has the ability to develop a chemical zone to inhibit the spread of decay in the trunk. If a long stub is left, this chemical barrier will not develop. If the pruning cut is made flush with the trunk this special layer of cells is removed. In either case, wood rotting organisms will be able to progress into the trunk causing heart rot. **Sapwood** (outer few annual rings) and **heartwood** (inner part of an older tree) are not dead, useless tissue. It is very important for structural support, conducting water and nutrients from roots and storage of **carbohydrates** (sugars and starches). Stored carbohydrates are the energy source for buds in early spring until young leaves develop enough to begin making sugars (also a carbohydrate) for continuation of growth.

Occasionally large branches need to be removed. If the branch is out of reach or near utility lines, its removal is a job for a professional arborist. If the branch is over 3-inches in diameter it can be safely removed using the **three cut method** (Fig. 13). The first cut is made from the lower side of the branch, 6 to 8-inches away from the collar. This cut is made only a third of the way through the branch. The second cut is made from the upper surface of the branch all the way through the branch several inches further out from the first cut. As the branch falls, bark peels back only to the first cut. Now that the weight of the branch has been removed, the third cut can be made without danger of damaging the trunk. The type of pruning equipment used is important.

Clippers come in two types, scissors and anvil. The scissors type has two blades that pass to make the cut. The anvil type has a single blade coming down onto a flat surface to make the cut. The latter type tends to crush stems on the bottom as the cut is made. Damaged tissues are a prime site for entry of disease organisms. The scissors type of pruner is generally preferred on woody plants. The anvil type is satisfactory in floral work where crushing the stem aids the uptake of water. Using clippers that are too small for the job can also result in damage to the branch. Pruning saws do a better job on large branches. A pruning saw differs from a carpenter's saw. While the teeth of a pruning saw cuts as it is pulled, a carpenter's saw cuts as it is pushed. This makes it easier to make cuts at or above shoulder level.

Pruning paints should never be used. We paint our houses to keep the wood from rotting. Common sense tells us that paint will also help prevent decay in trees. Pruning paints (also called wound dressing) not only does not prevent decay, they actually increase the rate of decay in living trees. A heavy asphalt wound dressing is even worse because it inhibits formation of wound wood (callus roll) that seals over the wound. A light coating of shellac may be used for cosmetic purposes but does nothing for the tree.

Protecting the Plant

Lawn Equipment - The **greatest single cause of damage to young trees** in the landscape comes from lawn equipment. Mowers and string trimmers damage bark on trunks they contact. Sometimes the only evidence of damage is lack of vigor. Wounding reduces the flow of sugars from leaves to roots and is an excellent site for entry of insects and microorganisms. The best way to protect the plant from lawn equipment is to control weeds at the base with herbicides (being careful not to get them on any part of the tree) or a layer of mulch. Herbicides that contact tree trunks can also cause serious damage. Some herbicides are absorbed by tree roots and translocated to the remainder of the plant. Use caution when using any herbicide near trees and shrubs.

Sun Scald - Sun scald is a physiological disorder generally found on young, recently transplanted, thin barked trees in the landscape growing in colder regions of the country. It is closely associated with water deficiencies in the trunk. On cold, sunny days the sun warms the trunk well above freezing. Cell dormancy is broken. When the sun goes behind a cloud or below the horizon the trunk temperature drops rapidly resulting in freezing and death of cells just below the bark. Damage does not show up until late spring or early summer when the bark begins cracking and peeling off. As time passes, the wood begins to decay where bark is missing.

Sunscald occurs most often on the southwest side of the tree. Reflected light or heat can result in damage to other parts of the trunk. Sun scald does not occur on mature trees because their thicker bark protects them against sudden changes in temperature. It is not found on young trees in a forest because of shading provided by the larger trees.

Sun scald is thought to result from crushing and severing of roots which prevents the uptake of water. This is especially serious when plants are dug with small soil balls. It can also occur when heavy items (foot traffic, equipment, building materials, etc.) crush the young feeder roots. The solution is to protect roots from damage. Wrapping the trunk with plastic screen or commercially available wrapping materials may help by shading the trunk. Paper type wraps should be put on from the bottom up to the first branches. Overlap each previous layer so that water is shed. Tree wraps should be put on in late fall and removed in early spring. Failure to remove tree wraps before summer can result in damage from girdling, boring insects and wood rotting organisms.

Frost Crack - Frost crack is another problem associated with winter though it can occur in areas that never freeze. Because of this, radial shake is a better term for this disorder. Radial shakes result from water stress within the trunk. Cracks begin at the point of a wound and become large, deep cracks. These cracks move mainly in an upward manner. They may be inactive for several years only to open up as a result of temperature differences or drought. The only solution is to prevent wounding.

Animals - Rabbits, mice and deer can be a problem in winter months when other food sources are limited. Hardware cloth around the trunk helps protect it. It must be at least 18-inches above the snow level to provide protection from rabbits. Scraping mulch back for 6 to 8-inches from trunks makes the site less favorable for mice. Moderate to good control of mice can be obtained by poison baits if they are kept dry. Hot pepper sprays to the plant and small bars of perfumed soaps have had limited success as repellants. Deer fencing (at least eight feet tall) and reducing the deer population have been the only really effective measure when this animal becomes a pest.

Fertilization

Woody ornamentals growing in fertile soils show little response to applications of phosphorus and potassium. Only a soil test will indicate if a soil is deficient in one of these elements. Most woody plants in the landscape respond only to nitrogen.

Fertilizer should be applied to woody landscape plants in fall after leaf drop. Roots grow any time the soil is at or above freezing. This continues until the soil warms up to about 55°F in the spring. At that point, growth begins on the shoots. As warming continues shoots grow more rapidly than roots. Fall fertilization with nitrogen encourages development of a good root system followed by good shoot growth the following spring. Fertilization in spring promotes growth of shoots without root growth. If there is more shoot growth than roots are able to support, leaf desiccation will occur during dry periods. Late summer applications of nitrogen delay hardening of the plant for winter, resulting in injury or death.

Mycorrhizae

Most woody plants have a **symbiotic relationship** with certain fungi called mycorrhizae. Symbiosis is when two different organisms live together better than either could separately. We normally think of fungi as causing plants to become sick or decay. In this case certain types of fungi are actually beneficial to plants. They are found everywhere that plants are and some plants can’t live at all without them. These fungi and plants have had this mutually beneficial relationship for many millions of years.

Mycorrhizae live on or in root tips and grow out into the soil. They are much more efficient than plant roots at exploring soil and absorbing water and nutrients that are then passed along to the plant. In return, they get carbohydrates (sugars) from the plant that they would not otherwise be able to make for themselves.

Since mycorrhizae are beneficial to plants, we want to do everything possible to encourage them in landscapes. Excessive amounts of nitrogen fertilizer will kill them as will de-icing salt, fungicides and many other chemicals. They will not grow in alkaline soils or soils low in oxygen, especially those that are compacted. Moisture is important but saturated soils kills them. These unique fungi like soils with organic matter.

Over time organic mulches decay and enter the soil making an area more favorable for the growth of these essential fungi. In brief, all of the soil conditions that we have recognized that promote good plant growth are also good for the growth of mycorrhizae. Loose, moist, friable soils that are slightly acid, have some organic matter and are well drained produce the healthiest plants and mycorrhizae. Landscape plants could use a helping hand on poorer sites like disturbed soils found in new subdivisions. Unfortunately assistance is not going to come from mycorrhizae because they are not going to be able to live under these conditions either.

The growth and development of plants is not clear cut and straight forward. One action often effects several other things that are going on in the environment. As we are all on the planet earth as guests of the plant kingdom, it is important that we learn as much as we can about how everything works together as a unit. The more we understand, the fewer mistakes we are likely to make.

Environment and Horticultural Plants

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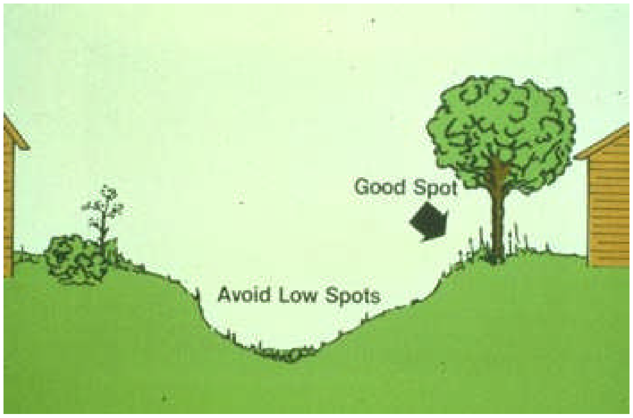


Horticultural plants grow in response to their environment. Plants are cultivated from many areas of the world. Each has a different set of environmental conditions to which the plant has become adapted. Much of horticulture is concerned with modifying plant environments to enhance growth. This chapter covers several of the major environmental factors that influence plant growth and the influence of climatic variations on horticultural plants.

Climate

Climate is the combined effects of temperature, light and elements of moisture such as clouds, rain, hail, snow and wind. Climate usually refers to long term weather patterns in a region or as it is often called, **macroclimate**.

Temperatures are greatest at the earth's surface near the equator where the sun's rays strike directly. As you move north or south from the equator it gradually becomes cooler. Altitude also influences temperatures with cooler temperatures occurring at higher altitudes. Climatic patterns are also altered by large bodies of water nearby. More energy is required to raise the temperature of water than air. Water releases this energy as it cools. Thus, water acts as a buffer for nearby land areas and reduces temperature extremes. Inland areas of the U.S. lack the protection of large bodies of water and experience high summer temperatures and cold, arctic fronts in the winter.

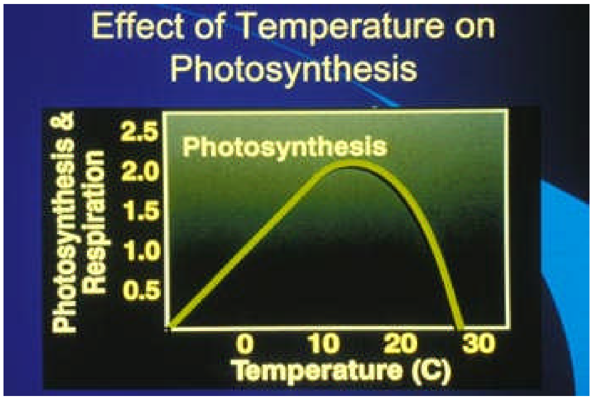
Mountains also alter climate by blocking natural wind and moisture movement. Several areas of the Pacific northwest have wet, rainy areas on the ocean side of mountains and dry areas on the inland side. Vegetation also influences climate. Forested areas have a higher relative humidity. This and additional evaporation of water from tree leaves has a cooling effect.

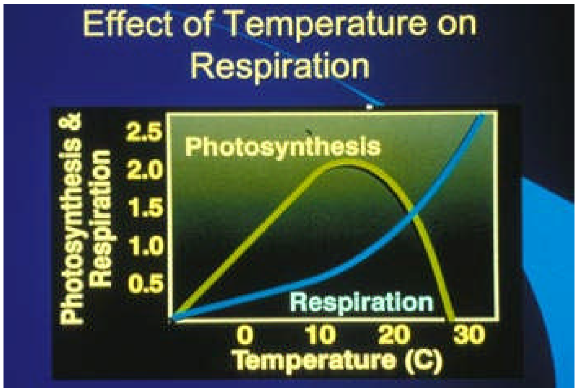
Human activities also influence climate. Large reservoirs have been constructed in many areas. Metropolitan areas are warmed by combustion used in heating and by buildings, streets and other structures absorbing and holding heat. Dust, environmental pollutants and smoke also alter the climate. A concern in many areas of the eastern U.S., Canada and Europe is acid rain, formed as rainfall absorbs acidic materials from air pollution. All of these macroclimate differences have an effect on plant species growing in an area and may cause climatic variations.

Microclimate refers to the climate in a small area such as near a plant or in a yard or garden. Cold air is heavier than warm air and tends to settle in low areas creating a **temperature inversion**. Temperatures in low areas can be several degrees cooler than surrounding hillsides. These pockets of cold air are called frost pockets. Orchards are generally located on hillsides to avoid areas likely to damage flowers in early spring. Selecting a home site on a sloping area can also avoid low temperature injury to ornamentals in the fall and spring. Carefully locating plants around a home can take advantage of microclimate differences. Shade loving plants can be grown on north or east exposures and plants can be protected from the blast of west or north winds by planting them on the protected side of the house. Horticulturists need to be aware of the influence of climate in a particular area, both macroclimates and microclimates. Selection and growth of horticultural plants is directly influenced by climate.

Temperature

Temperature largely determines what can be grown in a particular area. **Photosynthesis** (the conversion of solar energy for use by the plant) and **respiration** (the using of stored energy compounds in the plant for growth and development) are regulated by temperature. With most biological reactions **each 10°C (18°F) increase in temperature doubles the rate of the reaction**. Therefore, we expect the rate of growth at 68°F to be twice as fast as at 50°F. This relationship is known as **Q10**. Each plant has an optimum temperature for growth and development . There is a maximum temperature where plant growth stops and permanent injury to the plant occurs. Likewise, there is a minimum temperature where plant growth stops and freezing or chilling injury occurs.





Cool Season Plants

Depending on their area of native adaptation, plants prefer cooler or warmer temperatures. Cool loving plants tolerate temperatures slightly below the 32°F. Growth is poor at warmer temperatures. Examples of **cool season plants** include vegetables (cabbage, broccoli, lettuce, radishes, peas), flowers (crocus, daffodil, tulips, violets), fruits (apples, pears, plums, American grapes) and shrubs (forsythia, lilac, spirea, honeysuckle). Cool season plants prefer average daily temperatures below 70°F. Premature seed stalk formation or **bolting** of biennial vegetables is a problem for cool season crops. Cool temperatures following planting compresses their natural growth cycle and seed stalks often form later in the season.

Warm Season Plants

Some plants prefer temperatures above 70°F and are usually injured by freezing temperatures. Sometimes these plants are called **nonhardy** or **tender plants**, while those that can withstand freezing temperatures are called **hardy plants**. Examples of warm season crops are vegetables (beans, tomatoes, sweet corn, melons), flowers (roses, lilies tropical foliage plants) and fruits (peaches, apricots, sweet cherries).

Freezing Injury

When the temperature drops below 32°F there is a chance of injury to some plants. This is frequently called **frost injury**. Frost is ice formation on a surface while plant injury occurs only when ice forms within the plant. Generally, the period just before dawn is the time when the temperature reaches the lowest point and freezing injury occurs. Freezing injury results in an immediate water soaked, blackened appearance that quickly turns brown and dies. It is a common horticultural practice to cover plants with insulating materials or sprinkle plants with water to prevent freezing temperatures from occurring within the plant. While water from a sprinkler may feel very cold it has some heat energy that is passed on to the plant. There is a lot of current research on treatments to allow plants to be exposed to lower temperatures without injury and to understand the mechanism of freezing injury to plant tissues.

Chilling Injury

Injury can occur to warm season plants or products exposed to low temperatures. This low temperature injury is called **chilling injury** and results from a malfunction in the normal plant growth processes rather than the freezing of water within the plant. Crops such as cucumbers, tomatoes, tropical fruits and most tropical foliage plants, are subject to chilling injury. The development of chilling injury usually results in rapid respiration, the development of rots and molds, bitter or "off flavors" and abnormal colors. Chilling injury may occur at temperatures below 45-50°F in many plants or products. You see it when a banana turns black after being placed in a refrigerator.

Rest Period

There are periods when a plant or seed does not grow despite favorable conditions. These periods are called **rest periods**. They usually coincide with the natural period of dormancy for perennial plants during the winter. During this time deciduous plants lose their leaves and herbaceous plants are frozen back to the ground. Buds of woody plants do not grow due to physiological and biochemical processes. Following a period of cold, the buds break (end) their rest period and continue growth. The temperature and hours needed to break dormancy has been determined for many plants. Fruit varieties are grouped by their requirement of hours at or below a critical temperature (usually 40°F) to break the rest period. Desirable environmental conditions are necessary to resume growth following the breaking of the rest period.

Many temperate plants produce seeds with a natural rest period following ripening. This rest period can only be broken by exposure to cold temperatures for a period of time. This process is called **stratification**. We can artificially stratify seeds by storing them in a moist medium such as peat moss or sand at near freezing temperatures (usually 40°F) for a number of weeks. This breaks the normal rest period and allows the seeds to germinate uniformly.

Woody Plant Survival

An example of hardiness has already been provided for annual plants tolerant to low temperatures. Woody plants can also tolerate low temperatures to varying degrees. Native plants have, through the years, adapted to withstand low temperatures and are said to be hardy to the area where they evolved. The level of low winter temperatures that a particular type of plant can withstand has been determined for most woody plant species. The United States is divided into areas called **plant hardiness zones**. The zones are numbered 1-10 from colder to warmer areas. This map was developed by the US Department of Agriculture.

Woody ornamental plants survive average normal low winter temperatures in these areas and plants can be characterized by their adaptation to these climatic zones. It must be remembered that these zones are based on the average of all of the lowest winter temperatures recorded over a 50 year period. In certain extreme years, such as in January 1994, severe damage to plant material occurred because the temperatures were so much colder than normally would be expected. Damage also frequently occurs to normally hardy plants when an unusually early frost or freeze hits plants before they are fully dormant or in the spring after they have begun to lose dormancy.

Modifying Temperatures

Much of horticulture is involved in altering the environment to improve plant growth. Areas of horticultural production have developed in areas where natural protection from temperature extremes exists. Such protection is provided by large bodies of water such as the western area of Michigan and the western areas of New York bordering the Great Lakes. Buildings, streets, etc. in large cities absorb heat and reradiate it at night providing several degrees of warmth against the first freezing temperatures of the fall.

Growing plants in a managed environment like a greenhouse was developed to provide a favorable temperature during adverse periods. There are other examples of treatments horticulturists use to modify temperature. These including the use of **mulches**. Black or clear plastic absorbs heat and transfers it to the soil encouraging earlier plant growth in the spring. **Hotcaps** or **hot-tents** - paper or plastic covers also serve as miniature greenhouses to modify the microclimate around transplants in the spring.

Sheets of fiberglass or porous plastic are frequently placed over rows of plants to warm them in the spring. This type of structure is called a **cloche** (pronounced klosh) or row cover. Another example or a specialized plant growing structure is a **hotbed** or **coldframe** used to start seedling plants. Water mist is frequently used as a means of reducing freezing temperature injury. The protection provided by water mist is based on the principle that as water freezes it gives off heat. Thus, as the water freezes it gives off enough heat to protect plants for a few degrees. Other examples of frost protection include **smudge pots**, **stoves** and **air turbulators** used in orchards to force warmer air around plant surfaces. Horticulturists continue to study ways to understand the mechanisms of temperature injury, ways of improving the adaptation of plants to temperature extremes and ways of altering the temperature around horticultural plants to improve their growth.

Water

A brief drive through the desert, failure to water a pot of flowers, or wilted lettuce on a salad bar reminds us of the importance of water for plant growth and development. Just as with temperature extremes, plants have adapted to grow in areas of low water availability. Thick, fleshy leaves, layers of wax, specialized structures for water storage and other mechanisms help plants survive in areas of limited water. Such plants are called **xerophitic**.

Water in the Plant and Soil

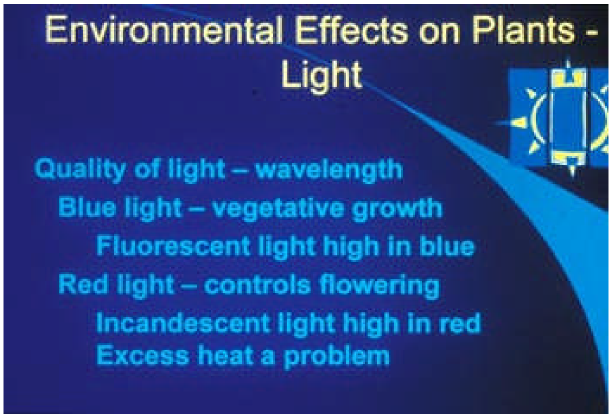
Water constitutes an important part of plants. Living plants need a constant flow of water from the roots to leaves to continue their life processes. Water in plant cells provides pressure on cell walls, called **turgor pressure**, keeping the plant rigid. Water is an important constituent of photosynthesis. Water flows from the root, up the stem and into the leaves in specialized conducting cells called **xylem** cells. Movement of nutrients and other constituents flow in water in the plant as well. Pressure from water in the cell enables cells to enlarge and expand. Water not used by plant cells evaporates and moves out of the leaf through small pores or openings in the leaf surface called **stomata**. Evaporation of water from the leaf is called **transpiration**. Evaporation of water from the leaf has a cooling effect and reduces temperatures in the surrounding environment.

Water moves into root cells from the soil. Soils differ in the amount of water that they can hold. Sandy soils hold less water than loam or clay soils. Water available to a plant from a particular soil is called the **soil water potential**. Some water is held so tightly by the soil that the plant cannot extract it. Water that the plant can extract from the soil is called **available water**. The root system develops in the soil to obtain water for the plant. Sudden flooding of the soil cuts off oxygen to the root system and causes root death. Plants in flooded locations can die quickly from such injury. Too much water can be as serious a problem as not enough water. For this reason, a greenhouse manager must carefully monitor the water level in containers to provide the proper amount of water to meet the crop's needs. In field situations, drainage tiles or pipes are often installed to allow excess water to be removed. Water is lost from soils by evaporation from the soil surface. **Evaporation** of water from soil combined with loss of water through the plant (**transpiration**) is referred to by the combined word **evapotranspiration**, or loss of water by plant and soil combined.

Applying Water to Plants

Horticultural production has developed where water is abundant. Applying water to supplement rainfall is a standard practice for many horticultural crops. Irrigation should replace water removed by plants. Considerations in irrigation amounts and frequency depend on the needs of the crop, the depth of roots and the ability of the soil to absorb water. A certain portion of the water is lost to evaporation before it reaches the soil. On a windy day a sprinkler system putting out a fine mist may lose 25-30% of the water applied before it reaches the soil. Drip or trickle irrigation allows small amounts of water to be applied frequently to a portion of the root zone. This reduces the amount of water needed to grow a crop.

Effects of Limited Water Availability



For many horticultural plants there is a period of critical water need when water may not be available. For most plants this is during the period of flowering and fruit development. A symptom of water need is wilting of the foliage. Plants are affected by stress before the external symptom of wilting occurs. Emphasis on water levels necessary to support plant growth and scheduling irrigation to minimize water use is important. Water needs can be predicted from climatic factors such as temperature, humidity, wind and solar radiation combined with particular characteristics of the crop and soil type. Microcomputers assemble various weather factors and develop predictions and schedules for adding supplemental water. Fluctuations in water available can cause sudden splitting of cherries, tomatoes and cabbage. Uniform water supplies are necessary to prevent these problems.

Light

Light is essential for **photosynthesis**. Green plants are the original solar collectors. They transfer energy from the sun to a usable form of energy for the plant. Light varies in **intensity**, **quality** and **duration** or **photoperiod**.

Intensity

The intensity or amount of light available has a direct influence on the amount of photo-synthesis that can occur. Some plants have adapted to growing in areas of low light availability such as a jungle floor. This is why tropical foliage plants grow well in limited indoor light. Grasses are native to the open plains and require high light intensity for growth. When light intensity is lowered, the rate of photosynthesis is reduced. When the **level of photosynthesis equals respiration**, it is referred to as the **compensation point**. Below compensation point growth ceases.

Sudden exposure to high light intensity can cause leaf scorch or sunburning. The symptoms are large, brown, dead areas on leaves. Plants growing in low light have a thinner layer of wax on leaf surfaces. This helps the leaf to capture more light. However, moving it suddenly into bright light results in rapid water loss. High light intensity can also cause fading of flowers, especially in hot summer weather. An area of special interest to the greenhouse industry is the use of high intensity lights to supplement natural light and to extend the photoperiod. Crops of high value make the expense of installing and operating high intensity supplemental lights economical.

Light Quality

Light **quality** refers to the "color" of the light or the portion of the light spectrum. The biochemical constituents of chlorophyll, the compound responsible for photosynthesis, absorb only light from particular portions of the light spectrum. Artificial lights supply light of particular portions of the spectrum. Light absorbed by plants is from the blue-violet and orange-red parts of the spectrum. Specialized lamps have been developed to provide light rich in wavelengths from this part of the spectrum. These lamps have the additional benefit of creating dark green foliage and a deep, intense flower color. Excellent plant growth can be achieved with ordinary fluorescent bulbs. Other portions of the spectrum such as ultraviolet light are important in the coloration of some fruits and the development of autumn color in leaves.

Photoperiod

The daily duration of light is important for many plants. The lengths of light and dark period in a 24 hour cycle influences the blooming response of many plants. Some plants form flowers with shorter day lengths (usually less than 12 hours). These plants are called **short-day plants** and grow without blooming during days with long photoperiods. Other plants are **long-day plants** and form flowers during longer days (usually 14 hours or longer). The most common examples of short-day plants are poinsettia and chrysanthemum that flower during the shorter days of autumn. Examples of long-day plants include many of our summer flowering annuals. Greenhouse producers must know the photoperiod requirements of plants and alter the day length to induce flowering at the proper time. Days are shortened by covering greenhouse benches with dark shade cloth. Day length is extended by artificial lights over the benches. Many plants are day **neutral**. These plants are not influenced by the number of hours of light. A common example is the tomato that blooms and fruits with favorable temperatures during any day length.

While we speak of day length, it is important to remember that it is really the length of the dark period that makes the difference. To keep a shortday plant from flowering naturally in the fall we only have to break up the dark period into two shorter segments. For some plants as little as five minutes of light in the middle of the night will keep it from flowering.

Relative Humidity and Wind

Relative humidity is the amount of water vapor in the air. It is closely related to temperature. As the temperature goes down, relative humidity goes up. Relative humidity is measured as a percent. When it reaches 100% we have rain, snow, fog, or sleet. This is why it rains as a cold front goes through.

As the relative humidity drops, evaporation increases. Plants leaves give off more water at 40% than 80% relative humidity. This water loss increases if the wind is blowing. Tropical foliage plants are native of humid, jungle environments and often suffer in the dry, indoor air in winter. Grouping plants together and placing plants on a layer of pebbles in standing water helps increase relative humidity. Lowering the interior temperature of homes is beneficial in reducing some of the low humidity problems with plants.

Humidity is often related to the development of certain plant diseases. Warm, damp conditions are ideal to encourage the growth of fungi. Many fungal spores must have water to begin growing. Damping off is a common problem for seedlings. It results from fungi rotting small plants at the soil line. Increasing air circulation to lower humidity and reducing watering can generally stop the problem.

Wind is a problem with plant production in some areas. In addition to blowing away valuable soil, wind can also cause injury to tender plant stems by sandblasting the stems at the soil line. New transplants and newly planted trees are often shaded as a protection from hot sun and wind. In many areas of the Great Plains of the U.S., the planting of rows of trees in a windbreak protects homes and animals. Strong winds in storms damage many trees and shrubs each year. Wind damage is especially severe when it is in combination with ice. The plant species is also important. Trees such as silver maple, Siberian elm and willow are more frequently injured by wind than oak, walnut and sugar maple.

Interrelationships

Plants are influenced simultaneously by all segments of their environment. As light intensity increases, temperature generally increases with a corresponding increase in photosynthesis and water loss by the plant. Many times horticulturists must alter one environmental factor as another changes. When light levels are reduced, a greenhouse manager will often lower temperatures. Without the temperature reduction, plants become tall and spindly. The reduction in temperature limits the problem. Although a lot is known about environment factors that influence horticultural plants, much is still to be learned. Urban conditions influence plants in both positive and negative ways. Learning to compensate for these negative influences will become more important in the future.

PLANT PROPAGATION

Tom Clark
Mount Holyoke College Botanic Garden

Propagating new plants is both a science and an art. The study of it can provide a lifetime of challenges and opportunities to learn more about this fascinating craft, or a basic knowledge of it can provide the home gardener with the skills and techniques to keep their garden well stocked with new plants. Plant propagation is the multiplication of plants by both sexual and asexual means. From the home gardener starting a few tomato plants from seed on the kitchen windowsill, to the conservationist growing endangered species of orchids in test tubes, to the nurseries that grow the millions of annuals, perennials, bulbs, shrubs and trees sold ever year, a working knowledge of plant propagation makes all of these endeavors possible.

Propagation Methods

There are probably as many methods of propagating plants as there are reasons for wanting to do so, but there are basically two types of propagation -- **sexual** and **asexual**. Nearly all plants in nature have the ability to reproduce sexually, that is, by **seed**. Along with producing seed they have developed many modifications that aid in the dispersal of that seed. Such modifications include:

- Seeds being enclosed in colorful fruits that are attractive to animals that eat the fruits and deposit the seeds elsewhere.
- Seeds with wing-like or tufted appendages that enable the seed to be carried by the wind.
- Seeds that are hooked or barbed that are easily attached to the coats of animals or out clothing and carried away.
- Seeds that can float thousands of miles away to wash up on a tropical island (such as a coconut).

Many types of plants in nature have also evolved means by which they can reproduce asexually. Some such means include strawberry runners, potato tubers, and Johnsongrass rhizomes.

Along with all the natural modifications, people have developed many ways to propagate plants more efficiently and ways that meet the needs of both the agricultural communities and the horticultural trade. Seeds can be treated in various ways to achieve better and more uniform germination rates. Cuttings of various plants can be rooted in greenhouses when the parent plants are under three feet of snow. The highly specialized techniques involved in micropropagation allow growers to produce thousands of genetically identical plants, tissues (thus the term tissue culture), or cells. Learning about these procedures and many others makes plant propagaton a tremendous way to expand one's knowledge of plants and gardening, and can lead to an interesting and rewarding profession.

Sexual Plant Propagation

Sexual propagation of flowering plants, as opposed to ferns and mosses, begins with flowering, followed by pollination, fertilization and seed production. Seeds are used in large-scale agriculture and forestry operations for growing wheat, corn, alfalfa and tree seedlings for reforestation projects. Propagation by seeds is also critical to many aspects of horticulture including the establishment of many turfgrasses, bedding plants, and a wide range of trees and shrubs, although propagation of many of these types of plants is not restricted to sexual propagation. Sexual propagation has several advantages when compared with asexual methods.

- It is generally the cheapest method.
- It generally requires the fewest skills, specialized equipment or facilities, and is thus the easiest method.
- Seed can be easily stored, often for several years, and still successfully germinated.
- Seeds are cheaply and easily shipped or transported around the world.
- If properly cleaned and stored, seeds are less likely to carry diseases.

Seedlings are likely to be genetically different from the parent plant – this may be desirable for research, breeding, plant selection and conservation work, but may be undesirable in regards to other interests.

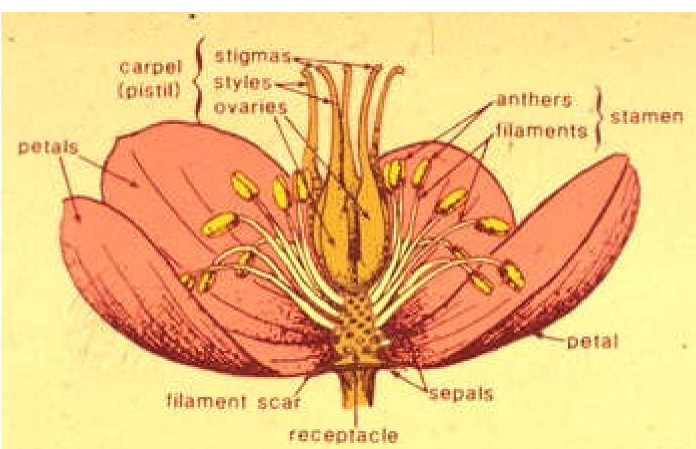
Some disadvantages of using this method include:

- Some plants don't produce live, (viable), seeds, and thus can not be grown this way.
- Seeds may take a long time to grow into mature plants.
- Seedlings are likely to be genetically different from parent plant, and may not have the same desirable characteristics.

The genetically difference is often especially true for many cultivars and hybrids.

Development of Seeds

For centuries people have grown plants for the beauty of the flowers – the spectrum of colors, the multitude of shapes, the intoxicating fragrances and the meaning we have associated with various flowers in relation to holidays and traditions. However, the basic function of flowers is to be pollinated so seeds can develop, grow and perpetuate the species. It is obvious just by casual observation that all flowers are not created equal, but flower types can be grouped in terms of their structure and how it relates to pollination and seed production.



Perfect flowers are individual flowers that have both male and female parts. The male part of a flower is known as the **stamen** and is made up of the **anther** and the **filament**. The female part of the flower is known as the **pistil** and is composed of the **stigma**, **style** and **ovary**. Perfect flowers may have one or many stamens and pistils in each flower. **Imperfect flowers** lack one or more of the parts that make up the stamen or pistil.

Some flowers contain only male or only female parts. When a plant develops separate male flowers, (**staminate flowers**), and separate female flowers, (**pistillate flowers**), and both occur on the same plant, the plant is referred to as **monoecious**. Examples of monoecious plants include corn, walnuts and many conifers. With corn, the tassels at the top of the plant are the male flowers, and the silks and young ear represent the female flowers.

Dioecious plants have separate pistillate and staminate flowers, but they are **always on separate plants**, thus you will have plants with **only female flowers** and others with **only male flowers**. Dioecious plants include hollies, date palm, asparagus and Ginkgo biloba. Male plants will never produce seeds or fruit. Females will only set fruit if a compatible male plant is nearby, neither male nor female plants will die if they are not close to each other however.

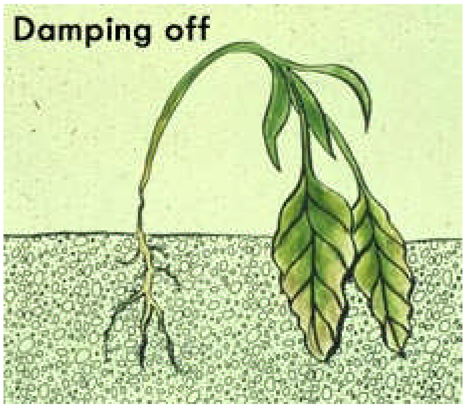
Pollination involves the transfer of pollen grains from the anther to the stigma. A variety of bees, butterflies, moths and birds are responsible for pollinating a wide range of plants. Flowers often attract pollinators by various characteristics such as color and color patterns, shape, fragrance, offer of food, or, in the case of many orchids, resembling a potential mate for the would-be pollinator. Other plants rely on wind to carry the pollen grains. Conifers and grasses, including many of our grain crops, are wind pollinated.

Once the pollen grain lands on a receptive stigma a **pollen tube** begins to grow downward through the style to the ovary where fertilization occurs. Often there are many ovules (eggs) within the ovary. The ovary will develop into the fruit and each **ovule** will develop into a seed.

Growing Plants from Seed

The success achieved when growing plants from seed is dependent on several factors including the seed itself, the medium and the conditions to which the seed and seedlings are subjected. The seed used should be of high quality and, usually, the newer the seed, the better the germination and subsequent seedling growth will be.

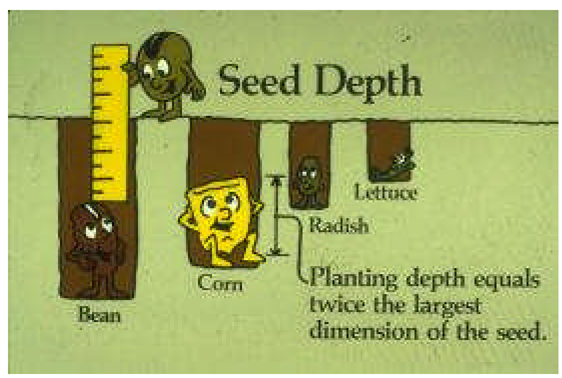
The **medium** refers to the soil into or onto which the seeds are sown. Whatever seed sowing mix is used, it should be free of weed seeds, harmful insects and pathogens that may prevent germination or kill the young seedlings.

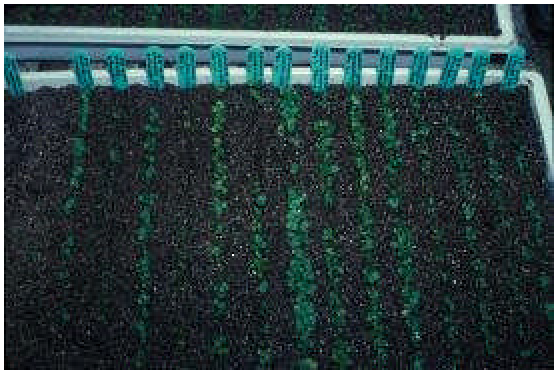


A disease known as **damping-off** is one of the most troublesome problems encountered if soil and sowing containers are contaminated. The mix should also be free-draining and should not remain soggy after watering. There are several ingredients that can be used to create a suitable medium. Common components include peat moss, vermiculite (a mineral), perlite (a material of volcanic origin – often mistakenly identified as Styrofoam in soil mixes), sand, fine milled bark, compost and milled sphagnum moss. Fortunately there are several very good, bagged mixes available in garden centers, but as you experiment with growing various types of plants from seed you may prefer to mix your own special blend.

The most common bagged mixes contain peat moss and vermiculite, and often a small amount of fertilizer to get the seedlings off to a strong start. Whatever seed mix is used, it need not be particularly rich in nutrients. It is much more important to have a mix with proper physical qualities. Once the seedlings are growing, attention can then be shifted to proper feeding with a dilute, water soluble fertilizer if necessary.

Seeds can be sown into almost any type of container, but of course, clay or plastic pots or flats are logical choices. The pots or flats should be sterilized before use (a dilute solution of bleach and water works well), and there must be drainage holes to allow excess water to drain away. When sowing the seed, the surface of the media should be even, firm (but not compacted), and slightly moistened. The depth of planting will vary with the type of plant being grown. A general rule is to **plant seed at a depth of one to four times the thickness of the seed**. There are, however, some seeds that require light for germination and should be left uncovered, and just to keep you on your toes, there are others for which light can inhibit germination! This is one reason why it is wise to do a little background check on the seed you are about to sow, or at the very least, read the seed packet that often has much useful information. Once sown, it is essential that the medium remains moist but not overly wet. Maintain the correct moisture level by placing seed pots in a plastic bag or a propagating case (creating an enclosed environment for high humidity), but keep a close eye on the temperature within. The widest range of the most commonly grown annual and biennial flowers, and vegetable plants germinate best between 65-75°F.



Depending on the seeds, germination will often occur within one to three weeks, but there are others that will take longer. Once the seedlings emerge, it is important that they receive good light, otherwise seedlings will be spindly, weak and quite difficult to transplant. It is often a good idea to lower the temperature by 5-10°F which will slow growth, but will help to keep the plants stocky.

Seeds of many plants, especially woody plants and perennials, have physical or chemical inhibitors within the seed that prevent the seed from germinating even if the proper medium, temperature and moisture levels are present. The good propagator has several techniques that will effectively overcome these natural barriers to germination. One such method is called **stratification**. This involves giving the seeds a moist, cool treatment. Frequently seeds are mixed with moist peat moss, vermiculite or sand, put in a plastic bag and placed in the refrigerator, (35-40°F), for a certain length of time - 90 days is a common duration.

The process of soaking up water is known as **imbibition**, and is the first step in germination. Certain seeds have hard, impervious seed coats that prevent water from being absorbed thus delaying germination. **Scarification** is a method often used to overcome this problem. Scarification involves wearing away at the seed coat to allow water in to the embryo. This can be done mechanically with a file, piece of sandpaper, or by carefully nicking the seed coat with a knife. Some propagators dealing with large numbers of seed will use various acids to eat away at the seed coat, but this is a very refined technique in which great attention must be paid to the concentration of acid, and to the duration for which the seeds are soaked.

There are many other techniques and “tricks” that propagators employ to get certain seeds to germinate. Many plants that have adapted to habitats prone to fire have developed seeds that rely on fire as a precondition to germinating. Other seeds germinate only when a certain microorganism is present in the soil, or when a particular plant is already growing. With many South African plants, exposing the seed to smoke is beneficial or necessary to germination. As much as we know about seeds and how to grow them, there is still much that we do not fully understand. Until we have all the “recipes” for germinating seeds down to an exact science, a good basic knowledge of the techniques along with personal experience will go a long way in bringing success to your seed sowing efforts.

Ferns from Spores

Ferns are one of the first groups of plants to be trendy. They were all the rage in Victorian times, but have since quietly gone out of favor. That is, up until recently when there has been renewed interest in this diverse group of plants, largely from native plant enthusiasts. Ferns belong to a group of plants known as Pteridophytes which also includes mosses and others. In terms of plant classification, they are amongst the most primitive members of the plant kingdom. As a group, the pteridophytes are often referred to as the lower plants with flowering plants being known as higher plants. Ferns do not flower and thus do not produce seeds, but rather produce spores. Because of this, ferns have a distinctly different life cycle. Ferns typically produce a great abundance of spores that makes it possible to grow thousands of plants from a single, mature fern plant if the conditions are suitable.

To propagate ferns from spores, the spores must be ripe (just as with seed). The medium onto which spores should be sown can be the same as that used for seed sowing, although it is critical that it be sterile. Spores are dust-like, therefore sow them very sparsely, as it is very easy to sow too many! The pot containing the spores should go in a plastic bag and then be placed in a warm, bright spot, but not in direct sun. The humidity within the bag should remain high. The speed at which fern spores germinate varies greatly depending on the species. Check the bag frequently to make sure the pot doesn't dry out. The first signs of life will be a green film developing on the surface of the medium. When this appears, mist the surface often. Gradually, young fern plants will begin to develop. When the young plants are large enough to handle easily, they can be transplanted to individual pots.

Many ferns can also be propagated using various asexual methods including division, bulblets, plantlets and micropropagation.

Asexual Plant Propagations

Asexual propagation is the production of plants using the vegetative parts of a plant. Vegetative parts include stems, leaves, roots, bulbs, corms, tubers, tuberous roots, rhizomes, and undifferentiated tissue often used in micropropagation. Propagation by division, cuttings, layering and grafting are all forms of asexual propagation. Although many plants can be propagated by at least one asexual method, there are some that for one reason or another can not. When compared to sexual methods, asexual methods have certain advantages.

- Plants are genetically identical to the parents so plants with desirable characteristics can be reliably cloned.
- It allows propagation of plants that do not produce seed, produce little seed, or are difficult or impossible to grow from seed.
- A grower can get a saleable or mature plant more quickly for many plants.

Some disadvantages include:

- Asexual methods are generally more expensive.
- Many asexual methods require greater skill, and/or special equipment or facilities.
- There is an increased likelihood of spreading or perpetuating certain diseases.

- Clones can become weakened and lose vigor after years of asexual production, although this is by no means a general rule.

Division

Dividing plants is probably the simplest form of asexual propagation. This method is regularly used in the propagation of a wide range of herbaceous perennials such as daylilies, Siberian iris, bee balm and ornamental grasses. It essentially involves splitting a single large plant with many crowns or growing points into several individual smaller plants. It is labor intensive, and for that reason is a last option for commercial nurseries when there is no other viable method of propagating a particular plant.

Cuttings

Cuttings can be taken from a variety of plant parts – stems, leaves, roots, buds – but not all plants can be propagated by cuttings and certainly few, if any, can be grown from all types mentioned. The plant from which the cuttings are taken is referred to as the stock plant or parent plant. There are many factors that effect the type of cutting used as well as the success achieved with a certain type of cutting, and include:

- The type of plant being considered for propagation,
- The age and health of the stock plant,
- The time of year, and
- The facilities, equipment and material available for propagation.

When taking any type of cutting, keep in mind that by removing the cutting from the parent plant, it is cut off from its supply of moisture and is instantly under stress. This is a particularly important consideration when dealing with leafy cuttings such as herbaceous, softwood and semihardwood cuttings. To reduce stress on the cuttings, take cuttings on cool, cloudy days; place cuttings in a plastic bag along with a damp paper towel until they can be inserted in the rooting medium; and prepare cuttings quickly. Also, make sure that cuttings are labeled with the plant name, the date taken and any special treatment given the cuttings, such as a particular hormone used. This can help you learn more about a plant and may be useful if you want to take cuttings again next year.

The **rooting medium** used can vary greatly from grower to grower, and may vary depending on the type of plant being propagated. The medium must provide support for the cutting to keep it upright. It must also hold an adequate amount of moisture and allow for oxygen to reach the root zone. Although rooting media are similar to seed sowing mixes, they are generally coarser. A mix of half peat moss and half perlite is commonly used, but many mixes exist to meet the needs of different plants, or simply produce good results for the nursery or gardener using them.

Water is the most critical aspect in the rooting process – too much and the cuttings are deprived of oxygen and the likelihood of disease is greatly increased, too little and the cuttings suffer, wilt and will root slowly, if at all. Professional growers and nurseries use mist or fog systems to maintain ideal moisture and humidity levels. These systems are controlled by a humidistat, timer, or a unit called an electronic leaf.

Light is also an important factor, at least for stem cuttings with leaves and leaf cuttings. Light is necessary for these types so the plant can continue to photosynthesize and produce carbohydrates needed for the development of roots. Too much sunlight, however is to be avoided as this can cause the cuttings to dry out too quickly. The **temperature** can also have an effect on root formation. Good success can be achieved with an air temperature of around 65°F for a wide range of cuttings. Often, roots will form even more quickly if bottom heat maintains the rooting media about 10°F warmer.

Auxins are one class of **plant hormones** that occur naturally in plants. **Rooting hormones** used by propagators are synthetic versions of these compounds. Used correctly, these types of hormones can hasten rooting, lead to denser root systems and help avoid certain disease problems. They are available as liquids or powders and vary in their concentrations of active ingredient. The bases of stem cuttings are dipped into the material and then inserted in the medium. Two common rooting hormones are **napthaleneacetic acid**, (NAA), and **indolebutyric acid**, (IBA). Care should be taken when using hormones as certain cuttings can be damaged by the incorrect strength. These materials break down quite quickly in light so they should be stored in an appropriate manner.

Types of Cuttings

Stem cuttings are certainly the most important type of cuttings in regards to commercial plant production. They can be divided into four groups based on the nature and maturity of the piece of stem used – hardwood, semi-hardwood, softwood and herbaceous. With the exception of hardwood cuttings which are often longer, cuttings of approximately three to five inches are ideal, although cuttings taken from certain dwarf plants will necessarily be shorter.

When taking cuttings work with a clean, sharp, knife or hand pruners. Cuts should generally be made just below a node, (the point at which a leaf joins the stem, and the point at which roots form most readily), and the leaves on the lower one-third to one-half of the stem should be removed prior to insertion into the media. The basic cutting is referred to as a **simple** or **straight cutting**. **Heal cuttings** are made by breaking a small, young shoot from the side of a branch. This will keep a small portion of the stem attached to the cutting. **Mallet cuttings** are similar but have a complete cross section of the main stem. Some evergreens root better when heal or mallet cuttings are used.

Wounding the base of cuttings of certain plants such as rhododendrons, hollies, magnolias and others can promote root production. Wounds are generally made by stripping lower leaves and some bark from the cutting or by cutting off a thin slice of bark from the lower third of the cutting.

Leaf cuttings and **leaf bud cuttings** are useful for propagating plants such as African violets, snakeplant, piggy-back plant and some begonias. A section of leaf, the entire leaf or the leaf and associated bud are inserted into a typical cutting media. In all cases, the cutting does not became a permanent part of the plant, but gradually disintegrates after the new, young plant is established.

A fairly wide range of plants can be propagated by **root cuttings**. Oriental poppies, certain species of phlox and roses, blackberries, raspberries, Japanese flowering quince among others are all likely candidates for this method. The biggest drawback to this technique is that it involves digging the parent plant out of the ground, or at the very least, severing much of the root system to get at the necessary root pieces. Root pieces can be from 1-6 inches long depending on how coarse the roots are – the finer the roots the shorter the segments. If root cuttings are inserted into media vertically it is essential that they avoid being put in upside down, thus maintaining correct **polarity**. In other words, the end of the root closest to the crown of the plant should be up and the farthest point should be down. Root cuttings of some plants can be laid horizontally, side stepping this problem altogether.

Bulbs are specialized organs with a growing point surrounded by thick fleshy scales. Tulips, onions, lilies and daffodils are all bulbous plants. Techniques for propagating bulbous plants include scaling, basal cutting, offsets and micropropagation.

Layering is yet another form of asexual propagation and is a method that encourages the development of roots on a stem while it is still attached to the parent plant. Tip layering involves bending a branch to the ground, wounding the branch where it touches the ground and covering it with some soil. Roots develop and soon send out new shoots. At this point the new plant can be cut off from the stock plant, lifted from the ground and transplanted. Black and purple raspberries, forsythia, spirea and many other common shrubs can be grown from tip layers.

Air layering is a similar technique but is a bit more involved and is used when a branch can not be bent to the ground. This technique can be used to propagate several tropical and sub-tropical trees and shrubs such as croton, rubber trees, and philodendron. The stem is wounded and the wound is covered with a generous amount of longfibered sphagnum moss. The moss is then wrapped in a sheet of plastic that is tied off above and below the wound. The new plant can be cut off and planted once roots are visible through the plastic.

Underground Structures

Many plants produce specialized structures beneath the soil that are generally used as food storage organs on which the plant relies during adverse growing conditions. Bulbs, corms, tuberous roots, tuberous stems, tubers, rhizomes and pseudobulbs are all such organs. Frequently, though technically incorrect, all or several of these structures are referred to as "bulbs." To the propagator they are often convenient means of producing plants that have developed these sorts of structures.

A **corm** is made up of the swollen base of a stem surrounded by dry, scaly leaves. Crocus and gladiolus grow from corms. Corms are propagated by inducing the natural reproduction of new corms and by the cultivation of cormels, which are also naturally produced during the plants life cycle.

A **rhizome** is a specialized stem structure that grows at or just below ground level such as in bearded Iris, lily of the valley, sugar cane and many grasses. Typically they are easily propagated by simple division or by a special type of cutting.

A **tuber** is a swollen stem structure that serves as an underground storage organ with nodes, often called eyes, from which shoots emerge. The potato, Jerusalem artichoke and caladiums are all tuber-producing plans. Tubers are easily propagated by dividing them into sections, with each section containing at least one eye.

Pseudobulbs, (meaning, “false bulb”), are typical storage structure of members of the orchid family. Pseudobulbs are readily separated from the parent plant as a means of propagation.

Grafting and Budding

Grafting and budding are both forms of asexual plant propagation. They both consist of connecting two pieces of living plant tissue in a way that allows the parts to unite and subsequently grow and develop as a single plant.

In any form of grafting, a piece of stem or shoot with dormant buds is the part that will grow and develop with branches. This part is known as the **scion**. In budding, the scion is reduced to a single bud with an attached pad of bark and cambium. The part of the graft that will develop into the root system is known as the **stock**, **rootstock** or **understock**. The stock can be comprised of a root system, a sapling or, for the purposes of topworking, a mature tree that has been reduced to a trunk and main scaffold branches. Fruits and nuts, as well as roses, lilacs, dwarf conifers and many ornamentals with unique habits are examples of plants that are frequently grafted.

There are several different types of grafts – splice, whip, cleft, approach, wedge, and others are all variations that have different applications for different situations and reasons for wanting to graft in the first place.

The reasons for grafting are quite varied and, among others, include:

- To perpetuate clones that can not be propagated, or are not easily done so by other methods.
- To obtain the benefits of certain root stocks, such as to control height, habit or vigor, or to impart disease resistance.

- To change the cultivar of established plants through a technique known as topworking.
- To obtain special growth habits or forms.
- To repair damaged parts of trees.

There are, however, certain disadvantages:

- It is frequently more expensive.
- Grafting and budding are fairly specialized skills, thus require great experience to be able to make grafts.
- Diseases are readily transmitted.
- Rootstock suckers can be troublesome and can weaken the growth of the scion.

Not just any scion and stock can be grafted successfully. The two parts must be from closely related plants. Plants from different families are incompatible and this is frequently true for plants in different genera within the same family. A scion and stock that can be successfully grafted are said to be **compatible**. A pairing that is incompatible will simply not grow, or will grow but never form a successful graft union leading to failure sometimes years from the time when the graft was first made. The time of year can also play a role in the success or failure of a graft. One technique that is sometimes employed to overcome the problem of incompatibility is to use an interstock. An interstock is a piece of stem inserted between the scion and stock that forms graft unions with both. An interstock is also useful, in some cases, for imparting hardiness or a growth regulating property.

When it comes to the actual act of grafting, the most critical point is that the cambium layers in the scion and stock be in close contact. The cambium is a layer of cells between the bark and the heartwood. This layer of cells is capable of dividing and forming new cells, forming callus in the process, that are necessary in order for the graft to be successful. It is important that the cambium layers do not dry out during the grafting process. The graft union is where the scion and stock are joined.

Micropropagation

Micropropagation, or tissue **culture** as it is also called, is the most cutting-edge means of propagating plants. It involves propagating plants from small plant parts, tissues or cells in specialized conditions in which the growing environment and nutrition are strictly controlled.

The basic principles of tissue culture have been known for about 100 years and such theories were suggested as long ago as the early 1800's. By 1939 scientists in the United States and France had made significant discoveries. Within another ten years, researchers had laid a solid foundation for today's large-scale tissue culture laboratories, propagation facilities, and further advances through ongoing research. It was not until recent decades that micropropagation became a feasible means of producing plants for the nursery industry. Today, many plants are propagated in this way. In catalogs, the names of plants that have been propagated by tissue culture methods are often followed by "TC" in parentheses. With every passing year more and more advances are made, and an increasingly wide range of plants find their way into the many tissue culture facilities which are appearing at an equally rapid pace.

Tissue culture makes use of an in vitro system. In vitro is from the Latin for “in glass,” that is in reference to the fact that plant tissues are developed in test tubes and flasks under laboratory conditions. The multiplication of plants in vitro does not create a new process within the plant, it simply directs and enhances the plants natural potential to put forth new growth and multiply in a highly efficient and predictable way.

There are several advantages to micropropagation when compared with traditional asexual methods of propagation.

- Plants can be mass-produced rapidly.
- A new plant can generally be introduced to the nursery industry more quickly.
- Tissue cultured plants are free of insect and disease pests when removed from test tubes.
- The growth of in vitro cultures requires little care on a day to day basis, apart from casual surveillance.

There are also several disadvantages.

- More expensive. The start-up costs for a commercial micropropagation facility are high.
- The techniques used require greater skill and training.
- Not all plants can be produced through tissue culture.
- Mutations may occur during the culturing process resulting in plants different from the parent. This can be disastrous if not noticed at an early stage.

The success of tissue culture for reproducing new plants is based on the ability of small plant parts, tissues or cells to undergo rapid cell multiplication under the proper chemical and physical conditions, and then to differentiate into the various parts that make up an entire plant. The plant part, tissue or cell type that is removed from a stock plant for purposes of being cultured is known as the explant. The explant can be a shoot tip, root tip, leaf tissue, pollen grain, seedling tissue, bulb scales and others.

There exist a number of factors that will effect the success of generating new plants by micropropagation. Sterility is of the utmost importance at all stages. Lab conditions are essential and much of the great expense is attributable to the need for such facilities. All surfaces with which the explant may come in contact, including countertops, tools and human hands, need to be sterile. The growth medium and glassware in which the new plants will be cultured must also be sterile. Apart from sterility, the explant itself and the culture conditions (light, medium, temperature) all play significant roles in the success.

The type of explant taken from a parent plant will also effect the generation of new cell growth and the subsequent new plants. Certain explant types work better for certain plants.

The medium used in tissue culture is unlike that used in any other type of plant propagation. A semi-solid, gelatinous material called agar is used. This provides support for the culture, but by itself is essentially inert. What is mixed in with the agar is what stimulates new growth. These ingredients will vary depending on the plant being cultured, as will the concentrations used.

Ingredients include inorganic salts of many essential plant nutrients and organic compounds like carbohydrates, vitamins, various hormones and growth regulators.

The four sequential stages in all tissue culture systems are:

1. Establishment
2. Multiplication
3. Pre-transplant
4. Transplant

The purpose of the **establishment stage** is to establish a sterile explant in culture. The initial explants from the first stage have developed a mass of shoots that are separated into individual propagules and transferred to a fresh medium culture. This second medium is frequently the same or similar to that used in Stage 1, but the concentrations of certain ingredients may be altered.

The **pre-transplant stage** is necessary to prepare the grown propagules, now known as plantlets, for the shift from the rigidly controlled in vitro environment to that of a more typical plant growth environment, usually in a greenhouse. The pre-transplant stage also offers an opportunity to cull mutated propagules or ones that somehow became infected with a disease.

The **transplant stage** is the point at which the plantlets are moved to a pasteurized soil mix essentially as seedlings would be transplanted. At this point the plantlets are very tender and dry air and/or bright sunlight can easily burn them. Gradually, humidity levels can be reduced and more sunlight provided to the young plants at which point they should be established and growing under standard conditions.

GREENHOUSE STRUCTURES

Greg Stack
University of Illinois

Floriculture crop production differs from other types of horticultural crop production in that it utilizes a structure called a greenhouse. A greenhouse is nothing more than a building that is covered with a material that allows light to reach the plants inside. It also serves as a barrier to the outside environment so that the inside environment can be controlled. This is a very simple view of the structures we call greenhouses. What you will find out though, is that greenhouse structures have come to be very sophisticated. This sophistication allows growers of floriculture crops to produce many types of crops, of high quality, on a very timely schedule.

Types of Structures

Styles of greenhouses vary widely. How they are built and what they are built with is often the result of factors such as budget, material availability, area of the country, crops to be grown and long term use. There are three basic styles of greenhouses: lean-to, even span and ridge and furrow.

Lean-To Greenhouse

Lean-to greenhouses have one side attached to a building. The building supports the roof at the ridge. One might look at this style of greenhouse as half of an even span greenhouse. Such greenhouses are best located on the south side of a building for maximum exposure to the sun.

Even Span Greenhouse

These are single houses that have roofs with an even pitch and an even width. They have pitched roofs like a house with straight sides and two gable ends. This type of structure is what one usually envisions when the word greenhouse is mentioned. The framework is usually made from wood, aluminum or steel. The covering tends to be permanent or semi-permanent material like glass or structured sheets.

Hoop houses have evolved from the even span greenhouse style. Hoop houses are constructed from bent tubular pipe for the framework, which is then covered with some type of plastic. Hoop houses are low cost alternatives to even span structures. Hoop houses are often used as temporary holding houses or long term growing structures. Many growers utilize hoop house structures as a way of economizing on structures while still being able to grow an excellent product. Hoop houses would require recovering with plastic every 3-4 years.

Ridge and Furrow Greenhouse

This type of structure consists of a number of even span greenhouses connected along the length of the house. All shared walls are eliminated giving you more growing space. These houses are sometimes called gutter connected because gutters are installed where the houses are joined to help move water. It is best to site ridge and furrow greenhouses in a north-south direction to help reduce the amount of shadows cast by the gutters.

Another greenhouse style that is a modification of the ridge and furrow house is a style called Venlo. Venlo houses are ridge and furrow houses where the gable ends are very narrow. This narrow gable end allows for the use of narrower bars and wider, single panes of glass to be used on the roof. This type of construction allows for a high percentage of winter light to reach the crop. Venlo structures are a product of Dutch horticulture and are used widely in Holland. Many northern U.S. growers are now using this type of structure where reduced winter sunlight tends to be a limiting factor in growing some crops.

Greenhouse Framework

Frameworks provide the support for the covering material. This framework needs to be strong yet narrow enough to permit maximum light with the fewest shadows. Wood such as redwood or cypress was the material of choice for many early structures. Wood requires costly maintenance in the form of painting, however. Today's greenhouses are made from aluminum, aluminum/steel combination or galvanized steel. All of these are long lasting and maintenance free.

Greenhouse Coverings

The covering on a greenhouse is also called glazing. The factors that go into selecting a glazing material are cost, durability, light transmission and heat loss. When glazing a greenhouse, three types of materials are available: polyethylene, structured sheets and glass.

Polyethylene (Poly)

Polyethylene is the number one covering and is used on the majority of all new greenhouses built today. It is nearly always a double sheet that is blown 3-6 inches apart by a small "squirrel cage" blower fan. The air space that is created provides for great insulation. A good, tight fitting inflated poly house will use about one-third less fuel than a single glass roof structure. This tight fit can have its drawbacks though. Poly houses can't "breathe" and this results in high humidity levels. The high humidity encourages fungal diseases, especially Botrytis. Also, double poly-covered greenhouses reduce the light levels to 75-80 percent. In the winter, this can be a factor in crop production.

Much of the poly being used has a useful life of 3-4 years. The greenhouse is then recovered because the poly starts to break down due to the effects of UV light.

Polyethylene coverings are constantly improving. Manufactures are now able to address issues such as excessive dripping inside poly houses, breakdown by UV radiation and heat retention. In the case of heat retention, infrared (IR) poly is able to diffuse sunlight, giving the house more available light and keep the heat (infrared energy) in. Plants use visible light for photosynthesis, so this diffusion helps plant growth.

Glass

Glass is probably the third choice of glazing material. Glass is the top of the line glazing material because of its light transmission capabilities and long life. When glass is used, several types can be selected. Most glass for greenhouses is double strength B (DSB) glass. Also available are triple strength, tempered triple strength and low-iron glass. The last type permits more and better light transmission.

Structured Sheets

Structured sheets can be made from three materials: polycarbonate, acrylics and fiberglass.

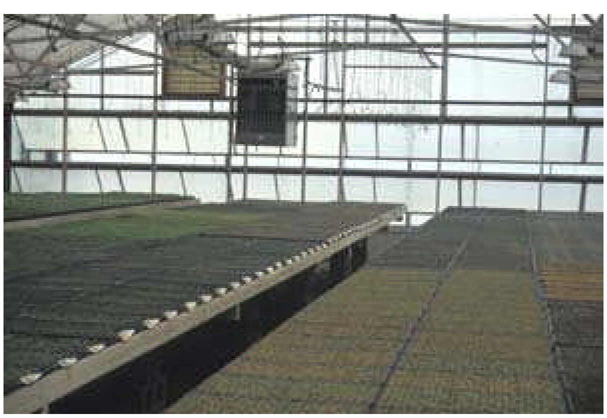
Polycarbonates are the most widely used structured sheets. They are manufactured as twin walls held together by ribs and looking almost like corrugated cardboard. The hollow tubes that hold the sheets together offer an effective dead air space that provides insulation and helps reduce heating costs. Polycarbonates offer good light penetration, up to 80 percent. Polycarbonate sheets are treated with UV inhibitors, which gives them a useful life of about 10 years. They are also very flexible being able to be bent around hoop houses. Polycarbonate coverings also have good hail damage resistance and fire resistance. Polycarbonates can be expensive, costing about 75 cents to one dollar per sq. ft. as compared to glass which costs about 60 to 65 cents per sq. ft.

Acrylic structured sheets are made the same way polycarbonate sheets are made. Thus, they offer similar insulation value. Acrylics offer better light transmission, up to 86 percent. Acrylics last about 8-10 years. Acrylics are less flexible than polycarbonates and are more prone to damage by hail. They also tend to burn easier.

Fiberglass was widely used in the 1960's and 1970's. Its use has declined significantly due to newer materials such as the polycarbonates and acrylics being made available. Fiberglass has a tendency to discolor after about 8-10 years reducing light transmission greatly. It also burns very easily and has no great insulation value.

Retractable Roof Greenhouses

Retractable roof greenhouses are becoming more popular with commercial growers. These structures have entire roofs that can be opened and closed. Retractable roof greenhouses are designed for crops such as bedding plants, perennials and field grown cup flowers that would prefer to be outdoors but can't take the rain and cold early in the season. In this case, the entire roof can be open when weather conditions are favorable for growing and closed when the weather starts to get inclement. When needed, parts of the roof can be pulled back and folded up by electric motors. Entire roofs can be opened or closed in minutes. Woven polyethylene is used to cover retractable roof greenhouses. This type of poly is six times stronger than regular poly.



Greenhouse Benches

Benches are structures that hold the crop off the floor. In a production greenhouse, crops can be grown on benches, on the floor, or in beds. Benches provide several advantages:

- The crop is at a convenient height,
- Allowance for good water drainage, and

- Good air movement around the crop.

Benches can be made out of a variety of materials ranging from expanded aluminum, steel, plastic or wood. Bench construction can be elaborate or simply the positioning of wood pallets on top of concrete block "legs."

In the early 1990's, many greenhouses converted to a style of bench called rolling benches which have now become the standard in many new greenhouse ranges. Rolling benches may be rolled several feet sideways either left or right. A typical greenhouse may have four benches and four walks. With rolling benches, they now have only one walk, which can be, positioned anywhere a grower wants simply by rolling the bench sideways. Large sections of rolling benches are designed to be easily moved, even when full, by one person.

The advantage to rolling benches is that growers can now use approximately 86-88 percent of the space available compared to 62-66 percent with standard fixed benches. This allows growers to produce about one-third more crop per year in their greenhouse.

Controlling the Greenhouse Environment

Greenhouses are becoming more and more complex. Managing the interior environment calls for controlling not only temperature but also irrigation, shade curtains, supplemental light, CO2 levels, mist and many other inputs. In order to accomplish the monitoring and control of systems, greenhouses rely on several types of controls. They include thermostats, analog controls, computer controls and computerized environmental management.

Thermostats are of two types: on-off and proportioning. Both are inexpensive and easy to install. On-off thermostats control fans, heaters and vents with a change in temperature. Proportioning devices provide continuous control of systems with temperature changes.

Analog controls utilize electronic sensors so that the operations of heating and cooling can be integrated giving better performance than with thermostats alone.

Computerized controls utilize microprocessors, which can make complex judgements based on information from sensors placed throughout the greenhouse.

Computerized environmental management offers the greatest flexibility. This system allows you to tie all of the equipment together giving unlimited environmental options. These systems are based on using zones within the greenhouse. Each zone has sensors that gather and send information to the computer to adjust the environment based upon certain parameters. Many growers now use some type of computer-assisted environmental management. This allows the grower to do a better job of providing the optimum environment without the added worry of having to do it manually.

Energy and Shade Curtains

Energy curtains are automated "window shades" that are installed gutter to gutter and can be automatically opened or closed based upon light levels or temperature. Many modern greenhouses are now making use of curtains that serve two main functions. First, they can help reduce light levels during the day providing some needed light shade for crops and, by pulling the curtains closed at sunset and opening them at sunrise, major fuel economies, up to 25-30 percent can be realized.

The same type of technology is applied to short day curtains. The purpose of short day curtains is to reduce day length to trigger flowering in short day crops like kalanchoe, poinsettia and chrysanthemums. It is the same as the black cloth idea.

Greenhouse Heating Systems

Three types of heating systems are used in greenhouses: hot water, steam and forced hot air. New greenhouse construction as well as those being remodeled, tend to use hot water as the source of heat. Modern boilers are small and very efficient. A hot water system consists of a boiler that heats the water and pumps that move it through pipes placed in the greenhouse. Pipes are generally placed under the benches, along the walls or buried in a porous concrete floor. Hot water systems have relatively low maintenance. Heat is also delivered evenly and can be adjusted as needed into zones for growing crops with different heat requirements.

Steam heat has been the standard method of greenhouse heating for a long time. Boilers tend to be large and require more maintenance. The boiler brings water to the boiling point providing steam. Steam flows through pipes, condenses and the water returned to the boiler. Steam heat does not tend to be as uniform as hot water nor is it easy to adjust temperatures. Steam heat can be an advantage in that it can be used to sterilize soil for greenhouse use.

Many small growers as well as new growing operations rely on low cost **unit or forced hot air** heaters. These units are hung in the greenhouse and, depending on the size of the greenhouse may require several units positioned in the greenhouse space. Air is heated within the units and blown by fans throughout the greenhouse. In order for the heated air to be distributed most efficiently, growers use large perforated poly tubes and fan jets to collect the hot air and move it the entire length of the greenhouse.

They may also use **horizontal airflow fans (HAF)** to move the heated air in the greenhouse. These fans are hung from the ceiling and are positioned to blow air in one direction down one side of the greenhouse and in the opposite direction down the other side of the greenhouse. This effectively sets up a circular air pattern moving heated air around the greenhouse. An advantage of the fan jet or HAF system is that they can be used without turning on the heaters. This can provide for air movement during warm days helping to cool the greenhouse as well as reducing conditions (warm, moist, still) that enhances disease.

Infrared heating is another system that is used in greenhouses and it is similar to how the sun heats the earth. Infrared systems are mounted in the peaks of the greenhouse. Energy is reflected directly down to the crops below. The plants, soil, benches and floor absorb the heat and transfer it to the plants and air space around them. The plants and soil are kept at the desired temperature, but the air in the greenhouse peak is kept much cooler. Infrared is most cost effective in the taller greenhouse structures that are now being built.

Greenhouse Cooling and Ventilation

The main form of cooling and ventilation in a greenhouse is done through the use of vents. Vents are located along the ridge of the greenhouse and along the sidewalls. When temperatures get too high, motorized vents are activated and open to allow hot air to escape. The design of newer greenhouses has lead to whole roof sections being able to be opened resulting in maximum ventilation.

Many greenhouses utilize cooling systems called **fan and pad systems**. These systems involve the use of a "wet wall" of cellulose pads installed along one side or in the end wall of the greenhouse. The pads are kept wet by a system of pumps and gutters that recirculate water. On the opposite end of the greenhouse is a series of fans. The fans are sized correctly so they pull air through the pads and across the greenhouse. As outside air passes through the pads, the water evaporates and as it does so it is cooled. This cool air is pulled across the greenhouse lowering the temperature inside.

Air is the coolest closest to the pads, warming up as it exists. The amount of cooling possible with fan and pad cooling varies with the dryness of the air. This changes not only by location in the country, but also the time of the year.

Some greenhouses combine both vents and fan and pad cooling. Initial cooling is done with vents open and when the temperature starts to rise, the vents shut and the fan and pad system is turned on.

Automation

There has been a revolution of sorts in the greenhouse business as many growers are utilizing technology to reduce the amount of human labor inputs when it comes to the most repetitive, labor intensive tasks. The labor required to fill pots, flats, seed, transplant, space, move plants, water, harvest and package is costly. Labor alone can account for about 30-35 percent of production costs. Technological developments have allowed greenhouse growers to utilize computers and robotics to grow more and better crops with less human handling.

The technology found in today's greenhouses can be a marvel to watch. Large greenhouse ranges can be filled with hundreds of thousands of plants and managed by only a few employees. Growers are now using automatic pot and flat fillers, automated precision seeders and transplanters, and mechanized tray systems to move whole benches of plants at the push of a button. Robots that can space plants and also grade them for the most uniform product are being used in today's greenhouses.

All of this is not without cost. Automatic seeders can cost from $4,000 - $30,000, transplanters $65,000 - $120,000, and pot fillers from $15,000 - $28,000. Growers have found that even though costs are high for such equipment, the savings in labor and increased production can justify such investments. Not every grower can afford to install such equipment. This does not mean they will not be successful in the greenhouse business. They may find a product, market or niche that allows them to be successful still using a conventional labor force.

Greehouse Growing Media and Fertility

The health and quality of floriculture crops rest largely with the growing media and how it is handled nutritionally. In outdoor gardening, the growing medium is soil. In greenhouse production, a variety of materials are used as growing media. Most mediums used in greenhouse production today consist of a mixture of two or more materials. These materials are other things besides soil. Soil is being used less frequently now than ever before. Growers are using more media that has no soil at all.

These media that lack any soil are often referred to as soilless mixes. Soilless mixes are the standard of the industry today. The one big advantage is that they are uniform and can be produced with a high degree of consistency. Growers either purchase prepared growing media in bulk or mix their own.

Materials that are often components of soilless mixes include sand, sphagnum peat moss, coir, vermiculite, pine bark, perlite, plastic foam beads, and rock wool. When combined in the right proportions these materials are able to provide and excellent medium for growing plants. The decision as to which materials to use is often a matter of cost, availability and grower preference.

Peat moss is an organic material harvested from bogs in Canada, Michigan and Florida. Peat has good moisture retention, good air space qualities, and good capacity to hold on the nutrients.

Coir is made from waste products of the coconut industry. It has similar qualities as peat. It has high water holding abilities and excellent drainage. It also encourages faster rooting of plants.

Vermiculite has its origins in the mineral mica. When heated, mica expands like an accordion. Vermiculite has good water holding capacity and good nutrient holding capacity.

Perlite is a volcanic rock that is also heated resulting in particles that look like tiny white beads. It is very light weight and is a good substitute for sand. It provides good water drainage and good aeration. It has very little ability to hold on to nutrients.

Bark is a by-product of the timber industry. Pine bark is most often used in growing medium. After being composted, it is incorporated into mixes and provides moisture holding ability and aeration. It is the second most used component after peat moss.

Sand is the result of weathered rock. It is heavy and helps to improve drainage and aeration in mixes using soil. When used in peat or bark based media it can actually reduce aeration and drainage because it fills up all of the pore spaces.

Plastic foam is styrofoam beads. It does improve the drainage and aeration, but it does little to improve water holding or nutrient holding capacity.

Rock wool is made from the rock called basalt. After heating it and causing it to liquefy, it is spun into fibers that look like cotton candy. Rock wool is often used in the propagation phase of growing where it is pressed into cubes and used for the rooting of cuttings.

Fertilizers in the Greenhouse

There are basically two ways fertilizer can be delivered to greenhouse crops. One is through the use of water-soluble fertilizers with an injection system where crops are fertilized each time they are watered (fertigation). The other method is through the use of slow release fertilizers.

Fertilizer injection systems are standard equipment in greenhouses. There are many types on the market but they all work basically the same. A concentrate fertilizer solution is mixed in a stock tank. The fertilizer injector has a pick up hose that is put into the stock solution and when the water is turned on, fertilizer is metered into the water line by the injector providing a very precise measured rate of fertilizer to be delivered. Nutrients in the fertilizer solution are measured in terms of parts per million (ppm). Growers can refer to tables, the injector, or the fertilizer bag to determine how much fertilizer needs to be added per gallon of concentrate to deliver a certain ppm.

Slow release fertilizers consist of a water soluble fertilizer held inside of a plastic resin or sulfur coating. The coating is designed to allow small amounts of nutrients to be released each time the crop is watered. Slow release can be used with a injected fertilizer program but usually one or the other is used. The trend is toward the use of fertilizer injectors in the growing of greenhouse crops.

COMMERCIAL HORTICULTURE PRODUCTION

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Many people enjoy horticultural products on a daily basis, but may not know where the products originated. For example, many people may realize that all of the top 10 maple syrup producing states (top three states are Vermont, New York, and Maine), are located in the northeastern quarter of the country. They may know that Hawaii has virtually all the U.S. tropical horticultural crop production including coffee, bananas, papaya, ginger root, pineapples and macadamia nuts as well as certain flowers such as anthuriums and protea due to its tropical climate. Many people are not aware of the production areas or the values of many commercial US horticultural crops however.

Commercial horticulture is an important part of the US crop production economy. Production of horticultural crops was worth more than $40 billion in 2001 according to figures from the United States Department of Agriculture National Agricultural Statistics Service and Economic Reporting System. When compared with the value of field crops ($61.6 billion) it becomes evident that commercial horticulture production is almost 40 percent of US crop production.

Commercial horticulture values were split almost evenly across three main areas in 2001:

- Vegetables $13.517 billion (includes potatoes and sweet potatoes)
- Nursery/Greenhouse $13.037 billion (includes sod/turf, floriculture & greenhouse, ornamentals)
- Fruits, nuts and berries $12.617 billion (includes peanuts and grapes/berries)

The diversity and production of commercial horticulture crops is not evenly distributed across all states, being restricted by climates and growing conditions. This has resulted in some states or geographic areas having developed some very large amounts of horticulture, and often this is specialized commercial production.

Horticultural crops are especially important to those states where large amounts of commercial horticulture is produced. Commercial horticulture is very diverse, and includes melons and vegetables, fruits and nuts, berries, mint, and floriculture, as well as the seed industries associated with each of these areas including landscape ornamental production. Knowledge of the value and amounts of commercial horticultural commodities and where they are produced is necessary to understand the importance of horticulture in the United States.

Vegetables and Melons

A wide variety of commercial vegetables are grown in the US, were valued at over $13 billion in 2001. This includes fresh and processed vegetables, as well as potatoes and sweet potatoes.

Fresh Vegetables

Fresh vegetables were planted on over 2.069 million acres in the US in 2001 (exclusive of potatoes and processed vegetables). Although a number of states have commercial fresh vegetable production, five states each grew more than 100,000 acres. The states and acreage were:

- California - 843,100 acres
- Florida - 196,300 acres
- Georgia - 140,550 acres
- Arizona - 125,800 acres
- Texas - 103,700 acres

Each of these states have year-round or nearly year-round growing conditions as well as being sizable states geographically. Parts of California and Arizona are also favored by low humidity and little rainfall, resulting in fewer foliar diseases that attack vegetables.

Many types of vegetables are planted each year. The most common vegetables (planted on at least 100,000 US acres in 2001) and acreages were:

- Potatoes* - 1,327,000**
- Sweet Corn* - 733,450**
- Tomatoes* - 413,890**
- Green peas - 217,440**
- Snap beans* - 210,780**
- Head Lettuce - 194,200
- Watermelons - 173,700
- Cucumbers* - 168,510**
- Onions - 166,880
- Broccoli* - 144,500
- Carrots* - 103,000
- Cantaloupes - 101,930

* Includes both processed and fresh
** Majority of acres are for processing

Potatoes were the most valuable vegetable commodity, worth $2.93 billion. Almost 20 percent of the US acreage is in Idaho (386,000 acres), followed by Washington (160,000 acres), and North Dakota (110,000 acres).

Vegetables for Processing

Vegetable acreage devoted for processing is very significant at over 1,330,000 acres, and is about two-thirds the acreage devoted for fresh market production. Vegetables planted for processing are usually dictated by the processing plant location. Vegetable fields too far away from the processing plants makes it difficult for crops to arrive at the processing plant in the excellent conditions necessary for processing and/or more expensive due to trucking costs. Some states, such as Minnesota, have almost the entire vegetable acreage (processed + fresh) destined for processing.

The top five vegetables grown for processing after potatoes and their acreage in the U.S. in 2001 according to the USDA-National Agricultural Statistics Service were:

- Sweet corn (457,650 acres)
- Tomatoes (279,830 acres)
- Green peas (217,440 acres)
- Snap beans (210,780 acres)
- Cucumbers (109,710 acres)

Most of these are grown in the Great Lakes states (Wisconsin, Minnesota, Michigan, etc.) or the West Coast states.

Processing Crop and Top State in Acreage:

- Beets - New York
- Cabbage -Wisconsin
- Carrots - Wisconsin
- Cucumbers - Michigan
- Green Beans - Minnesota
- Snap Beans - Wisconsin
- Spinach - Texas
- Sweet Corn - Minnesota
- Tomatoes - California

The top five states and acreages devoted solely for processed vegetables production in 2001 were:

- California - 293,500 acres

- Wisconsin - 237,700 acres
- Minnesota - 208,310 acres
- Washington - 146,400 acres
- New York - 78,200 acres

The top value vegetable for processing was tomatoes ($547 million), followed by sweet corn ($446 million). The value of processed vegetables grown in the US was $1.26 billion in 2001.

Fruits, Nuts, Berries and Grapes

Fruits, nuts and berries and grapes encompass a wide variety of crops, many that will bear for up to 20 or more years. Because these crops are almost all perennial, crop acreages change little from year to year. Some are very dependent upon bees for pollination (such as almonds), for production while others are not. These crops are very diverse, but almost all (with the exception of the nut crops) depend upon manual hand harvest from the tree, vine or bush.

Berries and Grapes

Many berries are primarily grown in the Pacific Coast states. Oregon is the primary state for blackberries, boysenberries, and loganberries, second leading raspberry producer, and is third in acres devoted to strawberry production. Washington leads the nation in production of raspberries. Huckleberries are grown in Washington. Value of all of these types of berries was $110 million in 2001.

Blueberries

Blueberries are mostly grown in the eastern US, where acidic soils are conducive to their growth. Michigan is the leading producer of blueberries with over 40 percent of the US blueberry acreage, followed by New Jersey, Oregon, Georgia, and Washington. Highest blueberry yields occur in Oregon and Washington. US blueberry production was worth $188 million in 2001.

Cranberries

Cranberry production is usually limited to areas that have standing water. Wisconsin lead the nation's production in 2001, followed by Massachusetts. These two states accounted for approximately 80 percent of the entire US production. Other states with commercial cranberry production include New Jersey, Oregon and Washington. US cranberry production was valued at just under $100 million in 2001.

Grapes

Grapes are grown across the US, with different types of grapes in different regions. Concord and Niagara grapes are grown in New York, Michigan and Pennsylvania, as well as in Washington which is the leading US leader for both types of grapes with approximately 33 percent of the Niagara grape production and 55 percent of the Concord grape production.

California is the main producer of grapes, where they are utilized for eating, as raisins, and for wine. California had 86 percent of the entire US grape acreage and 92 percent of the total US production in 2001. US grape production was valued at over $2.9 billion in 2001.

Strawberries

Strawberries are grown across the US with some 46,000 acres devoted to production in 2001. Approximately 50 percent of the acreage and 80 percent of the production occurred in California. Florida was the second leading state in both acreage and yields/acre in 2001. US strawberry production was worth more than $1 billion in 2001.

Fruits

The US grows a wide variety of fruits which include apples, apricots, avocadoes, bananas, cherries, dates, figs, guavas, kiwi fruit, nectarines, olives, papayas, peaches, pears, persimmons, pineapples, pomegranates and plums, and many types of citrus. This crop area was valued at over $8 billion in the US in 2001.

Apples

Apples are the second most widely grown commerical fruit in the US, with over 450,000 acres devoted to production. About 33 percent of these acres are located in Washington. Other states with over 10,000 acres of apples include New York, Michigan (both over 50,000 acres), California, Pennsylvania and Virginia. These six states have 75 percent of the US apple acreage. Apple production in the US is valued at over $1.5 billion in 2001.

Cherries

Cherries are also widely grown in the US, with two primary types having substantial acres. Sweet cherries are produced primarily in the West Coast States, while Michigan has two-thirds of the nation’s tart cherry acreage and produces about 78 percent of the total. There were more bearing acres of sweet cherries (68,220) than tart cherries (38,770) in 2001. US cherry production was valued at $327 million in 2001, with 82 percent of this from sweet cherries.

Citrus

Citrus production occurs chiefly in four states in areas that escape freezing temperatures: California, Arizona, Texas and Florida. Oranges are produced on almost 800,000 acres in the US, with 55 percent of this acrage devoted to 'Navel' oranges and about 45 percent devoted to 'Valencia' oranges. Oranges were valued at over $1.8 billion in 2001, with most of this production from Florida.

Florida also led US production of tangerines, and grapefruit, with California was a distant second in production of these types of citrus. Lemons are commercially produced in just California and Arizona. Lemons were valued at over $370 million in 2001, followed by grapfruit ($285 million) and tangerines ($124 million). Citrus production in the US was valued at over $2.6 billion, with about two-thirds of the value from oranges.

Peaches and Plums

Peaches and plums are both grown on more than 100,000 acres. California leads the nation in both with almost one-half of the peach acreage and 95 percent of the plum acreage. Other states with substantial peach acreage (10,000+ acres) include Georgia, South Carolina, Texas and New Jersey. Peaches were worth just under $500 million while US plum/prune production $173 million in 2001.

Pears

Pear production is similar to that of sweet cherry production in that it occurs mainly in the states of Washington, California and Oregon. These states had 93 percent of the bearing pear acreage and almost 98 percent of the production. US pear production was worth $272 million in 2001.

Other Fruits

California has virtually all the nation’s date, kiwi fruit, nectarine, apricot, olive, pomegranate and fig acreage. Olives, dates and pomegranates are also produced in Arizona. Hawaii has all the US banana, guava, papaya, and pineapple production. Both avocadoes ($296 million) and nectarines ($127 million) were valued at over $100 million in 2001.

US Commerical Fruit Acreage in 2001

Fruit	Acres in Production
Oranges	796,700
Apples	454,220
Peaches	167,900
Grapefruit	138,300
Plums including prunes	129,900
Cherries	88,550
Pears	70,110
Lemons	64,300
Tangerines	38,600
Nectarines	37,100
Olives	33,700

Apricots	21,890
Pineapples	19,900
Figs	16,000
Kiwi fruits	6,600
Dates	4,800
Persimmons	2,165
Papayas	2,000
Bananas	1,040

Nuts

A number of nut crops are commercially produced in the US. The combined values of these crops was $2.5 billion in 2001.

Nut crop and bearing acres, 2001

Crop	Bearing Acres
Peanuts	1,405,800
Almonds	420,000
Pecans	(data not available)
Walnuts	170,000
Pistachios	65,400
Hazelnuts	28,480
Macadamia Nuts	19,200

Peanuts

Peanut production has been tradionally limited to acreage granted via state quotas, with top production noted from the states of Georgia (38 percent of US total value), Texas, Alabama and Alabama. There may be a shift in future peanut acreage location due to the quotas being eliminated in the 2002 US Farm Bill as well as diseases such as tomato spotted wilt virus which has become very damaging in Georgia.

Pecans

Pecans are produced in a number of southern states, although 70 percent of the crop was produced in just three states (Georgia - 30 percent, Texas - 22 percent, New Mexico -19 percent). Arizona, Oklahoma, Louisiana, and Alabama also produce substantial amounts. Pecans were valued at just over $200 million in 2001.

Other Nuts

Many nuts which grow on trees are grown commercially in just one or two states. Oregon produces almost of the US hazelnuts, California grows virtually all the English walnuts, almonds, and pistachios, while virtually 100 percent of the US macadamia nuts production occurs in Hawaii. Almonds accounted for $730 million in 2001, followed by English walnuts ($341 million), and pistachios ($159 million)

Nursery/Greenhouse

This is a broad and diverse area, and includes sod, turf, and lawns, as well as floriculture and all the nursery and landscape ornamental production. These combined areas were worth over $13 billion in 2001.

Floriculture

Floriculture is an important horticulture industry in the United States, valued at over $4.74 billion in 2001. Five states(California, Florida, Michigan, Texas and Ohio) accounted for 53 percent of the total value, with the leading state of California producing $1.02 billion in wholesale value, followed by Florida ($765 million). Floriculture is sometimes divided into five main areas. These areas and value in 2001 were:

- Bedding and garden plants - $2.18 billion
- Potted flowering plants - $832 million
- Foliage- $585 million
- Cut flowers - $424 million
- Cut cultivated greens - $111 million

Bedding and Garden Plants

States with the leading production of bedding and garden plants are California, Michigan, Texas, Ohio and Florida. Bedding and garden flat sales were worth almost $900 million. The top three plants in this area (Impatiens, Pansies/ Violas, Petunias) accounted for over 1/3 of this value. Potted gereniums were the most valuable plant ($150 million), followed by flats of Impatiens ($117 million).

Potted Flowering Plants

Potted plants are often for indoor or patios. Poinsettias are the major plant in this category, accounting for $256 million in value.

Foliage

Florida is the leading state, and has 62 percent of the total US production. This category includes the potted foliage plants and hanging baskets.

Cut Flowers

The rose is the most popular cut flower in the US, with some 270+ million blooms. Rose production was valued at $67.7 million. Lilies were the second most valuable cut flower ($57.7 million) followed by tulips ($26.3 million). California produces about

of the entire US value of all fresh cut flowers. While cut flower demand has continued to increase in the United States, domestic production as has been declining. Over two-thirds of the major cut flowers are now imported from Columbia, Costa Rica, Ecuador, Mexico and the Netherlands. The shift to more reliance on imports is partially due to economics, as the minimum wages in other countries is lower than in the US, coupled with better post-harvest technology.

Cut Cultivated Greens

Florida produces almost 80 percent of the plants in this category, which includes leatherleaf ferns.

Nursery/Ornamentals

Nursery and ornamental production is valued at over $3.3 billion. California accounts for 28 percent this total, followed by Oregon (15 percent) and Florida (14 percent). The top valued nursery and ornamental production categories and values in 2000 were:

- Deciduous shrubs/ornamentals - $772 million
- Broadleaf evergreens - $593 million
- Deciduous shade trees - $406 million
- Coniferous evergreens - $403 million

Note: Does not include Christmas trees at $149 million.

Grass (Turf/Sod) Production

Although direct figures were not available, it is estimated that the sod, turf, and lawn grass seed segments are valued at almost $5 billion. Ryegrass seed is produced in the Pacific Northwest, while almost all bermudagrass seed production occurs in southeastern California and southwestern Arizona. Sod farms exist across the US.

Other Horticultural Crops

There are a number of crops that could be discussed, but these are two crop areas that deserve recognition.

Dry Edible Beans & Peas, Lentils

Dry edible beans and peas, as well as lentils, are sometimes forgotten and/or ignored crops. They are a major crop in terms of horticultural acreage for many states in the western and northern areas of the US, with over 1.85 million acres planted in 2001. This is a greater area than the combined area of all US vegetables planted for processing and is a larger area than the state of Rhode Island.

The majority of these acres (1.43 million) are dry edible beans, which include lima, navy, Great Northern, small white, pinto, red kidney, pink, small red, cranberry, black, garbanzo and blackeye. Pinto beans are the most widely grown (40+ percent of acres), followed by navy, garbanzo, kidney, and Great Northern beans. Each of these varieties were planted on over 100,000 acres in 2001.

Leading states in planted dry edible bean acreage in 2002 were:

- North Dakota - 750,000 acres
- Michigan - 270,000 acres
- Nebraska - 190,000 acres
- Minnesota - 165,000 acres
- California - 100,000 acres
- Colorado - 100,000 acres)

Washington and Idaho grow about two-thirds of the US dry edible peas and approximately 75 percent of all US lentils, with Washington being the lead state for both crops. The total production value of dry edible beans has declined in recent years, valued at just under $400 million, while dry edible peas and lentils were valued at more than $50 million in 2001.

Mint

Peppermint and spearmint are the most popular mints grown in the US, with commercial production in at least six states. Almost 100,000 acres of these two types of mint were harvested in 2001, primarily from four states (Oregon, Washington, Idaho and Indiana), with 80 percent of the acreage devoted to peppermint.

Total US production of peppermint and spearmint was 8.3 million pounds in 2001, and value of mint oil was over $18 million in 2001.

Billion Dollar Crops

Eight individual horticultural crops were valued at over $1 billion in 2001. These crops and values were:

1. Potatoes - $2.933 billion
2. Grapes - $2.794 billion
3. Oranges - $1.834 billion
4. Tomatoes - $1.666 billion
5. Apples - $1.514 billion
6. Head lettuce - $1.273 billion
7. Strawberries - $1.088 billion
8. Peanuts - $1.003 billion

Totaled together, these eight crops were valued at just under $14 billion and represent over one-third of the total US value of horticultural products. As US horticulture continues to increase in value, it is expected that more horticultural crops will be valued at over $1 billion in the near future.

JUDGING HORTICULTURAL PRODUCTS

Robert L. Renner, Jr.
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The eight classes of horticultural plants or produce to be judged will consist of:

- Two classes of fruits
- Two classes of vegetables
- Two classes of flowers and/or foliage plants
- Two classes of ornamental plants

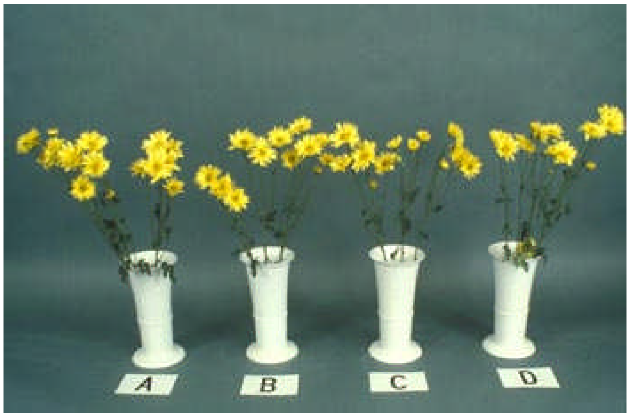
Each class consists of four specimens of groups of specimens, lettered A, B, C, or D from left to right.

Mentally arrange the specimens in order of highest to lowest overall quality and mark them in the appropriate space on the judging score sheet in the column labeled "Placing."

Judging Fruits and Vegetables

Specific considerations on judging the 90 possible classes of fruits and vegetables is beyond the scope of this section of the contest manual. However, some general guidelines are presented to help you better recognize high quality fruits and vegetables and rank each class accordingly.

Judging fruits and vegetables is simply a matter of making choices. Consumers buy fruits and vegetables at the market by selecting those most appealing to them on the basis of external quality and past experience. Visit produce markets or produce sections of grocery stores to examine fruits and vegetables. Try to identify the best quality produce and determine why some produce is of inferior quality. Notice that almost everyone "selects" fruits and vegetables - they do not just take the first ones or closest ones. The key is learning, through experience, how to select the best produce.



Judging fruits and vegetables is based on common sense factors. They are judged as you see them, not by what they could be if properly trimmed, cleaned, etc. The following criteria should be used when evaluating the quality of produce:

- The cultivar of a specimen should be properly identified. For example, if you think you are purchasing a `McIntosh' apple, you will probably not be satisfied with a `Red Delicious' apple.
- Specimens should be fresh and at the optimum stage of maturity for eating. Produce that is overmature or immature is downgraded.
- Specimens should be clean and free from insects and diseases or any damage caused by such pests.
- Specimens should be free of bruises and blemishes. Although many surface blemishes do not affect eating quality, they do reduce eye appeal.
- Specimens on a plate should be uniform in size, shape, color and type. Each plate within a class will have the same number of specimens.
- Transplant specimens in pots should have only one plant/pot, and should not be overgrown so that they are root-bound (roots encircling the pot).

When grading, first visualize the ideal specimen. Then, consider all departures from this based on the above criteria and common sense. Factors affecting usefulness are downgraded more than other factors. For example, severely overripe bananas would be ranked below bananas with slight abnormalities in size or shape. The plate with the most defects and serious faults should receive the lowest ranking.

It is usually best to first identify the worst group (plate) within a class. Then, pick the best of the remaining three groups. Finally, try to place the middle two plates in rank order.

In our scoring scheme, the correct selection of the best group or specimen within a class is worth 76 percent of the total score for that class regardless of how the other three specimens/groups are ranked. By correctly placing the best and worst groups (specimens) within a class, the contestant earns 88 percent of the possible points for that class.

Judging Flowers and Foliage

Flowers are divided into two categories for judging purposes - cut flowers and pot plants. Cut flowers can be divided into two main shapes - spike and round. Gladiolus and snapdragon are examples of spike flowers. Rose and chrysanthemum are examples of round flowers.

When judging spike flowers, look for long spikes with half the florets open and half unopened. The bottom florets should show no signs of over-maturity in the form of browning around the edges, shriveling, or fading of color. Spike form flowers should be just single spikes with no secondary side shoots.

Maturity is an important factor when judging round form flowers. The center petals must not be so tight and immature as to be green, but they should be tighter than the outer petals. The outer petals should begin to turn down, but show no signs of wilting and drying.

Spike or round flowers in the same class should be of one variety or cultivar and have typical characteristics of that variety. Flowers are judged as you see them, not by what they could be if properly trimmed, cleaned, etc. Flowers should be free of irregularities, spray residue and blemishes due to insect, disease, or mechanical injury. Stems should all be the same length, straight and strong enough to support the flower head without bending. Foliage should be clean, fresh and a bright shade of green.

Size of bloom, symmetry, color, freshness, arrangement of petals and true-to-variety flower shape are other important points to consider when judging flowers.

Potted flowering plants should be short, compact, well-shaped plants having dark green foliage with flower buds just beginning to show color or perhaps with a few buds open. Specimens having the most flower buds are normally more desirable.

Judging foliage plants is similar to judging potted plants, but much more attention should be given to the quality of the foliage. The size, color and number of the leaves as well as the size and shape of the plant and whether it appears to be growing, are all criteria to consider.

Judging Ornamentals

When judging ornamentals, look for a healthy, vigorous plant which is very well shaped, heavily branched and densely foliated. Specimens are judged as you see them, not by what their potential would be with proper pruning, cleaning, etc. Density and condition of the plant are more important qualities than the physical measurement or height. A shrub with a number of stocky, wellshaped branches is of better quality than one with long, thin branches. Factors that downgrade ornamental plants are:

1. Lack of health and vigor, or excessive succulence.
2. Canes or trunk(s) and branches:
    a. Weak or poorly formed
    b. Excessive scarring, scars not healed properly

c. Poor graft unions not healing properly
d. Branches poorly distributed
e. Dead wood
f. Cold damage

3. Foliage:

. Leaves of improper shape, size, texture and color
    a. Excessive chlorosis (yellowing) due to mineral deficiency or other causes
    b. Excessive pest or mechanical injury
    c. Dead leaves

4. Root system:

. Container grown stock
    1. Not well established in container
    2. Excessively root bound
    3. Large roots growing out of container
    4. Weeds in container

a. Balled and burlapped stock
    1. Loosely established in ball
    2. Ball soft or loosely tied
    3. Ball too small or shallow
    4. Weeds growing around trunk

Flowers and Indoor Plants

Plant Name/Type	Foliage/ Plant	Flower	Fruit, Nut or Edible Portion	Seed or Pit	Seedpod or Cone	Storage Organ
African Violet *Saintpaulia ionntha*	X	X				
Ageratum *Ageratum houstonianum*	X	X		X		
Amaryllis *Hippeastrum* hybrids	X	X				X
Bachelor Button *Centaurea cyanus*	X	X		X		
Begonia *Begonia* sp.	X	X				
Canna *Canna* x *generalis*	X	X				X
Celosia *Celosia* sp.	X	X		X		
Chrysanthemum *Chrysanthemum* x *morifolium*	X	X				
Coleus *Solenostemon scutellarioides*	X	X				
Columbine *Aquilegia* x *hybrida*	X	X		X		
Cosmos *Cosmos bipinnatus, C. sulphureus*	X	X		X		
Crocus	X	X				X
Cyclamen *Cyclamen persicum*	X	X				X
Daffodil *Narcissus* sp.	X	X				X
Dahlia *Dahlia* hybrids	X	X		X		X
Daylily *Hemerocallis* sp.	X	X			X	X
Dianthus spp. *Dianthus* sp.	X	X		X		
Dracaena *Dracaena* sp.	X					
Dumbcane/ Dieffenbachia *Dieffenbachia* sp.	X					
Ficus sp. *Ficus* sp.	X			X		
Geranium *Pelargonium* x *hortorum*	X	X			X	
Gladiolus *Gladiolus* x *hortulanus*	X	X				X

Plant Name/Type	Foliage/ Plant	Flower	Fruit, Nut or Edible Portion	Seed or Pit	Seedpod or Cone	Storage Organ
Gloxinia *Sinningia speciosa*	X	X				X
Hosta *Hosta* sp.	X	X			X	
Hyacinth *Hyacinthus orientalis*	X	X				X
Impatiens spp. *Impatiens wallerana*	X	X		X	X	
Iris *Iris* sp.	X	X			X	X
Jade *Crassula ovata*	X					
Lily (Easter, Asiatic, Oriental) *Lilium* sp.	X	X				X
Marigold *Tagetes erecta, T. patula*	X	X		X		
Nasturtium *Tropaeolum majus*	X	X		X		
Neantha Bella Palm *Chamaedorea elegans*	X				X	
Pansy *Viola* x *wittrockiana*	X	X		X		
Peony *Paeonia* hybrids	X	X			X	X
Peperomia *Peperomia* sp.	X	X				
Petunia *Petunia* x *hybrida*	X	X		X		
Philodendron *Philodendron* sp.	X					
Rose *Rosa* sp.	X	X	X	X		
Salvia *Salvia* sp.	X	X				
Schefflera *Schefflera* sp.	X	X				
Snakeplant/ Sansevieria *Sanseveria trifasciata, Sanseveria* sp.	X	X				
Snapdragon *Antirrhinum majus*	X	X		X		
Sweet alyssum *Lobularia maritima*	X	X		X		
Tulip *Tulipa* sp.	X	X				X
Zinnia *Zinnia* sp.	X	X		X		

Landscape Ornamentals

Plant Name/Type	Foliage/ Plant	Flower	Fruit, Nut or Edible Portion	Seed or Pit	Seedpod or Cone	Storage Organ
Arborvitae *Thuja* spp.	X			X	X	
American planetree *Platnaus occidentalis*	X			X	X	
Ash *Fraxinus* spp.	X			X		
Azalea, Rhododendron *Rhododendron* spp.	X	X		X		
Barberry *Berberis* spp.	X		X			
Basswood, Linden *Tilia americana*	X	X		X		
Beech *Fagus* spp.	X			X	X	
Birch *Betula* spp.	X			X	X	
Boxwood *Buxus* spp.	X					
Camellia *Camellia* sp.	X	X			X	
Cottonwood/ Poplar *Populus* spp.	X			X	X	
Dogwood *Cornus* spp.	X	X	X			
Elm *Ulmus* spp.	X			X		
English Ivy *Hedera helix*	X					
Euonymus *Euonymus* spp.	X			X	X	
Fir *Abies* spp.	X			X	X	
Forsythia *Forsythia* spp.	X	X				
Hawthorn *Crataegus* spp.	X		X			
Hemlock *Tsuga* spp.	X			X	X	
Holly *Ilex* spp.	X		X			
Honey locust *Gleditsia* spp.	X			X	X	
Hydrangea *Hydrangea* spp.	X	X				
Jasmine *Jasminum* spp.	X	X				
Juniper *Juniperus* sp.	X		X	X		

Plant Name/Type	Foliage/ Plant	Flower	Fruit, Nut or Edible Portion	Seed or Pit	Seedpod or Cone	Storage Organ
Lilac *Syringa* spp.	X	X		X	X	
Magnolia *Magnolia* spp.	X	X		X	X	
Maple *Acer* spp.	X			X		
Nandina *Nandina* spp.	X	X	X			
Natal Plum (Carissa spp.) *Carissa* sp.	X		X			
Oak *Quercus* spp.	X			X		
Pachysandra *Pachysandra terminalis*	X			X		
Periwinkle (Vinca spp.) *Vinca* spp.	X	X				
Photinia *Photinia* spp.	X	X				
Pine *Pinus* spp.	X			X	X	
Pittosporum *Pittosporum tobira*	X			X	X	
Potentilla *Potentilla fruticosa*	X				X	
Privet *Ligustrum amurense*	X			X		
Redbud *Cercis canadensis*	X	X		X	X	
Spirea *Spiraea* sp.	X	X				
Spruce *Picea* spp.	X			X	X	
Sweetgum *Liquidambar styraciflua*	X				X	
Viburnum *Viburnum* sp.	X	X	X			
Willow *Salix* sp.	X					
Wisteria *Wisteria* spp.	X	X		X		
Yew *Taxus* spp.	X		X	X		

Fruits, Nuts and Berries

Plant Name/Type	Foliage/ Plant	Flower	Fruit, Nut or Edible Portion	Seed or Pit	Seedpod or Cone	Storage Organ
Almond *Prunus amygdalus*	X		X	X		
Apple *Malus domestica*	X		X	X		
Apricot *Prunus armeniaca*	X	X	X	X		
Avocado *Persea americana*	X		X	X		
Banana *Musa* x *paridasiaca*	X	X	X			
Blackberry *Rubus* hybrids	X		X			
Black walnut *Juglans nigra*	X		X			
Blueberry *Vaccinium corymbosum*	X	X	X			
Brazil Nut *Bertholletia excelsa*			X	X	X	
Butternut *Juglans cinerea*	X		X	X		
Carambola (Starfruit)	X		X			
Cashew *Anacardium occidentale*	X		X			
Cherry *Prunus cerasus, P. avium*	X		X	X		
Chestnut *Castanea mollissima* (Chinese)	X		X	X		
Coconut *Cocos nucifera*	X		X	X		
Cranberry *Vaccinium macrocarpon*	X		X			
Currant *Ribes* spp.	X		X			
Date *Phoenix dactylifera*	X		X	X		
Elderberry *Sambucus canadensis*	X	X	X			
English walnut *Juglans regia*	X		X			
Fig *Ficus carica*	X		X			
Filbert *Corylus avellana*	X		X	X		
Goosberry *Ribes* spp.	X		X			
Grape *Vitis* spp.	X		X	X		

Plant Name/Type	Foliage/ Plant	Flower	Fruit, Nut or Edible Portion	Seed or Pit	Seedpod or Cone	Storage Organ
Grapefruit *Citrus paradisi*	X		X	X		
Kiwi *Actinidia chinensis*	X		X			
Kumquat *Fortunella* spp.	X		X			
Lemon *Citrus limon*	X		X			
Lime *Citrus aurantifolia*	X		X			
Macadamia Nut *Macadamia* sp.	X		X			
Mango *Mangifera indica*	X		X	X		
Mulberry *Morus alba*	X		X			
Nectarine *Prunus persica* var. *nectarina*	X		X	X		
Orange *Citrus sinensis*	X		X			
Papaya *Carica papaya*	X	X	X	X		
Peach *Prunus persica*	X	X	X	X		
Pear *Pyrus communis*	X		X			
Pecan *Carya illinoiensis*	X		X			
Persimmon *Diospyros* sp.	X		X	X		
Pineapple *Ananas comosus*	X		X			
Plum *Prunus domestica* (European), *P. salicina* (Japanese)	X		X	X		
Pomegranate *Punica granatum*	X	X	X			
Raspberry Rubus spp.	X		X			
Strawberry *Fragraria x ananassa*	X		X			
Tangerine *Citrus reticulata*	X		X			

Vegetables

Plant Name/Type	Foliage/ Plant	Flower	Fruit, Nut or Edible Portion	Seed or Pit	Seedpod or Cone	Storage Organ
Artichoke (Globe /Jerusalem) *Cynara scolymus, Helianthus tuberosus*	X	X	X	X		
Asparagus *Asparagus officinalis*	X		X	X		
Basil *Occimum basilicum*	X	X	X	X		
Bean *Phaseolus* spp.	X		X	X		
Beet *Beta vulgaris*	X		X	X		
Broccoli *Brassica oleracea*	X	X	X			
Brussels Sprouts *Brassica oleracea*	X		X			
Cabbage *Brassica oleracea*	X		X			
Carrot *Daucus carota* var. *sativus*	X	X	X	X		
Cauliflower *Brassica oleracea*	X		X			
Celery *Apium graveolens*	X		X	X		
Chinese Cabbage *Brassica rapa*	X		X			
Chives *Allium schoenoprasum*	X		X	X		
Collard *Brassica oleracea*	X		X			
Corn *Zea mays*	X	X	X	X		
Chayote *Sechium edule*	X		X			
Cucumber *Cucumis sativus*	X		X	X		
Dill *Anethum graveolens*	X	X	X	X		
Eggplant *Solanum melongena* var. *esculentum*	X	X	X	X		
Belgian Endive/Escarole *Cichorium* spp.	X		X	X		
Garlic *Allium sativum*	X	X	X			
Kale *Brassica oleracea*	X		X			
Kolhrabi *Brassica oleracea*	X		X			

Plant Name/Type	Foliage/ Plant	Flower	Fruit, Nut or Edible Portion	Seed or Pit	Seedpod or Cone	Storage Organ
Leek *Allium porrum*	X		X	X		
Lettuce *Lactua sativa*	X	X	X	X		
Muskmelon *Cucumis melo*	X		X	X		
Mustard *Brassica* spp.	X		X			
Okra *Hibiscus esculentus*	X	X	X	X		
Onion *Allium cepa*	X	X	X	X		
Parsley *Petroselinum crispum*	X		X	X		
Parsnip *Pastinaca sativa*	X		X	X		
Peas *Pisum sativum*	X		X	X		
Pepper *Capsicum annuum*	X		X	X		
Potato (Irish) *Solanum tuberosum*	X		X	X		
Potato (Sweet) *Ipomoea batatas*	X		X			
Radish *Raphanus sativus*	X	X	X	X		
Rhubarb	X		X	X		
Rutabaga *Brassica napus*	X		X			
Sage *Salvia officinalis*	X		X			
Spinach *Spinacia oleracea*	X		X	X		
Squash *Cucurbita* spp.	X		X	X		
Swiss chard *Beta vulgaris*	X		X			
Tomato *Lycopersicon esculentum*	X	X	X	X		
Turnip *Brassica rapa*	X		X			
Watermelon *Citrullus lanatus*	X		X	X		

NJHA Horticulture Contest Identification Answer Sheet

Name ________________________________ **State** ______ **Contestant No.** ________________

A- Flowers & Indoor Plants		**B-Landscape Ornamentals**	
A1 African Violet	1 ____	B1 Arborvitae	1 ____
A2 Ageratum	2 ____	B2 American planetree	2 ____
A3 Amaryllis		B3 Ash	
A4 Bachelor Button	3 ____	B4 Azalea, Rhododendron	3 ____
A5 Begonia	4 ____	B5 Barberry	4 ____
A6 Canna		B6 Basswood, Linden	
A7 Celosia	5 ____	B7 Beech	5 ____
A8 Chrysanthemum	6 ____	B8 Birch	6 ____
A9 Coleus		B9 Boxwood	
A10 Columbine	7 ____	B10 Camellia	7 ____
A11 Cosmos	8 ____	B11 Cottonwood/ Poplar	8 ____
A12 Crocus		B12 Dogwood	
A13 Cyclamen	9 ____	B13 Elm	9 ____
A14 Daffodil	10 ____	B14 English Ivy	10 ____
A15 Dahlia		B15 Euonymus	
A16 Daylily	11 ____	B16 Fir	11 ____
A17 Dianthus spp.	12 ____	B17 Forsythia	12 ____
A18 Dracaena		B18 Hawthorn	
A19 Dumbcane/ Dieffenbachia	13 ____	B19 Hemlock	13 ____
A20 Ficus sp.	14 ____	B20 Holly	14 ____
A21 Geranium		B21 Honey locust	
A22 Gladiolus	15 ____	B22 Hydrangea	15 ____
A23 Gloxinia	16 ____	B23 Jasmine	16 ____
A24 Hosta		B24 Juniper	
A25 Hyacinth	17 ____	B25 Lilac	17 ____
A26 Impatiens spp.	18 ____	B26 Magnolia	18 ____
A27 Iris		B27 Maple	
A28 Jade	19 ____	B28 Nandina	19 ____
A29 Lily (Easter, Asiatic, Oriental)	20 ____	B29 Natal Plum (Carissa spp.)	20 ____
A30 Marigold		B30 Oak	
A31 Nasturtium	21 ____	B31 Pachysandra	21 ____
A32 Neantha Bella Palm	22 ____	B32 Periwinkle (Vinca spp.)	22 ____
A33 Pansy		B33 Photinia	
A34 Peony	23 ____	B34 Pine	23 ____
A35 Peperomia	24 ____	B35 Pittosporum	24 ____
A36 Petunia		B36 Potentilla	
A37 Philodendron	25 ____	B37 Privet	25 ____
A38 Rose		B38 Redbud	
A39 Salvia		B39 Spirea	
A40 Scheffl era		B40 Spruce	
A41 Snakeplant/ Sansevieria		B41 Sweetgum	
A42 Snapdragon		B42 Viburnum	
A43 Sweet alyssum		B43 Willow	
A44 Tulip		B44 Wisteria	
A45 Zinnia		B45 Yew (Taxus spp.)	
Number of Flowers & Indoor Plants Correct ____		**Number of Landscape Ornamentals Correct** ____	

NJHA Horticulture Contest Identification Answer Sheet

Name ____________________________________ **State** _______ **Contestant No.** ____________________

C-Fruits, Nuts and Berries		**D-Vegetables**	
C1 Almond	1 ____	D1 Artichoke (Globe /Jerusalem)	1 ____
C2 Apple C3 Apricot	2 ____	D2 Asparagus D3 Basil	2 ____
C4 Avocado	3 ____	D4 Bean	3 ____
C5 Banana C6 Blackberry	4 ____	D5 Beet D6 Broccoli	4 ____
C7 Black walnut	5 ____	D7 Brussels Sprouts	5 ____
C8 Blueberry C9 Brazil Nut	6 ____	D8 Cabbage D9 Carrot	6 ____
C10 Butternut	7 ____	D10 Cauliflower	7 ____
C11 Carambola (Starfruit) C12 Cashew	8 ____	D11 Celery D12 Chinese Cabbage	8 ____
C13 Cherry	9 ____	D13 Chives	9 ____
C14 Chestnut C15 Coconut	10 ____	D14 Collard D15 Corn	10 ____
C16 Cranberry	11 ____	D16 Chayote	11 ____
C17 Currant C18 Date	12 ____	D17 Cucumber D18 Dill	12 ____
C19 Elderberry	13 ____	D19 Eggplant	13 ____
C20 English walnut C21 Fig	14 ____	D20 Endive (Belgian, escarole) D21 Garlic	14 ____
C22 Filbert	15 ____	D22 Kale	15 ____
C23 Gooseberry C24 Grape	16 ____	D23 Kolhrabi D24 Leek	16 ____
C25 Grapefruit	17 ____	D25 Lettuce	17 ____
C26 Kiwi C27 Kumquat	18 ____	D26 Muskmelon D27 Mustard	18 ____
C28 Lemon	19 ____	D28 Okra	19 ____
C29 Lime C30 Macadamia Nut	20 ____	D29 Onion D30 Parsley	20 ____
C31 Mango	21 ____	D31 Parsnip	21 ____
C32 Mulberry C33 Nectarine	22 ____	D32 Peas D33 Pepper	22 ____
C34 Orange	23 ____	D34 Potato (Irish)	23 ____
C35 Papaya C36 Peach	24 ____	D35 Potato (Sweet) D36 Radish	24 ____
C37 Pear	25 ____	D37 Rhubarb	25 ____
C38 Pecan C39 Persimmon C40 Pineapple C41 Plum C42 Pomegranate C43 Raspberry C44 Strawberry C45 Tangerine		D38 Rutabaga D39 Sage D40 Spinach D41 Squash D42 Swiss chard D43 Tomato D44 Turnip D45 Watermelon	
Number of Fruits, Nuts & Berries Correct _____		**Number of Vegetables Correct** _____	