PLANT PROPAGATION

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Plant propagation is the multiplication of plants by means of seeds or spores (sexual propagation) or by vegetative parts (asexual propagation). Propagating plants has been a fundamental occupation of mankind since civilization began. Without plant propagation, the nursery industry would not exist today. The preservation and reproduction of valuable plants depends upon successful plant propagation.

There are three main aspects to a successful study of plant propagation. Successful propagation first requires knowledge of plant growth and structure. This may be said to be the science of propagation. The propagator may gain this knowledge by working with the plants themselves, but it should be supplemented, when possible, with formal courses in botany, horticulture, genetics and plant physiology. This knowledge will aid the propagator in understanding why he does the things he does, enabling him to do them better and to cope with unexpected problems.

Secondly, successful propagation requires knowledge of mechanical manipulations and technical skills that take a certain amount of practice and experience to master, such as how to bud or graft or how to make cuttings. This aspect may be considered the art of propagation.

The third major aspect of plant propagation is the knowledge of different kinds of plants and the various methods by which certain plants can be successfully propagated. This knowledge is also gained by first-hand experience but much can be learned from other propagators, from numerous books and manuals of plant propagation, from the scientific literature and from associations such as the International Plant Propagators' Society. Each of these sources can be valuable.

Sexual propagation is accomplished with seeds for higher plants and with spores for ferns and their allies. Seeds are the result of pollination of a flower by pollen followed by fertilization of the ovules by the pollen. Fertilization results in the mixing of genetic material from each parent and produces individuals that may differ from each other and the parents. In nature, seeds will produce plants that are very similar to the parents but genetic recombination occasionally produces plants with traits that may be more desirable than those of either parent. Sexual reproduction maintains diversity in a population and allows for natural selection to occur, as well as selection by plant breeders. Selection of plants with such desirable traits has given us many of the cultivars available today.

Plant breeders who cross particular parents in order to produce seedlings with certain characteristics produce hybrid plants. Hybrids are common among perennials, annuals and vegetables used in the trade. Hybrid plants do not produce seed that is true to type. In other words, seed from hybrid plants does not necessarily produce seedlings that resemble the parent plant. Saving seed from your prized hybrid often gives disappointing results.

Asexual or vegetative propagation usually produces plants with the same traits as the stock plant, and is the means of perpetuating true-to-name varieties. The only time that vegetatively reproduced plants are not the same as the stock plant is when the genetic information in a cell is not copied correctly during cell division (a mutation occurs). Mutations change the character of the plant. Although most mutations result in plants with undesirable traits, some mutants or sports have useful or novel traits. Many prized ornamental and fruit tree cultivars originated as chance mutations.

Some forms of propagation require little equipment while others may require greenhouses, hotbeds, coldframes, misting equipment, or sterile laboratories, etc. A wide variety of growing media and containers are used as well. The medium may consist solely of soil, sand, organic material such as peat, sphagnum moss, shredded bark, or aged sawdust, or minerals such as perlite, vermiculite and pumice, but usually is a mixture of several of the above. Containers may be of clay, metal, plastic or pressed peat. Paraffin-coated paper or plastic cups punched for drainage, manufactured plant bands or containers made of asphalt-treated building paper are also useful.

Regardless of the materials used, sanitation is extremely important. During propagation, whether by sexual or asexual means, plants are susceptible to attack by pests and diseases. All plant material, tools, handling equipment, the work area, containers and media components need to be free of pathogens for successful propagation to occur.

Containers, tools and equipment can be boiled, soaked with commercial disinfectants or treated with a 1:9 solution of household bleach to disinfect surfaces. Many seeds can be surface sterilized using the same materials. Most soilless media components are relatively free of pathogens but soil can harbor weed seeds, undesirable insects, nematodes, and disease organisms. Stock plants need to be free of pests and diseases and care should be taken throughout propagation to keep plant material healthy and uninfected.

Propagation Records

Propagators should begin propagating a particular plant by learning all they can about that plant from colleagues and published references. Using this reference information as a base, personal experience will enable a propagator to develop individual and specific techniques. These modifications - the tricks of the trade - separate the average from the skilled propagator. Development of propagation skills depends upon accurate records. Experience gained each year can then be applied in subsequent years.

A journal may be the easiest way to keep propagation records. A good propagator makes entries as the work is accomplished, rather than at the end of the day or week. Details are easily lost in a short time. After the propagating season, summarize all journal entries and develop a recommended standard procedure for the next season. File each procedure by plant name for easy access.

The final step in record keeping is to update the summary and recommendations each season, using information from the current journal. Several years of experience are often the best tools for improving propagation techniques. The following information is essential for a propagation journal:

1. Date propagation began
2. Name of plant (common and scientific)
3. Source and type of propagating material
4. Propagation medium used
5. Treatment(s) applied including sanitation procedure.
6. Temperature and light conditions
7. Date propagation completed
8. Percentage of success and suspected reasons for failures
9. Percentage of survival and productivity of plants after propagation

Sexual Propagation

Sexual propagation by seeds is the major method by which many plants reproduce in nature and one of the most efficient and widely used propagation methods for cultivated plants. Seeds can be purchased for propagation or the propagator can collect them. Seed collection requires considerable knowledge of the timing of seed ripening and seed dispersal, size and appearance of seeds, location of seed-bearing plants, as well as techniques for cleaning and storing seeds.

A seed is a mature ovule enclosed in the mature ovary or fruit. Seeds consist of an immature plant (the embryo), food storage tissues, and seed coverings. Seeds and fruits of various plants differ greatly in size, appearance, and germination requirements.

Successful storage requires specific knowledge about the seeds. What works for one plant may not work for another. The seeds from some species, such as willows, poplars, elms and some maples, remain viable for only a short time in storage. Other seeds are sensitive to moisture content and lose viability rapidly after drying. The seeds from some species may remain viable for many years in storage. <u>In general, seed viability is best preserved under cool, dry conditions.</u>

For seeds that are not sensitive to low moisture conditions there are two "rules of thumb" for storage. The first

rule is that each 1 percent decrease in seed moisture (between 5 and 14 percent) doubles the life of the seed. Secondly, each decrease of 10° F (between 32° and 112° F) in storage temperature also doubles seed storage life. Moisture content or temperatures outside these ranges decrease the storage life of seeds.

Seed Germination

Seed germination typically begins following the uptake of water *(imbibition)* by dry seeds, although some seeds, such as acorns, germinate without having gone through a drying period. Following imbibition, food reserves are mobilized and growth regulators are produced or activated. If germination is successful, the root tip (the radical) emerges from the seed. Seed germination requires that a seed be viable, non-dormant, and exposed to appropriate environmental conditions. In general, germination requires moisture, proper temperatures, gas exchange, and appropriate light or darkness. Some species germinate more readily after exposure to light while germination in others is inhibited by light.

Because seed-germinating media are kept constantly moist, evaporative cooling usually lowers the temperature of the media. Cool germination conditions often slow the germination process and favor the development of fungi that cause damping off, a major disease of seedlings. Adding extra heat to the germination medium (bottom heat) often speeds germination and early seedling development, and can retard damping off. Other controls for damping off include the use of a medium with good drainage, such as sphagnum moss, sufficient but not excessive watering, good ventilation, low density plantings, seed treatment with fungicides, low pH of the germination medium, preventative fungicidal drenches after sowing or germination, and proper sanitation.

Seeds may be sown in or on pasteurized soil or soilless mix in flats or pots, or directly into outdoor seedbeds. Generally, seeds should be covered to a depth of 2 to 4 times their diameter, although seeds that require light for germination should be planted shallow. Seed coverings of coarse sand, perlite, or fine gravel are sometimes used to prevent algae growth and overheating of the soil. Very fine seed may be sown without covering by mixing the seed with sand or other inert material for more uniform distribution.

Germination media should be pre-soaked or moistened after sowing and kept moist. Glass or plastic coverings or frequent misting are effective ways of keeping media moist until germination occurs. Commercial algaecide drenches are available to help prevent the growth of algae and moss on the soil surface.

Once seeds germinate, coverings should be removed and the medium can be allowed to dry slightly on the surface. Light may be gradually increased and temperatures lowered to produce vigorous, stocky young plants. Plug seedling producers often keep night temperatures slightly higher than day temperatures to produce uniform, stocky seedlings. These treatments favor good root development and reduce losses from damping off. Seedlings can be transplanted, if necessary, after they develop two to four true leaves. Plants grown in the open are best transplanted on cloudy days or during evenings, and just before a rain, if possible. Shading newly transplanted seedlings for 2 to 3 days helps to reduce transplant shock.

Seed Dormancy

Some seeds can enter into a condition known as dormancy during their ripening, after removal from the fruit, after drying, or during storage. Dormant seeds germinate slowly or not at all, even when placed under appropriate germination conditions. Seed dormancy is an adaptation for natural survival, but often does not favor easy germination by propagators.

Seed dormancy may be due to one or a combination of three factors: (1) a hard, impervious seed coat (2) internal chemical inhibition and/or (3) an immature embryo. Treatments can be used to break seed dormancy.

(1) Hard Seed Coat

An easy way to determine whether seeds have a hard seed coat is to soak them overnight in warm water. If the seeds do not swell, the seed coat may be hard and impervious to water and/or oxygen. Hard seed coats may be broken by abrasion or scarification. With large seeds, a file or sandpaper can be used to penetrate the seed coat, but with small seeds some other method must be used.

Strong acids, such as sulfuric acid, can be used to scarify any size of seed. Handling strong acids is dangerous and requires special precautions. Many seeds with hard seed coats can be scarified safely with household bleach. Several hours of soaking in a 1:1 mixture of bleach and water often dissolves seed coats. Timing is important with both acid and bleach because once the hard seed coat is dissolved; the embryo is exposed and may be killed. Heavy watering of seeds after scarification can cause a disorder known as imbibition damage. This disorder kills the embryos before they can germinate. Exercise caution when watering seeds after scarification.

Scarification with hot water may also break hard seed coats. Drop seeds into four to five times their volume of hot (170° to 212° F) water and remove immediately from the heat source. Allow the water to cool for 12 hours or more. Unswollen seeds can be separated with appropriately sized screens and retreated. Swollen seeds should be sown immediately after the hot-water treatment. Aerating the seeds while they are soaking is advisable. An aquarium pump should provide adequate aeration for small volumes of seeds and water.

Planting them outdoors in the fall can naturally scarify some seeds. Fall sowing allows microbial action on the seed coat. Alternate freezing and thawing may further stress the seed coat and enhance water uptake. Exposure to several freeze-thaw episodes in a home freezer may be effective as a scarification treatment.

(2) Internal Chemical Inhibition

The seeds of many temperate-zone species are dormant when released from parent plants because of chemical conditions inside the seeds. Inhibiting chemicals can occasionally be washed or leached from seeds, but a more reliable method is cool, moist storage or stratification. Because stratification requires that seeds be imbibed (taking in moisture), cool or cold, dry storage will not break dormancy. The best cold stratification temperatures are above freezing (33 to 40°F). Although freezing usually will not harm dormant seeds, those which have broken dormancy and begun to germinate can be injured or killed by freezing. Stratification can be achieved naturally by sowing the seeds outdoors in the fall. Seed flats, covered with plastic to prevent drying, can be chilled in a refrigerator as well. To save space, all but the smallest seeds can be placed in moist sand or peat moss in plastic bags in the refrigerator, rather than sown in flats. The length of stratification necessary to overcome internal dormancy depends upon the species and varies widely. Although generalization is difficult, 4 to 6 weeks is often the minimum time required and some species require up to 26 weeks of stratification.

Cold stratification can be replaced for some species by soaking the seeds in gibberellic acid. Effective concentrations range from 100 to 1000 parts per million, with seeds soaked for 12 to 24 hours. Excessively high acid concentrations or extended soakings may not kill the seeds but can cause elongation of the young seedlings. Hard seed coats must be ruptured before soaking in gibberellic acid.

Some species require a warm stratification, followed by a cold stratification in order for germination to occur. Seeds from these species often germinate the second year after sowing out of doors. Warm stratification can also be carried out in incubators. Because the warm, moist conditions during warm stratification favor mold development, cleanliness and sanitation are critical for successful propagation. Seeds are often surface-sterilized using a 1:10 solution of household bleach in water before warm stratification.

(3) Immature embryo

The seeds of some species (especially woody plants) may be released from parent plants with underdeveloped or immature embryos. In order to germinate, these seeds typically need warm, moist conditions for the embryos to mature (after-ripening). Immature embryos may complete development if the seeds are sown outdoors in late summer or early fall. Direct sowing in the field can be challenging since it is difficult to weed without disturbing the seeds and seedlings. If seeds are planted inside a heated structure, water the seed flats well and keep them covered to prevent drying. Many seeds with immature embryos also exhibit other forms of dormancy and must be scarified or otherwise treated in addition to after-ripening.

Review

A. Describe, briefly, the three main aspects of plant propagation.

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B. What is sexual plant propagation? Give examples of how you would use it in a nursery.

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C. You've just received an order of several years' supply of seeds that you plan to use in propagating plants for your nursery. How will you store the seeds?

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D. What is seed dormancy? _____

E. Briefly describe the three types of seed dormancy and ways to overcome each.

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F. A customer wants to know how to germinate the tomato seeds she just bought from you. What is your advice? Hint: tomato seeds are normally not dormant.

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Asexual Propagation

Methods of asexual propagation are so diverse that a discussion of all methods is beyond the scope of this manual. The following are the most common methods for propagating nursery crops asexually.

Division

The simplest form of asexual propagation is division of one parent plant into two or more individuals. Plants that form clumps and an increasing number of stems, such as day lilies, are most suitable for division. The clump is simply removed from the soil and broken or cut into segments including a root or part of a root and a shoot or bud. While fibrous-rooted plants divide most easily, fleshy-rooted species, such as Peony, may also be divided. Use a sharp knife to cut apart the crown or roots so that a bud or stem remains on each division. Very large clumps need not be dug completely, provided enough propagating material can be obtained from a section of the clump. The section may be severed from the clump with a sharp spade, removed from the soil, and divided. Figure 5-1 shows several types of propagation divisions.

For most species, division is best conducted in the early spring or mid fall when foliage is ether undeveloped or fully matured and senescing (aging). Early-flowering plants are usually divided in autumn, while those flowering in late summer may be divided before growth starts in the spring. Some species, particularly those typically cut back severely after flowering, should be divided immediately after flowering. Divisions with fully developed, young, succulent foliage will wilt excessively and require shading and/or cutting back. Divisions planted in the fall must be mulched after the ground freezes to prevent freeze-thaw cycles from heaving them out of the ground. Very small divisions, especially those with expanded foliage and very little root, are best treated as cuttings.

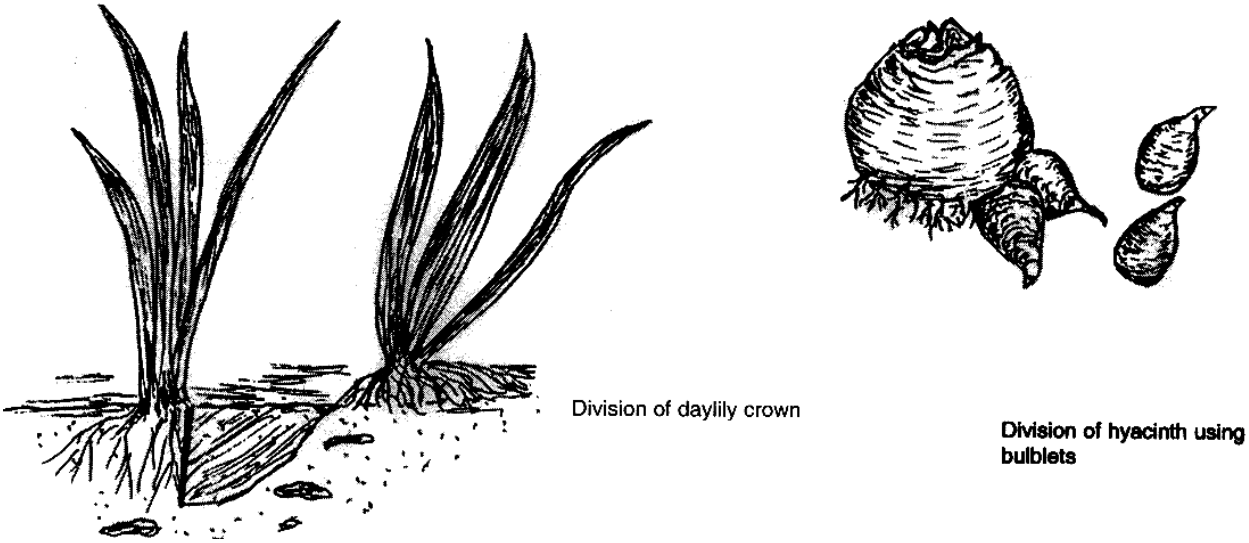

Figure 5.1. Propagation using divisions.

Layering

Layering involves rooting shoots while they are still attached to their parent plants. Some plants, such as blackberries, form natural layers. In other species, root production must be induced. Layering involves covering part of a shoot, stem, or branch with soil or other media into which roots can grow. Roots form on the covered stem while it is still attached to the plant. Layering is particularly useful for plants that do not root well from cuttings. Figure 5-2 illustrates several layering methods.

When layering in the nursery, stems are usually wounded and a root-promoting compound (auxin) is placed on the wounds. After rooting, new plants are detached by severing the rooted stem sections between the new roots and the stock plants. Layering is generally slower than some other forms of asexual propagation but, for difficult-to-root materials, it may be the only way. The main advantage of layering is that the layer remains attached to the plant and suffers little stress during the rooting process.

Layering may be done in spring, summer, or autumn and branches may usually be severed from stock plants at the end of a year. Quick-rooting layers may be transplanted immediately, but slower types, such as rhododendron or magnolia, should be left a second year for the formation of more roots. Layering may be used for perennials such as dianthus; woody ornamentals such as clematis, Philadelphia, and Ilex; or for house plants such as Ficus.

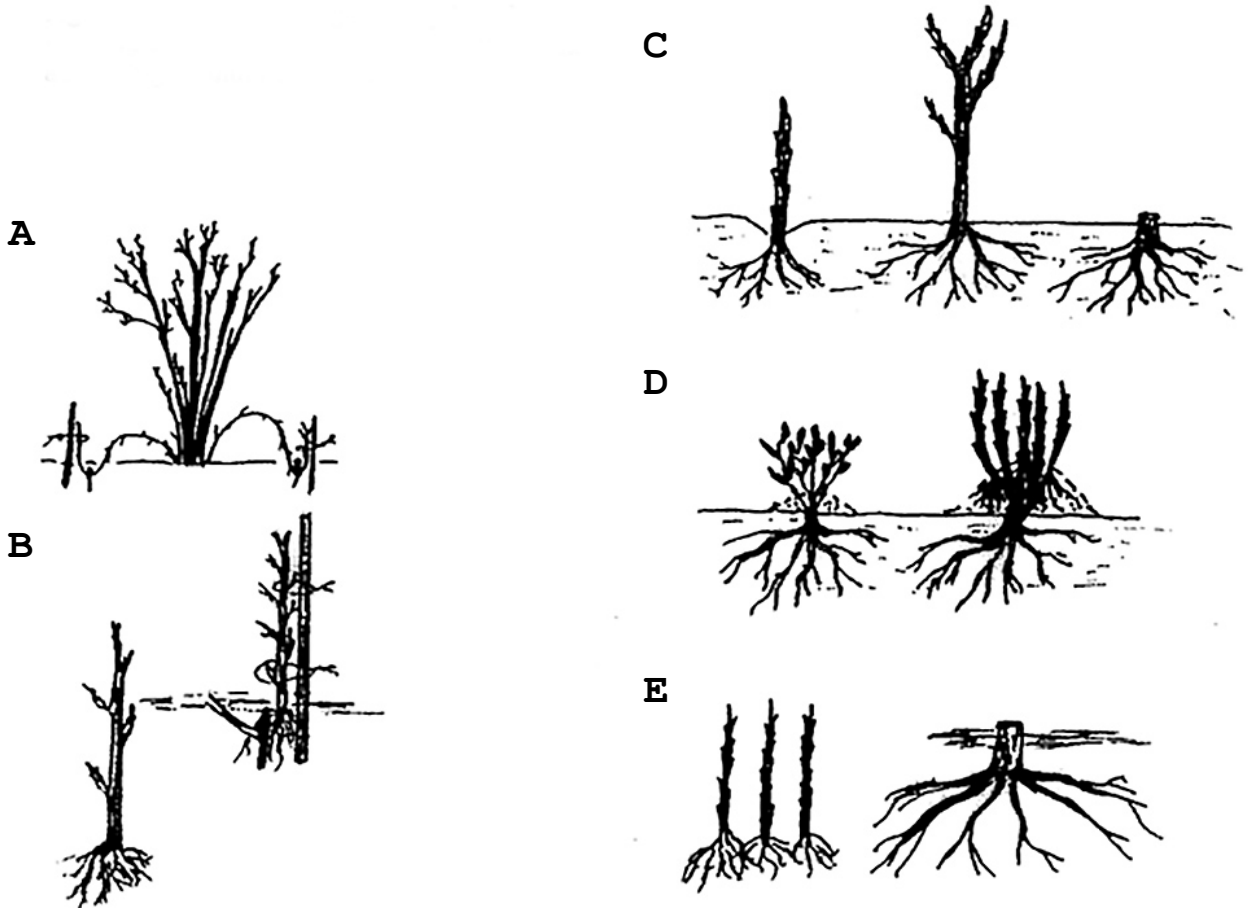

Figure 5.2. Plant propagation by layering. **Simple layering**: A- stems are secured into the soil; B- plants are detached from the parent plant following rooting. **Stool bed layering**: C- cutting is planted, then cut back following establishment; D- media is mounded around base of new stems; E- cuttings are removed from parent plant following rooting.

Stolons, Offsets, and Rhizomes

Some plants reproduce naturally by forming layers from stolons, offsets, and rhizomes. Rooted portions of stems are removed from stock plants by division and planted in a new site. Stolons, also known as runners, are horizontal stems, which lie on the soil surface and produce new plants at their nodes. Strawberries and carpet bugle (Ajuga) are often propagated by stolons. Offsets are merely very short stolons. Rhizomes are horizontal stems under the soil surface which root at their nodes and send up one or more leafy shoots. Figure 5-3 demonstrates propagation using stolons and rhizomes.

Plants with stolons or rhizomes typically spread to form clumps and can be propagated by division. Since each of these horizontal stems has nodes with buds and the potential to form roots, however, cutting the stems into short sections, each with its own bud, and rooting the cuttings can be used to produce more plants more quickly than by the use of clump division alone.

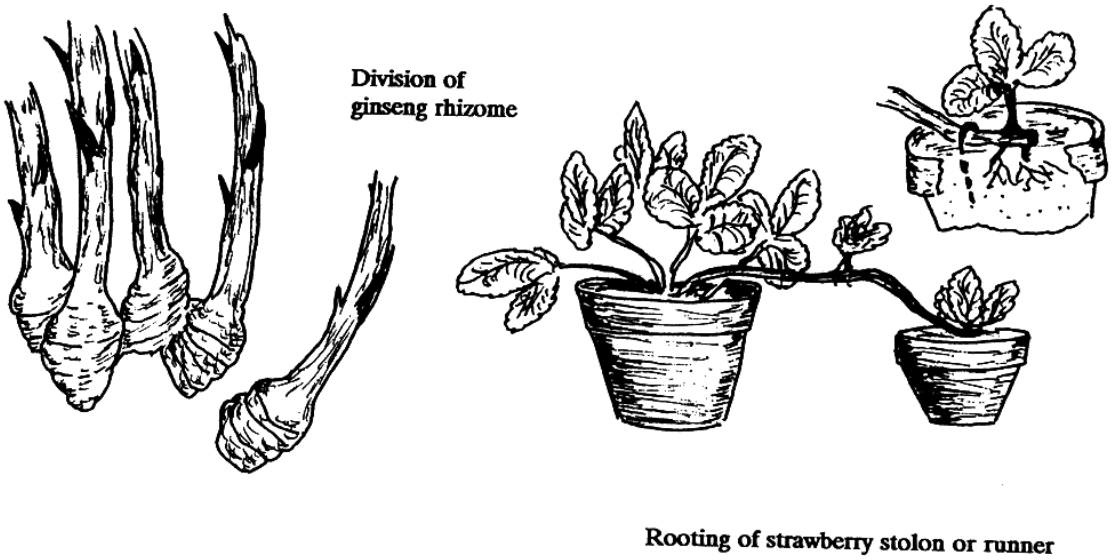

Figure 5.3. Propagation using rhizomes (left) and stolons (right).

Bulbs and Corms

Bulbs are underground storage organs composed of unextended stems and many leaves that are modified for storage. Tulips, daffodils and lilies are examples of plants with bulbs. Corms are underground storage organs composed of stem tissue. In contrast to bulbs, a corm is a solid stem structure with distinct nodes and internodes. Gladiolus and crocus are typical cormous plants. Both bulbs and corms divide naturally, with one bulb or corm forming 2 or 3 new bulbs or corms each year. Many bulbous plants also produce tiny bulbs (bulblets) near the base of mother bulbs, and cormous plants produce tiny corms (cormels) on stolons at the base of mother corms.

Propagation can be achieved by harvesting and planting bulbets and cormels, although flowering may not occur for one or more years. Many scaly bulbs, such as lilies, can be propagated from bulb scales, which are really leaf cuttings. Simply break the scales from the bulb and plant them.

Cuttings

Rooting cuttings is one of the most common propagation methods, especially for ornamental deciduous and evergreen shrubs, many greenhouse crops, and some fruit tree rootstocks. Cuttings are incomplete segments of a plant which, when placed under proper environmental conditions, will generate an entirely new plant. Stem cuttings produce roots and leaves, root cuttings produce stems and leaves, and leaf cuttings produce roots and stems. Not all plants can generate missing parts, so not all plants can be propagated from cuttings. Some plants, such as quaking aspen, produce shoots on root cuttings, while others do not. Succulent plants, such as African violets, can be propagated using leaf cuttings. Because cuttings are made from small segments of a stock plant, rapid propagation of many new plants is often possible. Because cuttings are missing important parts of the plant, they require special conditions to survive. Cuttings of some species, such as willow, may root when stuck in the field and ignored, but such plants are the exception.

Because cuttings are wounded in the cutting process, they are susceptible to diseases. Tools used to take the cuttings should be sharp and disinfected with a bleach solution between cuttings to prevent spreading diseases. Rooting media should be sterile and well drained. Drainage is important for air penetration into media, since lack of oxygen favors disease and damages stems and developing roots. Treating cut surfaces with fungicides helps to prevent rot. Many commercial rooting compounds contain fungicides along with the root-promoting substances. The propagator should keep in mind, however, that fungicides might inhibit rooting of some plants.

Because stem and leaf cuttings lack roots and can't take up water effectively, they must be protected from drying. Root and shoot formation requires energy, and leaf and stem cuttings must have light. Reducing water stress while providing as much light as possible can be challenging.

The most effective method of rooting stem and leaf cuttings is under intermittent mist in a cold frame or greenhouse. A fine mist is applied to the cuttings for 10 to 30 seconds every 10 to 20 minutes during sunny weather and less during cloudy weather or at night. The high humidity produced by the mist reduces water stress, while high light from the sun speeds rooting. The major disadvantages of mist propagation are startup expenses, maintenance, and the requirement for a clean water source to prevent clogging mist nozzles. Well-constructed mist systems are relatively free of disease, although fungal and bacterial problems may occur. Figure 5-4 demonstrates the handling of softwood and semi-hardwood cuttings.

High humidity for rooting cuttings without mist can be achieved by covering propagation flats with glass or plastic film. The glass or plastic is normally supported on frames. Protect the cuttings from direct sunlight by locating the frames on the north side of a building, under a shade tree, or under shade cloth. Rooting may be slower because of the decreased light intensity, but startup expenses are considerably less than with a misting system. Cleanliness in propagating cuttings is critical. A water source, preferably a mist nozzle on a hose, must be readily accessible. Propagation frames out of doors require daily attention, particularly with regard to watering.

Antitranspirants have also been used successfully in propagating some species without mist systems.

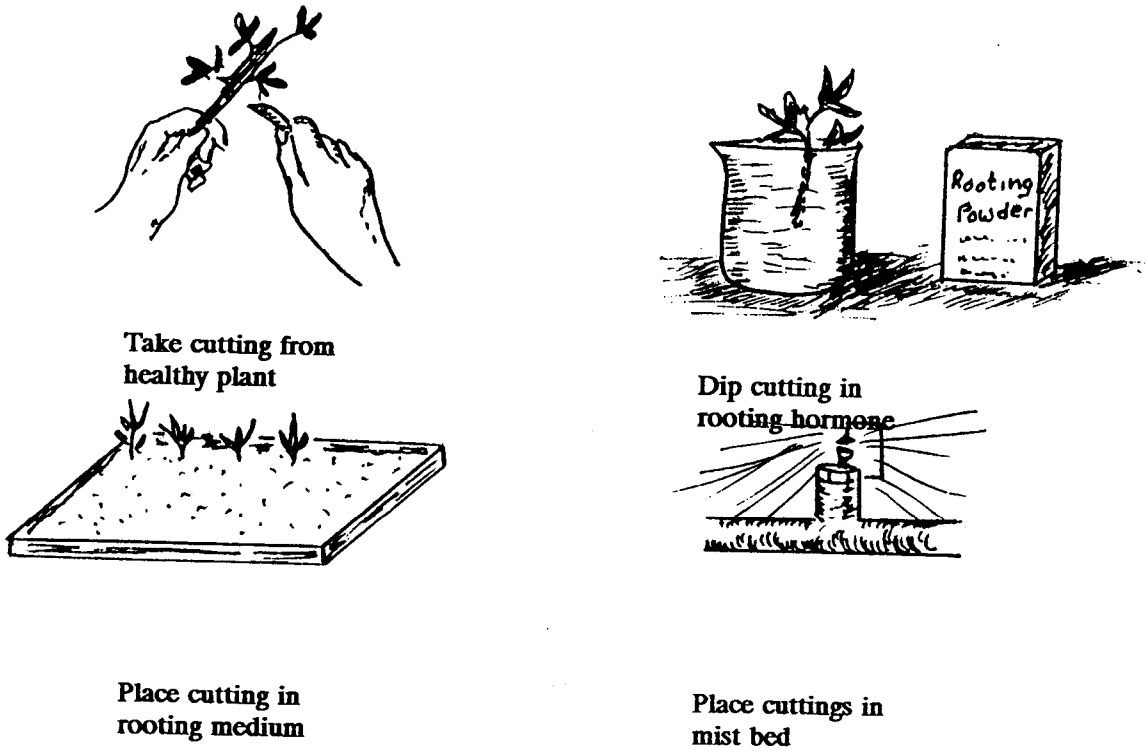

Figure 5-4. Propagation of softwood and semi-hardwood cuttings.

Stem cuttings of woody plants can be classified as softwood, semi-hardwood, or hardwood. The best kind of cutting to use depends upon the plant to be propagated. Softwood and semi-hardwood cuttings are current-season growth and generally root faster than hardwood cuttings, which are shoots from the previous season. Leaves on deciduous softwood and semi-hardwood cuttings produce carbohydrates through photosynthesis and provide plant growth substances to the cutting. Leaves also increase water loss, however, so that cuttings may be easily stressed. Deciduous hardwood cuttings are less easily water-stressed, but the lack of photosynthesis slows rooting. Hardwood cuttings are often preferred, even though they root more slowly, because they can be collected during the fall and winter. The advantages of green leaves for producing plant-growth substances and photosynthetic energy, as well as the disadvantages of increased water loss, also hold for hardwood cuttings of evergreens.

Leaf cuttings may be used to propagate plants such as begonia or African violet. The leaf blade and petiole is inserted into the medium and kept moist until roots form. If roots, but not shoots, form on leaf cuttings, new plants can usually be obtained by including a small portion of stem and an axillary bud in the cutting.

Budding and Grafting

Grafting is used to propagate cultivars that are not easily propagated by other methods, to combine in one plant the desirable qualities of two or more plants, to repair damage, or to produce large, mature plants quickly. Grafting can shorten the period to flowering or fruiting, change the shape or habit of a plant, or create fruit trees consisting of more than one cultivar. Currently, grafting propagates many fruit tree and shade tree cultivars.

Both budding and grafting involve the fusion or growing together of parts of two or more different plants to make a single individual. For the union to take place, dividing cells in the cambium of both stock (the part with roots) and scion (the part grafted to the rootstock) must touch firmly. Because dividing cells are extremely fragile and very susceptible to drying, the graft (or bud) union must be protected from drying and movement. With the stock and scion bound together and the union protected, cells of the cambium in both stock and scion begin dividing to form wound callus. The calli intermix and eventually the vascular tissues unite to form a single stem. Care should be taken while the graft is healing to prevent movement of stock against scion, since such movement will disrupt vascular connections and cause a failed union.

Types of grafting differ in several ways depending on the window of opportunity to perform the graft, and seasonal changes. The three most common types of grafting are bench grafting, whip grafting and bud grafting.

Bench grafting is performed at a bench using dormant scion wood (plant material collected for duplicating or cloning the host or parent variety) collected in late winter or early spring before breaking dormancy. The understock is normally a cutting grown for one year, harvested in fall and placed in storage until needed.

To accomplish a successful graft the scion and rootstock should be of similar caliper, each cut at the proper angle, fitted together and then securely wrapped to ensure there is no movement. The graft is dipped in grafting wax of the proper mix and temperature, and stored under optimal conditions before spring planting.

The advantages of bench grafting are that the window of opportunity to graft is several months long, and first season growth will develop after grafting. The disadvantages include having to collect and store of rootstocks and scion wood, waxing of grafts, and post graft care.

Whip grafting resembles bench grafting in that the plants are handled while dormant, but the understock is growing in the field. Scion wood is collected in the same manner as for bench grafting. The scion and understock are cut to fit in the field. As in bench grafting, properly fitting scion to understock is important for a successful graft. Grafts must be tied securely and waxed or coated with sealers specifically made for the process.

The principle advantage of whip grafting is that no transplanting is necessary and first season growth will develop after grafting. Many tree repairs or top working can be done with this method. The disadvantages of whip grafting include a very short window of opportunity to make the graft, and success can be impaired by weather conditions. Additionally, the size of the understock can vary sometimes making it difficult to match the scion wood.

Bud grafting is done in mid to late summer, close to the time of terminal bud set. Bud wood is collected a few days before propagation and stored under cool, moist conditions. Budding, like whip grafting, is performed in the field. The bud is slipped into a T or chip cut in the rootstock a few inches above the ground. The buds are tied in place with rubber or plastic strips so no waxing or sealing is required. Bud wood is similar to scion wood except that only the actual bud is used for grafting. Scion wood or bud wood sticks are current season's growth cut 12' to 18' in length. There may be as many as 15 buds to a stick that are suitable for bud grafting, or a stick can be cut into 2 or 3 pieces of scion wood to be used in bench or whip grafting.

The advantage of bud grafting is the high rate of success; however there is a short window of opportunity for this process and the proper storage of bud wood is critical. The process is easy because matching the rootstock to the size of the bud is not critical, and no waxing or sealers are needed.

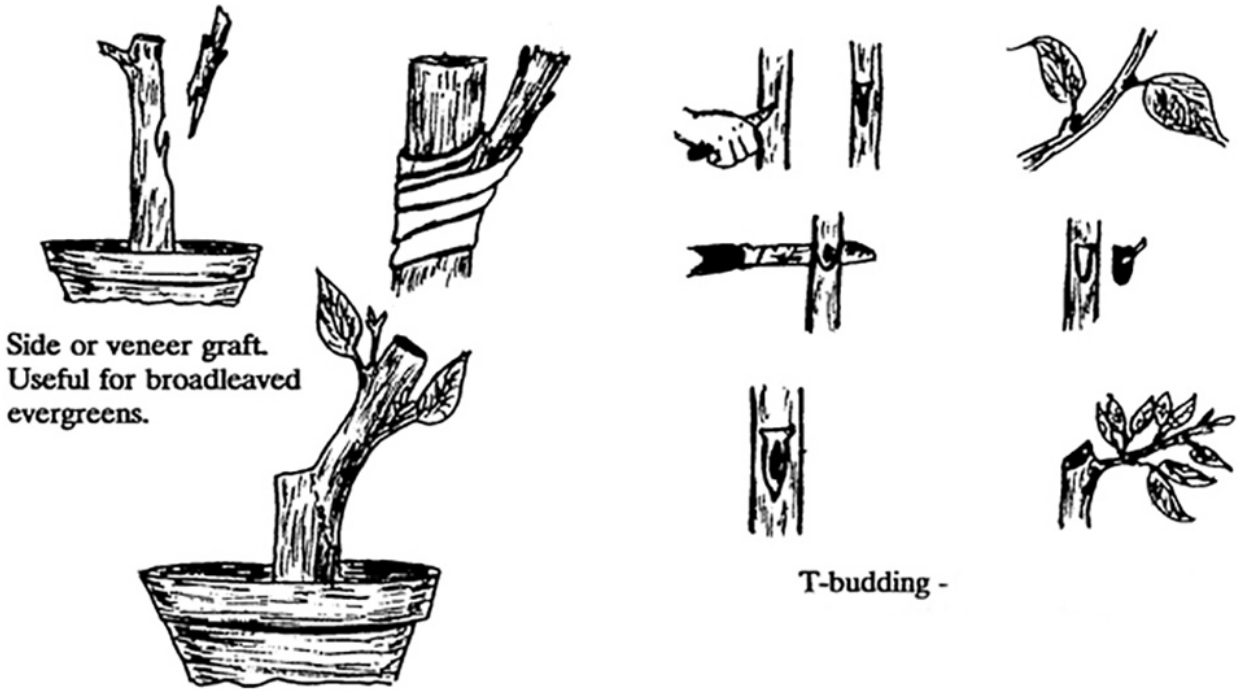

Figure 5-5. Typical budding and grafting techniques

The understock will compartmentalize the newly inserted bud, which will remain dormant. Before breaking dormancy the following spring, the understock is pruned back to slightly above the grafted bud. The bud will then sprout and grow, producing a three to four foot one-year whip by the end of the growing season.
The main disadvantage of bud grafting is that the rootstock must be grown for at least one season before it can be used for budding, and therefore the scion's first year growth will not occur until the following season.

Tissue Culture

Tissue culture, also known as micropropagation, is the rapid multiplication of plants in vitro. Micropropagation is most commonly performed using semi-solid nutrient media inside sterile containers that are placed in a rigidly controlled environment. Large-scale in vitro production requires extensive training, expensive equipment and considerable expertise.

For most plants, micropropagation is achieved using a shoot culture system, where stems grown in vitro are cut into single-node pieces and sub-cultured onto fresh media for continued growth (Fig. 5-6). This process results in an exponential increase in shoot numbers, allowing for a very large number of plants to be produced within a short period of time. This multiplication via buds formed at nodes is a highly reliable means of clonal reproduction. While adventitious shoots can be generated in vitro, particularly under high hormone levels, these shoots can result in mutant or off-type plants. Much of the expertise required for micropropagation involves the ability to control the rapid multiplication of shoots from buds while preventing adventitious shoot formation, and is a critical attribute of reputable tissue culture laboratories.

A shoot culture system can be divided into the following stages: 1) Isolation: the decontamination and growth of buds on explants. 2) Stabilization: obtaining uniform and continuous shoots from buds generated in vitro. 3) Optimization: enhancement of multiplication quantity and quality by refining media and environmental components. 4) Rooting and Acclimation: development of roots and acclimation of plant to ex vitro conditions.

Tissue culture is a valuable research tool and its use in commercial plant propagation continues to increase. Micropropagation allows for the rapid multiplication of pathogen-free clones, and has therefore become the preferred method of propagation for many economically-important plants, including houseplants, potatoes, lilies, orchids, blueberries, cherries, grapes and strawberries.

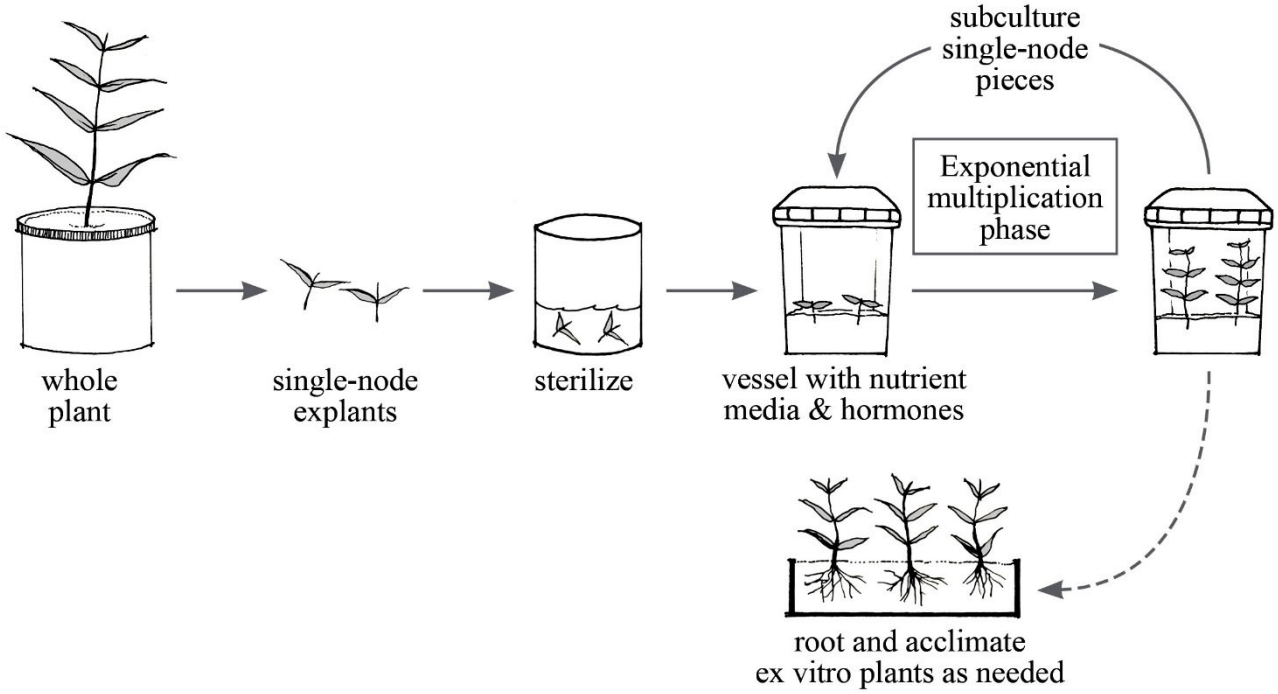

Figure 5-6. Micropropagation via a shoot-culture system. Stems grown in vitro are cut into single-node pieces and sub-cultured onto fresh media for continued growth. Propagules are removed from culture, rooted and acclimated to ex vitro conditions.

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Chapter Review

A. Describe the differences between sexual and asexual plant propagation. List advantages and disadvantages of each method and how each is used in the nursery trade.

_____

_____

_____

_____

B. What four things does a viable, nondormant seed need to germinate?

1. _____ 2. _____ 3. _____ 4. _____

C. What are the differences between stratification and scarification? Give an example of when each method might be used.

_____

_____

_____

D. List eight methods that you might use to control damping off in seed flats.

1. _____ 2. _____ 3. _____ 4. _____

5. _____ 6. _____ 7. _____ 8. _____

E. Describe seven methods of asexual plant propagation. Give examples of plants suitable for each method.

1. _____

_____

2. _____

_____

3. _____

_____

4. _____

_____

5. _____

_____

6. _____

_____

7. _____

_____

F. What three methods can be used to keep unrooted cuttings from drying out while rooting?

1. _____ 2. _____ 3. _____

G. What time of year is bud grafting done? Why? _____

_____

H. Describe how you would perform a bench graft. What precautions would you take to ensure that the union would fuse properly and not dry out?

_____

_____

_____

I. Give two reasons why propagation by tissue culture is becoming increasingly important in the nursery trade.

1. _____

2. _____

J. What is the best means of preventing the production of mutant or off-type plants during micropropagation?

_____

_____