Unit II

Pharmacognosy & Phytochemistry (BP405T)

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UNIT-II (Part 1)

Cultivation and Collection of drugs of natural origin

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Medicinal plants are a source of bio-molecules with therapeutic potential and as a lead to develop new drugs. Herbal medicines are considered as safer, better physiological compatibility and cost-effective. India is a gold mine of medicinal plants and a rich repository of traditional medicinal knowledge. Demand for the medicinal plant is increasing with expansion in human needs, numbers and trade purpose. Plants are mostly collected from wild sources that may pose a serious situation, along with this loss of biodiversity and forest is another major concern for sustainable supply of medicinal plants in the future. With the increased realization that many species are collected from wild sources and being over-exploited, agencies (private/public) are recommending bringing the important medicinal plants into cultivation systems. Cultivation of medicinal plant can decrease the amount to which wild populations are harvested, it will also help to preserve plant species from extinction and will promote socio-economic growth. This chapter deals with the medicinal importance and cultivation of yam, sarpagandha, opium, periwinkle, aloe, guggal, belladonna, nux-vomica, medicinal solanum, aonla/amla, senna, isubgol, stevia, coleus, acorus, and ocimum.

The importance of herb, shrub and trees for curing and preventing ailments is an old age tradition, which has been relegated to the background due to invasion of modern allopathic system of drug. There is an awakening all over the globe to turn back to the traditional treatment using plants part as an affordable way and to revive traditional system of medicine uninterrupted supply of genuine raw material are of prime necessity. The resource pools of the medicinal plants were abundant in forest but forest areas are dwindling fast due to anthropogenic pressure. Therefore the alternative means to generate more raw materials could be only through cultivation of medicinal plants in agriculture fields.

Cultivation

Cultivation of Crude Drugs:

Cultivation of medicinal plants requires intensive care and management. The conditions and duration of cultivation required vary depending on the quality of medicinal plant materials required.

Methods of Propagation:

Vegetative propagation (Asexual propagation):

Vegetative propagation can be defined as regeneration or formation of a new individual from any vegetative part of the plant body. The method of vegetative propagation involves separation of a part of plant body, which develops into a new plant.

Methods of vegetative propagation:

Vegetative propagation is something very peculiar to plants. Moreover, avid gardeners exploit this feature for commercial purposes. As a matter of fact, we don't always need seeds to grow plants. Because new plants can grow from older plants using vegetative propagation methods such as grafting and budding. It is a form of asexual reproduction seen in plants. This process involves only a single plant and the offspring that arises is identical, both genetically and morphologically, to the parent plant.

Vegetative propagation occurs through vegetative plant structures. In non-vascular plants, the vegetative reproductive structures are gemmae and spores whereas, in vascular plants, the roots, stems, leaves, and nodes are the vegetative propagation structures. Also, we have learned about the meristem tissue in plants. This tissue helps in the vegetative propagation. It has undifferentiated cells which divide. As a result, it paves the way for the growth of the plant. Also, from the meristems, specialized permanent tissues are formed.

They are two types:

1. Methods of natural vegetative propagation:
2. Methods of artificial vegetative propagation.

A. Methods of natural vegetative propagation:

a. Vegetative propagation by stem:

Vegetative propagation occurs through stems when new plants arise from the nodes. This is where buds are formed, which grow into new plants.

Runners or stolons

Stems that grow horizontally on the ground are called runners or stolon. As these runners grow, buds form at the nodes, which later develop the roots and shoots, resulting in the formation of a new plant. Example – Cyanodon, Mint, strawberry etc.

Bulb

The bulb is the round, swollen part of the underground stem. Within the bulb lies the organ for vegetative propagation such as the central shoot that grows into a new plant. Bulbs have a bud surrounded by layers of fleshy leaves. A few examples include Onions, Garlic, Squill and Tulips etc.

Corms

The stem character of bulbs is obscured by their very fleshy leaves. From the prominent terminal bud and smaller ones in the axils of its scale-like leaves, corms develop new plants, and often small, subsidiary corms known as cormels. Corms are frequently used to propagate a plant by digging them out of the ground, then cutting the corms into individual sections and replanting. Each section of the corm that has at least a single bud can usually generate a new corm, example Colchicum.

Tubers

Tubers, such as potatoes, are fleshy underground storage structures composed of enlarged parts of the stem. A tuber functions in asexual propagation as a result of the tiny scale leaves equipped with buds that grow on its surface. Each of these buds can form a new plant, genetically identical to the parent, examples potatoes, aconite etc.

Offset

These are also known as condensed runners. These originate as short, more or less thickened, horizontal branches in the axil of lower leaves of the main shoots. Unlike a runner, an offset produces a tuft of leaves above and a cluster of roots below. On breaking off from the parent plant, each branch forms an independent plant. These are the clones and genetically identical to the plants. These are produced by the mitotic division of the main stem of the plant. . Example Valerian.

Rhizomes

Rhizomes are root-like stems that grow horizontally under the ground. New roots and shoots form at the nodes with shoots growing upwards to form new plantlets. Lateral buds grow out to form new rhizomes. Examples include Ginger and turmeric.

Propagation by Leaves

Leaves are not a common means of vegetative propagation in nature. However, Bryophyllum is known for its remarkable ability to reproduce by leaves. In Bryophyllum plantlets develop from the buds present on the marginal notches of the intact leaves. These plantlets become detached and develop into independent plants.

b. Vegetative propagation by root: examples: Asparagus

2. Methods of artificial vegetative propagation:

Artificial vegetative propagation is a type of plant reproduction that involves human intervention. The most common types of artificial vegetative reproductive techniques include cutting, layering, grafting, suckering, and tissue culturing. These methods are employed by many farmers and horticulturists to produce healthier crops with more desirable qualities.

Following methods are used:

1. Stem Cuttings

Collecting Stems

The best time of the year for making stem cuttings of perennials is late spring or early summer when the plant is in a full flush of growth. Cuttings should be made early in the day when the temperature is cool and the mother plant most turgid. The plant providing the cuttings should be vigorous, healthy and disease free. Using a sharp knife or pruners, remove a 3-6 inch terminal segment of a shoot just below a node. The cutting should have at least 3 nodes. Place the cuttings in a plastic bag with a few ice cubes or in an ice chest with several ice cubes in the bottom. Alternately, cuttings can be wrapped in damp newspaper or cloth to keep them cool. Dampened sphagnum moss can also be used to wrap them until they are ready to be stuck. Keep the cuttings out of direct sunlight and do not place them in water.

Sanitation

The pruners or knife used to make stem cuttings should be disinfected in a mixture of 9 parts water to 1 part bleach before each use. The work area should be as clean as possible. The flats, pots, etc. that the cuttings are to be stuck in should be dipped in bleach solution also.

Wounding

A sharp, sterilized knife can be used to make a vertical wound of about 1/2-inch on one or both sides along the bottom of the stem that will be covered in the rooting medium. Wounding is not really necessary for herbaceous plants but with woody plants, wounding is thought to induce internal hormonal changes that may improve rooting. It also exposes active cells to hormone preparation.

Hormones

The first hormone to be used to propagate plants was indol acetic acid (IAA), which is naturally found in plants. Eventually, two synthetic auxins, indole butyric acid, (IBA), and naphthalene acetic acid, (NAA), were found to be more effective than IAA. The favorite commercial root formulations are Hormodin, HormoRoot, Hormex, Rootone, Dip and Grow and Woods.

Propagation Medium

The most important consideration is that the medium must have excellent drainage in order to prevent the cuttings from rotting. A one to one mixture of course building sand and perlite makes a good medium for rooting cuttings. Some people have just as much success using the building sand alone. Sand and seed starter mix can also be combined to use as a medium. The medium should be course enough to support the stem upright under misting or light spraying.

Inserting Cuttings

Before sticking the cuttings in rooting medium, remove all fruit and flowers and strip the stem of its lower leaves. Any leaves inserted under the soil will rot. If the cutting has very large leaves, such as hydrangea and witch hazel, the leaves left on the top of the stem can be trimmed in half to reduce their size. If wounding is to be used on the cutting, make the l/2-inch vertical cut, apply the rooting hormone on the bottom portion of the stem along the wound, dusting any excess hormone powder off the cutting. Moisten the medium and with a finger, pencil or wooden dibber make a hole in the medium large enough to accommodate the stem. Insert the stem into the hole and firm the medium. Using a gentle spray, water the cuttings immediately. Label the container with the name and date of the cutting. Place the container in a location so that it gets bright light but not direct sun. The best success comes with keeping the root zone warm and the exposed stem cool. Check for roots after 2 or 3 weeks by gently tugging on the top of the cutting. If resistance is felt, rooting has begun.

Care of Newly Rooted Cuttings

After cuttings have developed roots, the new plant needs special care to survive its first year. If it is to be planted outside for the winter, it must have sufficient root system to support itself. It must first be hardened off in a shady location to acclimate. Leave it in the pot and harden it off for several weeks, gradually moving it to a more exposed location each week. Ideally, the new plant should be left undisturbed in the pot it was rooted in and placed in a shade house or other protected place through its first winter. By spring, the plant will be hardy enough to support itself and be planted out. These are the parts of the plant (stem, root or leaf) which, if grown under

suitable' conditions, develop new plants. Stem cutting are generally used to obtained new plants. Examples: Sugarcane and rose, etc.

2. Layering:

This method involves bending plant branches or stems so that they touch the ground. The portions of branches or stems in contact with the ground are then covered with soil. Adventitious roots or roots that extend from structures other than plant roots develop in the parts covered by soil and the attached shoot (branch or stem) with new roots is known as a layer. This type of layering also occurs naturally. In another technique called air layering, branches are scraped and covered with plastic to reduce moisture loss. New roots develop where the branches were scraped and the branches are removed from the tree and planted.

3. Grafting:

New variety is produced by joining parts of two different plants. The rooted shoot of one plant, called stock, is joined with a piece of shoot of another plant known as scion. Examples: Rose, citrus and rubber, etc.

4. Suckering: Suckers attach to a parent plant and form a dense, compact mat. Since too many suckers can lead to smaller crop size, excess numbers are pruned. Mature suckers are cut away from a parent plant and transplanted to a new area where they sprout new plants. Suckering has the dual purpose of growing new shoots and removing nutrient-sucking buds that prohibit a main plant from growing.

5. Micro propagation:

This method consists of growing cell, tissue and organ in culture. Small pieces of plant organs or tissues are grown in a container with suitable nutrient medium, under sterilized conditions. The tissue grows into a mass of undifferentiated cells called callus which later differentiates into plantlets. These are then transferred into pots or nursery beds and allowed to grow into full plants.

Advantages of Asexual Propagation

As resultant species formed through asexual process are genetically identical, useful traits can be preserved among them. Asexual propagation allows propagation of crops that do not possess seeds or those which are not possible to grow from seeds. For e.g. Jasmine, sugarcane, potato, banana, rose etc. Plants grown through vegetative propagation bear fruits early. In this type, only a single parent is required and thus it eliminates the need for propagation mechanisms such as

pollination, cross pollination etc. The process is faster than sexual propagation. This helps in rapid generation of crops which in turn balances the loss.

Importance of asexual propagation:

1. It is a cheaper, easier and rapid method of multiplication. Many fruit trees usually require 4-5 years to bear the fruits when developed from seeds. The plants developed by vegetative methods, take only a year to bear fruits.
2. Plants like roses and chrysanthemum, etc do not form viable seeds. Thus, vegetative propagation is the only method of propagation is the only method of reproduction and continuation of species in such plants.
3. All the plants developed by these methods will be generally similar to the parent plant.
4. Micro propagation is useful in raising disease free plants, homozygous diploids, and those without viable seeds.

B. Seed Propagation (Sexual Propagation):

Sexual propagation involves the union of the pollen (male) with the egg (female) to produce a seed. The seed is made up of three parts: the outer seed coat, which protects the seed; the endosperm, which is a food reserve; and the embryo, which is the young plant itself. When a seed is mature and put in a favorable environment, it will germinate (begin active growth). The process of sexual propagation is summarized below:

- Sexual propagation or reproduction refers to multiplication of plants by seeds. Seeds are formed after successful pollination and fertilization by the union of male and female gametes.
- Meiosis division takes place in the course of fusion and the chromosome numbers are reduced to half, which after fertilization becomes normal.
- Sexual plant propagation involves the union of the pollen (male organ) with the egg (female organ) in plants to produce a seed.
- The plants raised through seed are called seedling plants.
- Sexual propagation involves careful management of germination conditions and facilities and knowledge of the requirements of individual kind of seeds.

- When a mature seed is exposed to favorable environment, it germinates and begins its active growth.

The Success seed propagation depends upon some conditions:

- Using seed of proper genetic characteristics to produce the cultivar or species, of provenance desired. This can be accomplished by obtaining seed from a reliable source.
- Using good quality seeds which germinate rapidly and vigorously to withstand possible adverse environmental conditions in the seed bed and provide a high percentage of usable seedlings.
- Manipulating the seed dormancy by applying pre-germination treatments or proper timing of planting.
- Providing proper environment for seed germination *i.e.*, supplying sufficient water, proper temperature, adequate oxygen and either light or darkness (depending upon kind of seed) to the seeds and resulting seedlings until they are well established.

Germination

Germination will begin when certain internal requirements have been met. A seed must have a mature embryo, contain a large enough endosperm to sustain the embryo during germination, and contain sufficient hormones to initiate the process. In general, do not expect more than 65% to 80% of new seeds to germinate. From those germinating, expect about 60% to 75% to produce satisfactory, vigorous, sturdy seedlings. There are four environmental factors which affect germination: water, oxygen, light, and heat.

Water

The first step in the germination process is the imbibition or absorption of water. Even though seeds have great absorbing power due to the nature of the seed coat, the amount of available water in the substrate affects the uptake of water. An adequate, continuous supply of water is important to ensure germination. Once the germination process has begun, a dry period can cause the death of the embryo.

Light

Light is known to stimulate or to inhibit germination of some types of seed. The light reaction involved here is a complex process. Some crops which have a requirement for light to assist seed germination are ageratum, begonia, browallia, impatiens, lettuce, and petunia. Conversely, beans, calendula, centaurea, annual phlox, and vinca will germinate best in the dark. When sowing light-requiring seed, do as nature does, and leave them on the soil surface. If they are covered at all, cover them lightly with fine peat moss or fine vermiculite. These two materials, if not applied too heavily, will permit some light to reach the seed and will not limit germination. When starting seed in the home, supplemental light can be provided by fluorescent fixtures suspended 6 to 12 inches above the seeds for 16 hours a day. High intensity lights will provide more light over the course of the day and will enhance the quality of seedlings. These lights cost more than the common shop lights, but are often worth the investment if you plan on growing plants indoors.

Oxygen

In all viable seed, respiration takes place. The respiration in dormant seed is low, but some oxygen is required. The respiration rate increases during germination, therefore, the substrate in which the seeds are placed should be loose and well-aerated. If the oxygen supply during germination is limited or reduced, germination can be severely retarded or inhibited.

Temperature

A favorable temperature is another important requirement of germination. It not only affects the germination percentage but also the rate of germination. Some seeds will germinate over a wide range of temperatures, whereas others require a narrow range. Many seeds have minimum, maximum, and optimum temperatures at which they germinate. For example, tomato seed has a minimum germination temperature of 50 degrees F. and a maximum temperature of 95 degrees, but an optimum germination temperature of about 80 degrees. Where germination temperatures are listed, they are usually the optimum temperatures unless otherwise specified. Generally, 65 to 75 degrees F. is best for most plants. This often means the germination flats may have to be placed in special chambers or on radiators, heating cables, or heating mats to maintain optimum

temperature. The importance of maintaining proper substrate temperature to achieve maximum germination percentages cannot be over-emphasized. It's also very important to note that the recommended temperatures need to be maintained 24 hours a day.

Methods of Breaking Dormancy

One of the functions of dormancy is to prevent a seed from germinating before it is surrounded by a favorable environment. In some trees and shrubs, seed dormancy is difficult to break, even when the environment is ideal. Various treatments are performed on the seed to break dormancy and begin germination.

Scarification

Seed scarification involves breaking, scratching, or softening the seed coat so that water can enter and begin the germination process. There are several methods of scarifying seeds. In acid scarification, seeds are put in a glass container and covered with concentrated sulfuric acid. The seeds are gently stirred and allowed to soak from 10 minutes to several hours, depending on the hardness of the seed coat. When the seed coat has become thin, the seeds can be removed, washed, and planted. Another scarification method is mechanical. Seeds are filed with a metal file, rubbed with sandpaper, or cracked with a hammer to weaken the seed coat. Hot water scarification involves putting the seed into hot water (170 to 212 degrees F). The seeds are allowed to soak in the water, as it cools, for 12 to 24 hours and then planted. A fourth method is one of warm, moist scarification. In this case, seeds are stored in nonsterile, warm, damp containers where the seed coat will be broken down by decay over several months.

Stratification

Seeds of some fall-ripening trees and shrubs of the temperate zone will not germinate unless chilled underground as they over winter. This so called "after ripening" may be accomplished artificially by a practice called stratification. The following procedure is usually successful. Put sand or vermiculite in a clay pot to about 1 inch from the top. Place the seeds on top of the medium and cover with ½ inch of sand or vermiculite. Wet the medium thoroughly and allow excess water to drain through the hole in the pot. Place the pot containing the moist medium and

seeds in a plastic bag and seal. Place the bag in a refrigerator. Periodically check to see that the medium is moist, but not wet. Additional water will probably not be necessary. After 10 to 12 weeks, remove the bag from the refrigerator. Take the pot out and set it in a warm place in the house. Water often enough to keep the medium moist. Soon the seedlings should emerge. When the young plants are about 3 inches tall, transplant them into pots to grow until time for setting outside.

Another procedure that is usually successful uses sphagnum moss or peat moss. Wet the moss thoroughly, then squeeze out the excess water with your hands. Mix seed with the sphagnum or peat and place in a plastic bag. Seal the bag and put it in a refrigerator. Check periodically. If there is condensation on the inside of the bag, the process will probably be successful. After 10 to 12 weeks, remove the bag from the refrigerator. Plant the seeds in pots to germinate and grow. Handle seeds carefully. Often the small roots and shoots are emerging at the end of the stratification period. Care must be taken not to break these off. Temperatures in the range of 35 to 45 degrees F (2 to 70C) are effective. Most refrigerators operate in this range. Seeds of most fruit and nut trees can be successfully germinated by these procedures. Seeds of peaches should be removed from the hard pit. Care must be taken when cracking the pits. Any injury to the seed itself can be an entry path for disease organisms.

Advantages of Sexual Propagation:

- It is the easiest and least expensive method of plant propagation.
- Seed propagation is only mean of diversity particularly in the selection of chance seedlings.
- Seedling plants are long lived, productive and have greater tolerance to adverse soil and climatic conditions and diseases.
- Seed propagation makes feasible to propagate plants like papaya, phalsa and coconut in which asexual means of propagation is not common.
- Hybrids can only be developed by sexual means.
- Sexual propagation offers opportunities of polyembryony (more than one seedling from one seed) (citrus, mango or jamun) and apomixis, which produces true- to - type plants.
- Seed is the source for production of rootstocks for asexual propagation.

- The rootstocks on which the fruit varieties are budded or grafted are usually obtained by means of sexual propagation.
- Seeds, if stored properly can be kept for longer duration /period for future use.

Disadvantages of Sexual Plant Propagation:

- Seedling plants are not true to type to the mother plants due to heterozygous nature of fruit plants.
- Seedling plants have long juvenile phase (6-10 years) and hence flowering and fruiting commences very late.
- Sexually raised plants are generally tall and spreading type and thus are cumbersome for carrying out various management practices like pruning, spraying, harvesting etc.
- Seeds of many fruits are to be sown immediately after extraction from the fruits as they lose their viability very soon e.g. cashew nut, jamun, jackfruit, citrus, mango and papaya.
- Seedling plants usually produce fruits of inferior quality.
- Quality of existing plants cannot be improved by sexual propagation.
- In case of sexually propagated plants, there is no assurance about genetic purity of the offspring or seedling.

Harvesting:

Medicinal plants should be harvested during the optimal season or time period to ensure the production of medicinal plant materials and finished herbal products of the best possible quality. The time of harvest depends on the plant part to be used. Detailed information concerning the appropriate timing of harvest is often available in national pharmacopoeias, published standards, official monographs and major reference books. However, it is well known that the concentration of biologically active constituents varies with the stage of plant growth and development. This also applies to non-targeted toxic or poisonous indigenous plant ingredients. The best time for harvest (quality peak season/time of day) should be determined according to the quality and quantity of biologically active constituents rather than the total vegetative yield of the targeted medicinal plant parts during harvest, care should be taken to ensure that no foreign matter, weeds or toxic plants are mixed with the harvested medicinal plant materials.

Medicinal plants should be harvested under the best possible conditions, avoiding dew, rain or exceptionally high humidity. If harvesting occurs in wet conditions, the harvested material should be transported immediately to an indoor drying facility to expedite drying so as to prevent any possible deleterious effects due to increased moisture levels, which promote microbial fermentation and mould. Cutting devices, harvesters, and other machines should be kept clean and adjusted to reduce damage and contamination from soil and other materials. They should be stored in an uncontaminated, dry place or facility free from insects, rodents, birds and other pests, and inaccessible to livestock and domestic animals. Contact with soil should be avoided to the extent possible so as to minimize the microbial load of harvested medicinal plant materials where necessary, large drop cloths, preferably made of clean muslin, may be used as an interface between the harvested plants and the soil. If the underground parts (such as the roots) are used, any adhering soil should be removed from the medicinal plant materials as soon as they are harvested.

The harvested raw medicinal plant materials should be transported promptly in clean, dry conditions they may be placed in clean baskets, dry sacks, trailers, hoppers or other well-aerated containers and carried to a central point for transport to the processing facility. All containers used at harvest should be kept clean and free from contamination by previously harvested medicinal plants and other foreign matter. If plastic containers are used, particular attention should be paid to any possible retention of moisture that could lead to the growth of mould. When containers are not in use, they should be kept in dry conditions, in an area that is protected from insects, rodents, birds and other pests, and inaccessible to livestock and domestic animals. Any mechanical damage or compacting of the raw medicinal plant materials, as a consequence, for example, of overfilling or stacking of sacks or bags that may result in composting or otherwise diminish quality should be avoided. Decomposed medicinal plant materials should be identified and discarded during harvest, post-harvest inspections and processing, in order to avoid microbial contamination and loss of product quality.

Collection of drugs:

Collection of crude drugs from cultivated plants gives a better yield and therapeutic quality. However, it is a skilled operation and requires some professional excellence, if the collection of

crude drugs for market is done from cultivated plants by skilled and well-experienced personnel, the high yield and therapeutic quality of drugs can be maintained. For example, collection of latex from poppy capsules and oleo-resins from Pinus species, if done by experienced persons, can result in better yield of crude drugs. Preservation of green colour of senna leaves and minimizing the deterioration of cardiac glycosides in freshly collected leaves of digitalis can be achieved only by highly skilled labour. Medicinal plant materials should be collected during the appropriate season or time period to ensure the best possible quality of both source materials and finished products. It is well known that the quantitative concentration of biologically active constituents varies with the stage of plant growth and development. This also applies to non-targeted toxic or poisonous indigenous plant ingredients. The best time for collection (quality peak season or time of day) should be determined according to the quality and quantity of biologically active constituents rather than the total vegetative yield of the targeted medicinal plant parts.

In general, the collected raw medicinal plant materials should not come into direct contact with the soil. If underground parts (such as the roots) are used, any adhering soil should be removed from the plants as soon as they are collected. Collected material should be placed in clean baskets, mesh bags, other well aerated containers or drop cloths that are free from foreign matter, including plant remnants from previous collecting activities. After collection, the raw medicinal plant materials may be subjected to appropriate preliminary processing, including elimination of undesirable materials and contaminants, washing (to remove excess soil), sorting and cutting.

The collected medicinal plant materials should be protected from insects, rodents, birds and other pests, and from livestock and domestic animals. If the collection site is located some distance from processing facilities, it may be necessary to air or sun-dry the raw medicinal plant materials prior to transport.

If more than one medicinal plant part is to be collected, the different plant species or plant materials should be gathered separately and transported in separate containers. Cross-contamination should be avoided at all times. Collecting implements, such as machetes, shears, saws and mechanical tools, should be kept clean and maintained in proper condition. Those parts that come into direct contact with the collected medicinal plant materials should be free from excess oil and other contamination.

Time of collection:

The period of growth or development at which medicinal activity is highest has been carefully determined for many plants. The proportion, of alkaloid in the leaves of *Hyocyamus Niger* and of belladonna is largest at the beginning of flowering, whilst with Stromonium the peak coincides with full bloom. Leaves and flowering tops should be collected during the active reproductive process of the plant, i.e. from the beginning of the flowering to early fruiting. Since the photosynthetic process is most active in the plant during this period, the leaves and flowering tops contain the maximum amount of secondary metabolites. Example: Stromonium leaves, gathered in the morning, contain a higher proportion of alkaloids than those collected in the evening.

Flowers should be collected prior to or just about the time of pollination, *i.e.* before they open or just star opening and collection should be affected in dry weather and towards the middle of the day. Fruits may be collected when they are fully mature but unripe (e.g., Black pepper, Cubeb) or when fully ripe (e.g., Umbelliferous fruits). Seeds should be collected when they are fully mature and have ripened, but before the fruits open. Barks are generally collected at the end of the winter season and before the new growing season or vegetative process starts. Roots and rhizomes of annual plants should be collected shortly before flowering, those of the biennials in winter at the end of the first year's growth, and those of the perennials should also be collected in winter at the end of the second or third year's growth or when the vegetative processes cease.

Influence of time of collection on the quality of drugs:

The time of collection of plant drugs from their natural sources influences their quality to a great extent. The following examples will illustrate this point:

- Hyoscyamus and Belladonna leaves have been found to contain the highest amount of tropane alkaloids when collected at the beginning of flowering period, while the alkaloid content is highest in Stramonium leaves when the plant is in full bloom.
- Stramonium leaves, collected in the morning, contain a higher proportion of alkaloid than those collected in the evening.

- Full grown but green Conium fruits yield more than 3 percent of the alkaloid coniine, but the yellow or ripe fruits yield not more than 1 percent of the alkaloid, i.e., the alkaloid content reduced rapidly as the Conium fruits ripen.
- Fully mature but unripe capsules of Papaver somniferu.m contain highest amount of morphine. The latex of its yellow capsules contains lower amount of morphine. Thus the latex of yellow capsules produces substandard Opium.
- The unexpanded Santonica flowers yield as much as 3 percent of santonin, but as soon as the flowers mature or open up this anthelmintic principle rapidly disappears.
- Closed Pyrethrum flowers produce the finest and most powerful insecticide powder, but the ones produced from the half-open or full open flowers possess less than half of its potency.

Treatment after collection:

Certain treatments are required for some drugs prior to drying.

For most ***roots*** and ***rhizomes*** the following treatments are often necessary:

(a) Removal of adhering soil by washing and brushing,

(b) Cutting into pieces or slicing assist drying large and fleshy roots and rhizomes and

(c) Peeling and washing of fleshy rhizomes.

For leaves:

a) Removal of large stalks, and

(b) A brief process of fermentation or curing in some cases, e.g. Tea leaves.

For barks

(a) Scrapping off of the cork and

(b) Covering the bark for a certain period of time to induce slight fermentation in cases like Cinnamon. Many other similar treatments are done to various drugs before they are subjected to drying.

As per WHO Guidelines:

1. Medicinal plants/herbal drugs should be harvested when they are at the best possible quality for the proposed use.
2. Damaged plants or parts plants need to be excluded.

3. Medicinal plants/herbal drugs should be harvested under the best possible conditions avoiding wet soil, dew, rain or exceptionally high air humidity. If harvesting occurs in wet conditions possible adverse effects on the medicinal plant/herbal drug due to increased moisture levels should be counteracted.
4. Cutting devices or harvesters must be adjusted such that contamination from soil particles is reduced to a minimum.
5. The harvested medicinal plant/herbal drug should not come into direct contact with the soil. It must be promptly collected and transported in dry, clean conditions.
6. During harvesting, care should be taken to ensure that no toxic weeds mix with harvested medicinal plants/herbal drugs.
7. All containers used during harvesting must be clean and free of contamination from previous harvests. When containers are not in use, they must be kept in dry conditions free of pests and inaccessible to mice/rodents, livestock and domestic animals.
8. Mechanical damage and compacting of the harvested medicinal plant/herbal drug that would result in undesirable quality changes must be avoided. In this respect, attention must be paid to overfilling of the sacks and stacking up of sacks.
9. Freshly harvested medicinal plants/herbal drugs must be delivered as quickly as possible to the processing facility in order to prevent thermal degradation.
10. The harvested crop must be protected from pests, mice/rodents, livestock and domestic animals. Any pest control measures taken should be documented.

Primary processing:

Harvested or collected raw medicinal plant materials should be promptly unloaded and unpacked upon arrival at the processing facility. Prior to processing, the medicinal plant materials should be protected from rain, moisture and any other conditions that might cause deterioration. Medicinal plant materials should be exposed to direct sunlight only where there is a specific need for this mode of drying. Medicinal plant materials that are to be used in the fresh state should be harvested/collected and delivered as quickly as possible to the processing facility in order to prevent microbial fermentation and thermal degradation.

The materials may be stored under refrigeration, in jars, in sandboxes, or using enzymatic and other appropriate conservation measures immediately following harvest/collection and during transit to the end-user. The use of preservatives should be avoided if used, they should conform

to national and/or regional regulations for growers/collectors and end-users. Medicinal plant materials that are to be employed fresh should be stored under refrigeration, in jars, in sandboxes, or using enzymatic or other appropriate conservation measures, and transported to the end-user in the most expeditious manner possible.

The use of preservatives should be avoided. If used, this should be documented and they should conform to national and/or regional regulatory requirements in both the source country and the end-user country. All medicinal plant materials should be inspected during the primary-processing stages of production, and any substandard products or foreign matter should be eliminated mechanically or by hand. For example, dried medicinal plant materials should be inspected, sieved or winnowed to remove discoloured, mouldy or damaged materials, as well as soil, stones and other foreign matter. Mechanical devices such as sieves should be regularly cleaned and maintained. All processed medicinal plant materials should be protected from contamination and decomposition as well as from insects, rodents, birds and other pests, and from livestock and domestic animals.

Drying:

When medicinal plant materials are prepared for use in dry form, the moisture content of the material should be kept as low as possible in order to reduce damage from mould and other microbial infestation.

Medicinal plants can be dried in a number of ways:

1. In the open air (shaded from direct sunlight);
2. Placed in thin layers on drying frames, wire-screened rooms or buildings.
3. By direct sunlight, if appropriate.
4. In drying ovens/rooms and solar dryers.
5. By indirect fire; baking; lyophilization; microwave; or infrared devices.
6. Vacuum drying
7. Spray dryer: Examples: Papaya latex and pectin’s, etc.

When possible, temperature and humidity should be controlled to avoid damage to the active chemical constituents. The method and temperature used for drying may have a considerable impact on the quality of the resulting medicinal plant materials. For example, shade drying is preferred to maintain or minimize loss of colour of leaves and flowers; and lower temperatures should be employed in the case of medicinal plant materials containing volatile substances. The

drying conditions should be recorded. In the case of natural drying in the open air, medicinal plant materials should be spread out in thin layers on drying frames and stirred or turned frequently. In order to secure adequate air circulation, the drying frames should be located at a sufficient height above the ground. Efforts should be made to achieve uniform drying of medicinal plant materials and so avoid mould formation.

Drying medicinal plant material directly on bare ground should be avoided. If a concrete or cement surface is used, medicinal plant materials should be laid on a tarpaulin or other appropriate cloth or sheeting. Insects, rodents, birds and other pests, and livestock and domestic animals should be kept away from drying sites. For indoor drying, the duration of drying, drying temperature, humidity and other conditions should be determined on the basis of the plant part concerned (root, leaf, stem, bark, flower, etc.) and any volatile natural constituents, such as essential oils. If possible, the source of heat for direct drying (fire) should be limited to butane, propane or natural gas, and temperatures should be kept below 60°C. If other sources of fire are used, contact between those materials, smoke and medicinal plant material should be avoided.

Vacuum drying:

This is conducted in steam- heated ovens with perfect closure, and a pump is used to exhaust the air. The low pressure maintained within the oven ensures rapid and complete drying. Example: Digitalis

Advantages of vacuum drying:

(i) Rapid drying.
(ii) Relatively low temperature.
(iii) Cleanliness and freedom from odour and dust.
(iv) Independence of climate conditions.
(v) Control of temperature.
(vi) Elimination, of risk of fire.
(vii) Compactness.

Specific Processing:

Some medicinal plant materials require specific processing to: improve the purity of the plant part being employed; reduce drying time; prevent damage from mould, other microorganisms and insects; detoxify indigenous toxic ingredients; and enhance therapeutic efficacy. Common

specific processing practices include pre selection, peeling the skins of roots and rhizomes, boiling in water, steaming, soaking, pickling, distillation, fumigation, roasting, natural fermentation, treatment with lime and chopping. Processing procedures involving the formation of certain shapes, bundling and special drying may also have an impact on the quality of the medicinal plant materials.

Antimicrobial treatments of medicinal plant materials (raw or processed) by various methods, including irradiation, must be declared and the materials must be labelled as required. Only suitably trained staff using approved equipment should carry out such applications, and they should be conducted in accordance with standard operating procedures and national and/or regional regulations in both the grower/collector country and the end-user country. Maximum residue limits, as stipulated by national and/or regional authorities, should be respected.

Storage:

1. Storage facilities for medicinal material should be well aerated, dry and protected from light, and, when necessary, be supplied with air-conditioning and humidity control equipment as well as facilities to protect against rodents, insects and livestock.
2. The floor should be tidy, without cracks and easy to clean. Medicinal material should be stored on shelves which keep the material a sufficient distance from the walls; measures should be taken to prevent the occurrence of pest infestation, mould formation, rotting or loss of oil; and inspections should be carried out at regular intervals.
3. Continuous in-process quality control measures should be implemented to eliminate substandard materials, contaminants and foreign matter prior to and during the final stages of packaging. Processed medicinal plant materials should be packaged in clean, dry boxes, sacks, bags or other containers in accordance with standard operating procedures and national and/or regional regulations of the producer and the end-user countries.
4. Materials used for packaging should be non-polluting, clean, dry and in undamaged condition and should conform to the quality requirements for the medicinal plant materials concerned. Fragile medicinal plant materials should be packaged in rigid containers.

5. Dried medicinal plants/herbal drugs, including essential oils, should be stored in a dry, well-aerated building, in which daily temperature fluctuations are limited and good aeration is ensured
6. Fresh medicinal plant materials should be stored at appropriate low temperatures, ideally at 2-8°C; frozen products should be stored at less than -20°C.
7. Small quantity of crude drugs could be readily stored in air tight, moisture proof and light proof container such as tin, cans, covered metal tins or amber glass containers.
8. Wooden boxes and paper bags should not be used for storage of crude drugs.