AS-2931

B.Sc (IIIrd Semester Examination), 2013 Forestry

(Principles and methods of Tree Improvement)

Question 1. Objective Type question

Answer- **Fill in the blanks**

i) Half Sib

ii) Scion is the aerial vegetative parts obtained from the ortet and grafted on to root stock

iii) The plants of two different species belonging to the same genus are crossed together.

iv) 7 Pairs of Characters.

v) Progeny test- The evaluation of the worth of the plant on the basis of the performance of their progenies is known as progeny testing. It is the major component of variation study. Progeny is of two types (1) Half sib (2) Full sib.

vi) Air layering: - this method of propagation involves the development of roots from a stem while it is still attached to the mother plant. In this method 1-2 cm circular bark is removed from the middle of an erect branch .peat moss or well developed organic manure with a little root hormone is placed in this region and tied securely with a polythene cover. The rooted stem is detached to be grown on new plant.

vii) Ramet:- Individual member of a clone or individual propagule from ortet.

viii) Isogamy :- The gametes of both the parents are similar i.e. Morphologically not differentiated into male and female, they are known as isogametes.

ix) Heterosis :- It is growth superiority in which the hybrid exceed that of both parents or Heterosis is the increased vigour growth yield or function of a hybrid over the parents resulting from the crossing of genetically unlike organism.

x) Seed Orchard – seed orchard is plantation of genetically superior trees isolated to reduce pollination from genetically inferior outside sources and intensively managed to produce frequent, abundant, easily harvested seed crops. (Zobel etal ,1958) Seed orchard are of two types.

a) Clonal Seed Orchard

b) Seedling Seed Orchard

Q2.- Define the role of other discipline of plant sciences in relation to tree Improvement?

Ans-As the knowledge in genetics and other related plant sciences progressed, plant breeding become less of an art and more of science. The scientist like Lamarck 1744-1829,Darwin 1809-1882,Mendal 1822-1884, Weismann 1834-1914 johannsen 1857 -1927, Hugo devaries 1848-1935, nilsonehle 1908 and vavilov 1887-1942 added a lot is the knowledge of this sciences and they discovered biological principles underlying the science of plant breeding specially the discovery of mendals work in 1900 simultaneously devaries in Holland corrins in Germany tschermark in Austria and bateson in England added the laws of inheritance to this science and gone more complexity and exactness to it b this knowledge of inheritance of characters it become possible to control the heredity of plants and to create new type plant more or less it will.

Development of plant breeding as special field of study has been associated with and development upon the growth of other plant sciences it is an applied science can be carried out efficiently only through the application of principles of this sciences prominent among the which are-

1. Genetics
2. Cytology
3. Biometry
4. Taxonomy
5. Plant physiology
6. Plant pathology and entomology
7. Floral morphology
8. Bacteriology

Q.3. How genetic variation can be utilized in tree improvement?

Ans-Tree improvement is the application of forest genetics its work is accomplished by testing wild tree selection and determining which will grow best when planted in certain sites or in specific geographic locations. Tree improvement takes advantage of the natural genetic variation which exists within a species. A number of improvement techniques are available which exploit this variation at different levels.

Seed origin or provenance testing

Most tree species used in British forestry show large differences in the rate of growth or in form throughout their natural distribution. An essential prerequisite of more sophisticated methods of tree improvement is to investigate this basic variation within a species by comparing range-wide collections of material in experiments planted at a number of relevant test sites. This is the process of seed origin or provenance testing which was started by the Forestry Commission in the 1920s. Since then over 400 experiments have been established consisting of all the major and a number of minor coniferous species and several broadleaved species. However, it is interesting to note that this work, fundamental to effective tree breeding, remained with the Silviculture Branches until the mid-1980s to allow the geneticists to concentrate on breeding activities.

Tree breeding

Within the broad differences attributable to origin, considerable variation exists among individual trees and the more detailed techniques of tree breeding exploit variation at this level. Breeding work seeks to establish whether the observed superiority of an individual is passed on through seed to its progeny in the next generation. The most basic form of improvement is based on this assumption by using superior stands of trees as sources of seed. Stands of an appropriate origin are selected and managed for seed collection from the better individuals within the stand. Use of seed stands quickly results in well-adapted seed but is not likely to be associated with high levels of improvement.

Using plus trees

The tree breeder can achieve higher gains, however, by concentrating on the selection of superior individuals which are referred to as plus trees. The degree of superiority which must be shown by a plus tree with respect to the mean of the population from which it is selected is a reflection of the selection intensity used, a higher threshold reflecting a higher intensity. The collection of plus-trees identified at the beginning of a breeding programme is referred to as the base population.

Establishing whether the observed superiority of a plus-tree is inherited by its progeny is much longer-term, but it can bring considerably greater rewards. When an individual seed collection is made from a plus tree, the seeds collected or the progeny subsequently grown from it are referred to as a family. Because the family members have only the female parent in common (the flowers being wind pollinated with a pollen mixture from surrounding sources) they are half-siblings and this is referred to as a half-sib family. The families of a number of trees are compared against material grown from a standard commercial seedlot in forest stage progeny tests at relevant test sites throughout the country.

These experiments allow the breeder to identify the parent trees whose previously observed superiority is actually inherited by their progeny. The breeder can then use these parents to produce improved seed, and because progeny performance influences parental choice, this is known as backward selection. Plus-trees identified in this way for further use in breeding work are recognized as members of the breeding population. This work of progeny-testing is a very important part of the tree-breeding process involving long-term commitment and making heavy demands on resources. It enables the breeder not only to identify superior parents, but also to study the types and levels of genetic variation present and to determine heritability, the degree to which particular traits (eg height, volume, form) are inherited.

Vegetative propagation

Genetically identical clonal representatives or ramets of one original tree (sometimes called the ortet) may be created by vegetative propagation. Once a parent has been identified as superior in progeny tests it can be propagated in this way, usually by grafting, which maintains some of the mature characteristics of the parent tree. Many grafts can be planted with those of other superior parents in a clonal seed orchard where their genetically superior progeny will be reproduced and can be collected as commercial quantities of seed. The grafts of the different parents are planted in an intimate mixture to promote the maximum amount of intercrossing between parents. Orchards can be constructed to emphasize different selection traits or combinations. Plus-trees used to produce a specific orchard are identified as a production population.

Creating an untested orchard

The procedure described so far can involve a period of at least 20 years between plus tree selection and production of commercial seed from an orchard. This period can be halved by creating an untested orchard established using grafts made at the same time as the parent trees were selected. The parent trees in the orchard would be untested at this stage but the expected improvement to be gained in seed from this orchard would be slightly greater than that obtainable from a registered seed stand because the selection criteria for plus trees will be more intensive and also because both parents are phenotypically superior, whereas the male parents for seed stand progeny are unknown. Information on the performance of the parents in progeny tests could later be used to cull inferior parents from an untested orchard, a process known as rouging, but the risks of reducing the orchard to too small a number of parents are high if a large number of potential parents in progeny tests emerge as unacceptable. In contrast, much higher gains are to be expected from an orchard based on tested parents.

Seedling seed orchards

For species such as pines, which flower at an early age, seedling seed orchards can be planted at the same time as progeny tests. Seedling progeny of plus trees are planted as the component material of these orchards rather than grafts. They can later be thinned to the best progeny based on evaluation data.

Clone banks

Grafting is also used to propagate material from individual plus trees for systematic archiving. This has the advantage of bringing together a number of ramets from a range of plus trees which are likely to have had a wide geographic distribution. Clonal archives established for this purpose are commonly called clone banks.

Family-mixtures

Some species have shown themselves to be amenable to bulk propagation by cuttings. The quantity of seed required to raise initial stock-plants for this process is comparatively small and can be based on a number of families and reproduced from orchards or clone banks by the tree breeder using artificial pollination techniques. Such work can often be carried out before an orchard is sufficiently mature to produce commercial quantities of seed and during the course of a progeny testing programme. Family-mixtures can therefore be based on the best known parents identified by the most recent progeny test information.

Potential genetic gain

The achievements of tree breeding will ultimately be dependent on three factors:

- The amount of variation present in the population in which selection is being made
- The selection intensity imposed
- The heritability of the selection trait. These combine to enable the breeder to calculate the potential genetic gain from a breeding programme. Sometimes it will be of interest to verify this by comparing actual commercial products of orchards or family mixtures with unimproved material in genetic gain trials.

It is often convenient to recognise 3 main stages in tree-breeding work:

- Selection - choosing and archiveing potential breeding material
- Testing - validating the actual genetic worth of individual selections
- Production - making the products of tree breeding available to the user in commercial quantities

Under the breeding scheme described above, the breeder will reach an upper limit of genetic gain for a given level of selection intensity in this first generation. The methods exploit the genetic expression of a trait which can be passed on to the next generation in which it will become fixed. This is known as additive genetic variation. Specific crosses involving two known parents (yielding full-siblings or a full-sib family) may show genetic superiority in excess of the expectation from the individual parents which is due to non-additive genetic variation. This type of material is amenable to vegetative propagation based on family mixtures. Beyond this, more improvement can only be made by releasing more genetic variation through recombination of genes in the second generation. This will be maximized by creating families using the very best first generation parents. This type of work has now begun in Sitka spruce.

Q.4. Write notes on the following:

(a) Advanced generation selection

(b) Phenotypic Selection

Ans- Advanced generation selection- Within-family selection – in the first generation or two of a tree improvement program, it is common to eliminate large numbers of inferior parents (or families) from contributing to future breeding populations based on poor performance of their progeny (or siblings) in genetic tests. As an example, suppose a first generation breeding program starts with 300 unrelated parents and eliminates the bottom half of the parents and their progeny based on their predicted breeding values. In this example, second generation selections come from families in the top half of the ranking, and this among family selection (also called family selection.)

It is the selection done from the genetic tests of crosses among parents from the previous generation .Advance generation (Selection) is more advantageous than the first generation selection and its main object is to get maximum possible gain per unit time. In advance generation selection the important consideration are the method of selection , intensity of selection , layout of the mating design , proper management of genetic base (maintain sufficient genetic variability to ensure continued long term gain . it involved recurrent selection , which means the crossing of the best progeny from selected parents are successive generations.

Since long term selection programmes is beyond the scope of this. It has very briefly discussed

Source population
Natural Stand or plantation

↓ Select good trees from source population

Base Population
(progeny of selected parent trees from source identified)

↓ Select best individuals from best families

Breeding population
(Broad genetic base)

↓ Select best individuals for seed production for afforestation

Advanced generation production population

In the first generation selection, the base population usually consists of trees growing in natural stands or plantations, but in advanced generation selection the base population is most often a genetic test consisting of the progeny of selected trees from the source population or previous generation. The base population contains large number of genotypes which maximize genetic diversity in the breeding population. The breeding population consists of the selected material from the base population .however care is taken to keep the genetic base broad to carry out the breeding population for further generation .the production population which is strictly for propagule purpose in the forestation program , is the best selected material of breeding population , which increase the genetic gain to the maximum production population of course is a dead end from a breeding stand point because of its narrow genetic base .

In the first generation mostly individual or mass selection is practiced , whereas in advance generation tree improvement programme the family and within family selection system is followed .however ,the individual selections per family are restricted to accommodate more number of families in the programme. Even selection indices have also been used in several tree species for advance generation in tree improvement programme.

(b) Phenotypic Selection- Phenotypic selection is the method of selection, where the best individuals are selected on the basis of their appearance without any knowledge about the genetic parameters of the traits of interest. It includes also selecting of trees based on measurements but without calculating the genetic parameters. phenotype (from Greek *phainein*, 'to show' + *typos*, 'type') is the composite of an organism's observable characteristics or traits, such as its morphology, development, biochemical or physiological properties, phenology, behavior, and products of behavior (such as a bird's nest). Phenotypes result from the expression of an organism's genes as well as the influence of environmental factors and the interactions between the two. When two or more clearly different phenotypes exist in the same population of a species, it is called polymorph. Phenotypic variation (due to underlying heritable genetic variation) is a fundamental prerequisite for evolution by natural selection. It is the living organism as a whole that contributes (or not) to the next generation, so natural selection affects the genetic structure of a population indirectly via the contribution of phenotypes. Without phenotypic variation, there would be no evolution by natural selection. The interaction between genotype and phenotype has often been conceptualized by the following relationship:

genotype (G) + environment (E) → phenotype (P)

A more nuanced version of the relationship is:

genotype (G) + environment (E) + genotype & environment interactions (GE) → phenotype (P)

Genotypes often have much flexibility in the modification and expression of phenotypes; in many organisms these phenotypes are very different under varying environmental conditions.

Q.5. Differentiate between cross pollination and self pollination with suitable example.

Ans 5- Pollination is the process by which pollen is transferred in the reproduction of plants, thereby enabling fertilization and sexual reproduction. The transfer of pollen from the male reproductive organ (an anther or a male cone) of one plant to the female reproductive organ (a stigma or a female cone) of another plant. Insects and wind are the main agents of cross-pollination. Most plants reproduce by cross-pollination, which increases the genetic diversity of a population (increases the number of heterozygous individuals). Mechanisms that promote cross-pollination include having male flowers on one plant and female flowers on another, having pollen mature before the stigmas on the same plant are chemically receptive to being pollinated, and having anatomical arrangements (such as stigmas that are taller than anthers) that make self-pollination less likely.

i. Cross pollination is the transfer of pollen grains from the anther of a flower to the stigma of a flower of a different plant of the same species.
ii. Seen in insects: Apples, grapes, plums, pears, raspberries, blackberries, strawberries, runner beans, pumpkins, daffodils, tulips, lavender Wind: grasses, catkins, dandelions, maple trees, and goat’s beard.
iii. Transfer through Wind, insects, water, animals, etc.
iv. Plant differences Brightly colored petals, nector and scent, long stamens and pistils.
v. More variety in species. It allows for diversity in the species, as the genetic information of different plants are combined. However, it relies on the existence of pollinators that will travel from plant to plant existence of pollinators that will travel from plant to plant.
vi. Number of pollen grain large number.
vii. Reproduction type Allogamy
viii. Either perfect or imperfect flowers

Self-pollination is a form of pollination that can occur when a flower has both stamen and a carpel (pistil) in which the cultivar or species is self fertile and the stamens and the sticky stigma of the carpel contact each other in order to accomplish pollination. The term is inaccurately used in many cases where an outside pollinator is actually required; such plants are merely self-fertile, or self pollenizing. Self pollination is the transfer of pollen grains from the anther to the stigma of the same flower.

i. Seen in Some legumes, e.g. peanuts. Orchids, peas and sunflowers, wheat, barley, oats, rice, tomatoes, potatoes, apricots and peaches.
ii. Transfer through Shed pollen directly onto stigma
iii. Smaller flowers
iv. More uniform progeny. Allows plant to be less resistant as a whole to disease. However, it does not need to expend energy on attracting pollinators and can spread beyond areas where suitable pollinators can be found.
v. Number of pollen grain small number.
vi. Reproduction type Autogamy, Geitonogamy.
vii. Occurs in Perfect flowers.

Q.6. Why vegetative propagation is necessary. Describe the method of cuttings.

Ans. Vegetative propagation, the ability of plants to reproduce without sexual reproduction, by producing new plants from existing vegetative structures. Some plants, such as the populas and most bamboos, send out long underground stems that produce new plants, often at considerable distances from the original plant. Such plants can form enormous colonies of new plants within a relatively few years. Many trees, such as the beech and aspen, send up root sprouts, and large colonies of new trees thus arise. In other trees, the lower branches may produce roots where they rest upon the ground, and new trees are produced. The leaves of some plants produce buds at their edges, which develop in turn into miniature plants that fall off and take root. Specialists in the fields of agriculture and horticulture take advantage of the regenerative ability of plants through such techniques as the rooting of cuttings; grafting and budding of fruit trees; layering, or inducing the tips of branches to produce new plants; the cutting apart of clusters of perennials perennial, any plant that under natural conditions lives for several too many growing seasons, as contrasted to an annual or a biennial.

i. The offsprings are genetically identical and therefore advantageous traits can be preserved.
ii. Only one parent is required which eliminates the need for special mechanisms such as pollination, etc.
iii. It is faster. For example, bacteria can multiply every 20 minutes. This helps the organisms to increase in number at a rapid rate that balances the loss in number due to various causes.
iv. Many plants are able to tide over unfavorable conditions. This is because of the presence of organs of asexual reproduction like the tubers, corm, bulbs, etc.
v. Vegetative propagation is especially beneficial to the agriculturists and horticulturists.
vi. The modern technique of tissue culture can be used to grow virus-free plants.

Method of Cutting

Cuttings

Many types of plants, both woody and herbaceous, are frequently propagated by cuttings. A cutting is a vegetative plant part which is severed from the parent plant in order to regenerate itself, thereby forming a whole new plant. Take cuttings with a sharp blade to reduce injury to the parent plant. Dip the cutting tool in rubbing alcohol or a mixture of one part bleach to nine parts water to prevent transmitting diseases from infected plant parts to healthy ones. Remove flowers and flower buds to allow the cutting to use its energy and stored carbohydrates for root and shoot formation rather than fruit and seed production. With large-leaved cuttings (i.e., Rhododendron) and limited space in the propagation container, trimming up to half the leaf length can improve efficiency, as well as light and air circulation for all the cuttings. To hasten rooting, increase the number of roots, or to obtain uniform rooting (except on soft, fleshy stems), use a rooting hormone, preferably one containing a fungicide. Prevent possible contamination of the entire supply of rooting hormone by putting some hormone in a separate container for dipping cuttings. Discard this hormone after all the cuttings are treated.

Place stem and leaf cuttings in bright, indirect light. Root cuttings can be kept in the dark until new shoots appear.

Stems Cuttings

Numerous plant species are propagated by stem cuttings. Most can be taken throughout summer and fall, but stem cuttings of some woody plants root better if taken in the fall or in the dormant season. Success with herbaceous plants is generally enhanced when done in the spring; these plants are actively growing then, and more apt to root quickly on their own. There are several different types of stem cuttings depending on the part of the stem needed. At least one node (the point on a stem where leaves are attached and buds form) should be below the media surface. Although some plants root at internodes (the space between nodes), others only root at nodal tissue.

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There are two main types of stem cuttings:

Softwood cuttings (leafed cuttings) are young soft succulent cuttings with leaves (sometimes pruned).

Hardwood cuttings are made of matured, dormant hardwood after the leaves have been shed. Tip cuttings possess terminal buds; basal cuttings are without terminal buds.

Some general characteristics of the two types are mentioned below:

Softwood cuttings	Hardwood cuttings
Leaves on the lower part removed, those on the upper part retained and often pruned.	All leaves are shed.

Young branchlets. Always tip cuttings. Best cuttings have some degree of flexibility but, is mature enough to break when bent sharply.	Young branches. Central and basal parts of the shoots (basal cuttings), or end of the shoots (tip cuttings).
75–125 mm long with two or more nodes.	10–75 cm long with at least two nodes. 6–25 mm diameter.
Basal cut made just below a node.	Basal cut made just below a node. In basal cuttings the top cut is made 15–25 mm above the node.

Q.7. Write notes on the following:

a) Role of Growth Hormone in rooting of cutting

b) Utility of vegetative propagation in tree improvement.

Ans- a) Role of Growth Hormone in rooting of cutting - There are a number of plant growth regulators that have been shown to influence the rooting of cuttings. The most important of these regulators is auxin, named after a Greek word meaning "to increase". Auxin is involved in many growth processes and its principal function is to stimulate increases in cell length. It also appears to reverse the cellular process of differentiation which is the process whereby cells become specialized in their function. In simple terms differentiation is the where cells become roots, stems or leaves. By reversing the process, auxin in effect, returns the cells of stems and leaves to "square one" so that they can become roots instead. It has been confirmed by many scientific studies that auxin is required for the initiation of roots on stem cuttings.

The chemical name for the auxin naturally produced by a plant is indole-3-acetic acid ("IAA") which is synthesized by the plant from the amino acid L-tryptophan. It was first isolated and identified in 1934, by the scientist F.W. Went at the University of Utrecht in the Netherlands.

After the discovery of IAA, two synthetic auxins, indole-3-butyric acid ("IBA") and naphthalene acetic acid ("NAA"), were discovered in 1935 to have the same functions as IAA and to be more effective in rooting stem cuttings. Later it was shown that IBA is also a naturally occurring substance in pants. Also both have been shown to be more stable than IAA. As a result IBA and NAA are the active ingredients in most commercially available rooting hormone products.

b)**Utility of vegetative propagation in tree improvement.-** Plants have two ways of reproduction, sexual by means of seeds, and asexually or vegetatively by means of vegetative tissue. Both ways occur in living plants in nature. In nature, some plants reproduce mainly vegetatively while others rely almost totally on sexual reproduction. For the plant breeder it is desirable to be able to manipulate sexual and vegetative reproduction (propagation) to fit into the tree improvement programme. Genetically the two ways of reproduction differ. Seeds contain genes from the female parent (where we collect the seeds) and the male parent (which contribute the pollen and which is often unknown). Vegetative material is genetically identical to the mother plant from where it was collected. The present guide entirely deals with vegetative propagation.

There are four main uses of vegetative propagation in a Tree Breeding Programme:

1. The establishment of clonal seed orchards.
2. The establishment of clonal banks.
3. The propagation of special breeding material, e.g. exceptional hybrids that are lost through sexual reproduction, sterile hybrids etc.
4. Mass propagation of selected materials.

Q.8. What are the main steps involved in hybridization.

Ans 8. The object of hybridization is to combine desirable genes found in two or more different varieties and to produce pure-breeding progeny superior in many respects to the parental types. Hybridization is one of the methods for developing new variety by crossing two lines or plants having unlike genetic constitution or it is the mating or crossing of two plants or lines of dissimilar genotype in order to combine desirable characters from both the parents.

The chief objective of hybridization is to create genetic variation. When two plants having unlike genetic constitution are crossed, the genes from both the parents are brought together. Segregation and recombination produce many new gene combinations in F2 and the subsequent generation. The degree of variation produced by hybridization in the segregating generation depends upon the number of heterozygous genes in the F1, and this depends upon the number of gene for which two parents differ.

The process of hybridization involved following steps:

i) Choice of the Parents:

ii) Evaluation of the parents,

iii) Selfing of parents,

iv) Emasculation,

v) Bagging

vi) Tagging

vii) Pollination

viii) Harvesting

ix) Threshing, drying and storage etc.