Education Department

Course Code: EDU246 (BOTANY)

Unit-IV

Significance of Seeds : Ecological Adaptation and Dispersal Strategies

Seed is a tiny particle performing mighty functions. –

-Seeds are perfect natural package that facilitate the migration of plant species across the land and sea.

- Seed is a microcosm of life itself. It is neatly wrapped package containing a living organism capable of exhibiting almost all the processes found in mature plant.

- One botanist has called a seed as ”a miniature plant telescoped in a box and provided with lunch”. Seed consists of three parts:

(1) Tough protective seed coat (the box),(2) an embryo(miniature plant) ,and (3) endosperm (lunch).

-Seeds have been and still are the main food supply for animals, plants and man on this planet. -Seed is the hope for hungry people of this world.

-Seeds undergo many physiological and biochemical changes prior to maturation, during germination and at the time of germination. Water content of living cells in dormant seeds becomes only 10 to 15%, while as water content in metabolically active cells ranges from 60 to 95%; if it falls down below 34% ,cells may die .These changes in the dormant seed are so drastic and puzzling that they are regarded as physiological enigma of the living world. Seed is largely independent of environmental resources for its survival as it has a package of food reserves. Unlike seedling which depends on supply of light, carbon dioxide, water and minerals, etc from environment for autotrophic growth. Like many other plant structures, seeds cannot be rigidly defined. Consortium for Educational Communication The term seed must remain in morphological use and will commonly be applied to matured ovules that contain an embryo at some stage of development.

Basically seeds are of two types: Monocot and Dicot (Fig. 3). Both are having a hard covering outside for protection. Inside there is a mature embryo. In dicots, the cotyledons get filled with nutritive tissue and become thick (non endospermic or exalbuminous seeds). But in monocots the nutritive tissue does not get absorbed by the embryo hence remains separate as endosperm (endospermic or albuminous). The embryo has rudementary leaf, stem and root, called cotyledon, plumule and radical respectively (Fig. 2). The primary function of seeds is to enable a plant to survive unfavorable conditions and to permit the sedentary adult organism to disperse its kind widely in the environment. Main purpose of seed is to grow a new plant, thus propagating the species, thereby ensuring the survival of the species. Since seeds are produced after the sexual reproduction which bring about recombinant genes together and give birth to new varieties which is the basis of evolution. Seeds are produced by plants to ensure perpetuation of their types, for most of the annual plants, seeds are the only means of multiplication and existence. Seeds have the capacity of undergoing a period

of dormancy. During this time, they spread to newer and newer areas where, after germination, they develop into new plants. Seeds being so important in the life cycle of a plant, compensate beautifully by producing seeds in great abundance to ensure survival of their species, despite the formidable odds.

In addition to this seeds are highly beneficial to the mankind on this planet.

1. Man has progressed from stone age to modern atomic age without any reduction on his dependence on seeds.

2. Seeds have been and still are the mainstay of diet on this planet. In developed countries, 75% of diet is provided to the humans in the form of grains, the remaining 25% is provided by animal food which is indirect product of plant (seed). In developing countries, more than 95% of diet of the humans is in the form of cereals and legumes.

3. Many seeds are used whole or grounded as spices by man.

4. Beverages, like coffee, cola and cocoa are derived from seeds.

5. Alcoholic beverages are obtained from cereal grains.

6. Fats and oils are obtained from many seeds.

7. Many seeds are used as medicines.

8. Forensic uses of seeds: -identification of seed and seed parts is sometimes an important contribution to evidence presented in criminals.

9-The seeds of the Carob tree (Ceratonia siliqua) were used as weights because of their evenness in size and weight. They gave us the word ‘carat’.

10-Wheat husk is often used in small cushions for heating in a microwave and applying to a stiff neck.

11- Now seeds have been used as jewellery and other products. Seeds of Persian Lilac (Melia azederach) are drilled and threaded on to necklaces

12- Seeds are used in manufacture of soaps, paints, varnishes and linoleum, etc. 13- Cotton and other seeds are source of commercial fiber.

14- Seeds are used as material for biological investigations by the researchers.

DORMANCY

Few things are more important for plants than ensuring that germination takes place in the right place and at the right time. In some plants, this requirement is satisfied by germination as soon as the seeds are shed (non-dormant seeds). But in majority of the plants there is a delay in germination from days to decades. Important mechanism to achieve this delay is to undergo suspended animation by the seed. There is however, a large group of plants whose seeds do not readily germinate even when provided with favourable conditions. One important function of most of these seeds is to delay germination -the embryos put their life processes on hold within a state of suspended animation, the contents still cling to life. This state of these seeds is called as dormancy and the seeds as dormant (Fig. 4). The staggering of germination safeguards some seeds as seedlings from suffering damage or death from short

periods of bad weather or from transient herbivores. It also allows some seeds to germinate when competition from other plants for light and water might be less intense. In nature, dormancy period coincides with the unfavorable period for the seedlings of species. Dormancy is defined as a state of the seed that does not permit germination ,although conditions of germination may be favourable (temperature, water and oxygen). Dormancy thus, effectively delays germination. Functions of Dormancy -To prevent germination and seedling establishment during periods that are unsuitable for germination and establishment. Consortium for Educational Communication Crucial function of dormancy is to prevent germination when conditions are suitable for germination but the probability of survival and growth of seedling is low. -Plant Scientists in 1990 found that in Japanese grassland in which germination was confined to spring, all species that shed their seeds early in the growing season had an absolute requirement for a period of chilling before the seed would germinate. Many species that shed their seeds late in the season lacked dormancy. Since by then temperature was already low enough to prevent germination until the spring

Types of Dormancy

Primary or Innate Dormancy: In this case seeds are dormant upon the release from mother plant.

Secondary or Induced Dormancy: In this type the dormancy is induced in seeds after they have been non-dormant.

Primary or Innate Dormancy: It is of following types :

1. Exogenous Dormancy

2. Endogenous Dormancy

3. Combined Dormancy

1. Exogenous Dormancy:Here the factors inducing dormancy are external. It is of following types:

Physical dormancy: It occurs when seed coats are impermeable to water or exchange of gases,e.g. Fabaceae and Malvacae, they have low moisture content and are prevented from imbibing water by seed coat. Seed coats are often impregnated with fats and waxes. Water uptake occurs only when the seed coat is sufficiently deteriorated. Imbibition increases with the degree of damage to seed coat. In some seeds, the seed coat is not hard but outer layer such as endosperm and seed coat can represent a mechanical barrier in combination with the force exerted by the embryo (imposed dormancy).

Mechanical Dormancy: It occurs when seed coats or other coverings are too hard to allow embryo to expand during germination.

Chemical Dormancy: In this case there are growth regulators etc present in the coverings around the embryo which inhibit growth. These may be leached out of the tissues by washing or soaking the seeds. Rain or snow melting can also leach it out.

2. Endogenous Dormancy :It is caused by the conditions within the embryo itself.

It is of two types:

a) Physiological dormancy: It prevents embryo growth and seed germination until chemical changes occur. These chemicals include growth inhibitors that often retard embryo growth. Conditions that affect physiological dormancy of seeds include: Drying –After dispersal, some seeds need to dry (lower the moisture to germinate). Photo dormancy or Light sensitivity-Some seeds need a period of darkness or light to trigger germination process. Thermo dormancy-Some seeds need the exposure to higher temperature (30 0C), e.g. Amaranths and some seeds need cool temperature to germinate.

b) Morphological dormancy: In this type seeds are shed from Consortium for Educational Communication the maternal plants but the embryos in them are underdeveloped or undifferentiated. These seeds need some time for embryos to develop fully or get well differentiated before they start germinating.

3 Combined Dormancy: In this type of dormancy seeds are both morphologically (underdeveloped embryo) and physiologically dormant. They require both ,time to develop fully into grown embryo, and dormancy breaking treatment. It is of two types:

a) Combinational dormancy: In this case, seeds have both exogenous and endogenous dormancy, e.g. Iris has both hard seed coat and physiological dormancy.

b) Secondary dormancy: In this case dormancy is induced in non-dormant seeds by some factors like high temperature. Not all seeds undergo a period of dormancy .Seeds of many species are released when temperature is too low or environment is dry. If these seeds are collected and sown in an environment which is moist enough and warm they germinate. They are nondormant seeds. Seeds that do not germinate because they are covered by fleshy fruits which retard germination are called quiescent,not dormant. Many trees, particularly temperate and tropical species of undisturbed forests, lack pronounced dormancy and their large seeds often do not tolerate dessication. Their seeds germinate quickly after dispersal. Some seeds that lack dormancy are viviparous. They germinate prior to or coincide with abscission from the maternal plant, e.g. seeds of many mangroves and sea grass species.

ENFORCED DORMANCY

In some cases environmental factors, such as absence of light, nitrates, and/or diurnally fluctuating temperature may keep seeds in dormant state. It is called enforced dormancy. Here the environmental factor function as an environmental signal, removing a block leading to germination rather than being involved in metabolism as in the case of water, temperature and oxygen.

ECOLOGICAL ADAPTATIONS OF SEEDS

Each species has a characteristic germination season or seasons. For many species time of the year when germination is possible is quite limited e.g. autumn, spring or wet season. For other species, it is long ,i.e. throughout the growing season. How the timing of germination is controlled in nature and what are it's ecological consequences? The ecological conditions prevailing in a given habitat affects germination. The determinating factors, most probably are micro climatic conditions prevailing in the immediate vicinity of the seed. These include water, temperature, soil condition, germination inhibitors and biotic factors. a) Water: Water being very important condition for germination. Non dormant seeds germinate immediately

after falling from the tree over a wide range of temperature when water is available. Water is the major determining factor. In deserts where there is scarcity of water, seeds have adapted in such a way that when there is rainfall of 12 to 15mm, seeds germinate and grow in this short period of rainfall. Water dissolves the growth inhibitors in seeds, and the rain water leaches it out, e.g. Euphorbia. Seeds of Baeria chryostoma are sensitive to salt solution and have ability to detect insufficient rainfall through concentration Consortium for Educational Communication of soil solution. They germinate only when osmotic potential of solution in topsoil is low. Seeds of cercidium aculeatum have adapted in such a way that heavy rains carry them through stones and sand and bring about a scarification of seed coat. Water absorption takes place and germination starts. b) Temperature: Seeds which germinate only after they have been subjected to cold temperature (chilling), start growing in early spring. It helps in avoiding the emergence of seedlings before winter and help seedlings to grow in favorable spring season when there is no shade of leaves. c) Soil salt content: Mangroves living along coasts inhibit germination of seeds due to osmotic effect. They have special mechanism to avoid this unfavorable environment. The seeds germinate within the fruit while still on mother plant phenomenon called Vivipary. d) Germination inhibitors: Germination inhibitors in seed coat act as sensors of external condition, especially of rainfall. The germination inhibitors present in fruit prevents seeds from germinating within the fruit. This plays an important role in seed dispersal as germination will occur only after fruit is decomposed, damaged or eaten by animals. It increases chances of seeds to be carried far away from the parent plants. Abscisic acid (ABA) is a common germination inhibitor present in embryo and seed coats of many species. It ensures the germination of seeds only after sufficient rainfall by which soil becomes moist and seedling establishment is ensured. e) Biotic factor: It includes interaction between plant part of same species, between plant species and role of animals and man. Leaves and leaf litter also contain compounds inhibiting germination of some seeds. Accumulation of leaf litter under trees have regulatory effect on germination. Seeds have sensitivity to such inhibitors and , therefore, do not germinate in close vicinity of these trees. Litter of hard leathery leaves, e.g. Oak etc. presents mechanical obstruction to seedling development. Degeneration of plants in old coffee plantation is ascribed to the toxic effects of caffeine (present in the coffee endosperm) on the roots. Seeds of root parasitic angiosperms (Orobanche spp and Striga spp) can germinate only after the host plant leaches out a stimulator. Sticky nature of the fruits of Viscum album increase the chances of getting attached to the trees after being carried by birds. thereby enabling them to reach suitable hosts. Animals have a big role to play in seed dispersal. Animals and birds eat fruits and seeds and pass seeds through their elementary canals to different areas, thereby bringing about dispersion of seeds. Ants also play a role in seed distribution.

Dispersal

Dispersal is defined as the unidirectional movement of an organism away from its place of birth mainly through its propagules (such as fruits and seeds in case of plants). In other words, it is the scattering of fruits and seeds to other places or their transfer from one place to another by themselves or by external agencies. Different dispersal strategies facilitate movement of plants to either short or long-distances, with a strong bearing on the range of the species. In view of its vital significance for invasiveness, long-distance seed dispersal has

currently assumed intense interest, though it is very difficult to document directly and only a few attempts have been made to do so.

Importance of Fruit and Seed Dispersal

Seed and fruit dispersal is currently of intense interest, because of its critical importance for plant community dynamics, population structure, and vegetation response to various land-use changes as well as climate change. Dispersal of propagules (seeds and fruits) mainly occurs to find new sites for establishment (safe sites) where germination and further survival is likely to be guaranteed. Different advantages of seed dispersal for the plant species are documented below:

¬ Dispersal reduces competition between the parent plant and the seeds, the forerunners of the subsequent individuals of the same species.

¬ It reduces overcrowding, hence better resource partitioning and use.

¬ It provides opportunities to spread the plant to new localities and expand its territorial distribution and range expansion. In fact, germination and growth away from the mother plant allows opportunities to find advantageous areas to inhabit, in addition to avoiding unfavourable conditions around the mother plant such as inbreeding and sibling competition.

¬ Seed dispersal is essential for the success of plant reproduction and adaptation.

¬ This enables new plant seedlings to grow better.

Evolution of dispersal

For evolution of plants into different lines and their speciation and diversification, dispersal to varying distances has been a key driving factor. In fact, the origin of fruits of angiosperms represents a major evolutionary innovation that greatly enhanced seed dispersal efficiency and triggered rapid diversification of flowering plants. The seed-dispersion pattern not only determines the potential area of plant recruitment, but also serves as a template for subsequent processes, such as predation, competition and mating. There are numerous examples of very interesting co-evolutionary relationships between various plant species and their dispersal vectors. A number of such examples are discussed in the subsequent part of the present e-content module and students are expected to look for similar examples in their immediate surroundings for appropriate understanding. Seed dispersal can contribute to species coexistence through tradeoffs between colonization ability and other characters across species, and through the slowing of competitive exclusion when seeds fail to arrive. Dispersal also affects the rates of gene flow, and thus influences genetic structure within and among populations. Studies suggest that seed and fruit evolution was driven, at least in part, by dispersal agents. However, the actual spatial pattern of dispersed seeds remains understudied and little is known about the evolutionary force that drove rapid diversification of seed and fruit types. Therefore, prospective students can find the evolution of fruit and seed dispersal as not only a challenging but also a promising area of research to unravel the hitherto unknown mechanisms and strategies of plant dispersal. It is important to note that plant species do not use often one form of seed dispersal only instead different strategies or forms may complement or supplement each other to ensure and safeguard better dispersal. Students

need to know the term Seed dispersal syndromes. Seed dispersal syndromes are the morphological characters of seeds correlated to particular seed dispersal agents, which are basically the result of a mutualistic plant-animal (or dispersal agent) interaction.

Vectors of Seed Dispersal

A large number of different means of dispersal of fruits and seeds needs a broad understanding of the vectors and mechanisms. Vectors of the propagule transport can be grouped into three broad types:

i. **Autochory** ---- where the dispersal of propagules is carried out by the plant itself. Consortium for Educational Communication

ii. **Allochory** ---- where the plant exploits different means of transport (vectors, such as wind, water, animals, etc.).

iii. **Atelochory** ---- where dispersal is inhibited. Autochory Autochory refers to self-dispersal by plants. Plants have evolved many mechanisms for self dispersal which ensure their spatial distribution in many ways. This type of dispersal contributes to transport of species over short-distances.

Some major means of autochory are briefly discussed below:

a. Barochory (transport via gravity)

– In this case of autochory propagules are transported through gravity without any special aid, a mechanism that may result in distribution over a steep slope. In this case usually, the highest density of seeds is reached near the mother plant (seed shade).

b. Blastochory (dispersal via runners)

– Here propagules find suitable growing sites by growth processes, e.g. via scions (vegetative shoots) or pedicels, as in Cymbalaria muralis.

c. Herpochory (short distance transport via active creeping)

– The best example of this is Trifolium stellatum in which the awns have hygroscopic characteristics and twist with changes in humidity, thereby dispersing propagules.

d. Ballochory (self seeder) – In this type of dispersal propagules are propelled by a single impulse from the mother plant. The necessary impulse may be provided by factors such as wind, animals or even a raindrop.

Autoballochory is, however, a type of self dispersal where no such impulse is required and the pressure is produced via:

-Either differences in turgor (e.g. Ecballium elaterium) or

-Drying fruits or seed cases (e.g. Bauhinia purpurea). Self-Dispersal can involve an explosion of the fruit which then Consortium for Educational Communication throws the seeds away from the fruit. Examples of plants that use this mechanism are the Gorse, squirting cucumber and the pea plant. Amongst these Gorse (Ulex europaeus) is the best example. Sitting near Gorse bushes on a hot day in summer in Britain, can be like sitting near a firing range, as the exploding pods sound almost like gun shots thereby throwing the small seeds very effectively away from the immediate area. As a pod dries, tensions are set up in the wall of the pod

eventually causing it to split along two lines of weakness. As the two halves curl back, suddenly released like a tense spring, they flick out the seeds inside in an explosive manner.

Allochory

Allochory, in contrast to autochory, refers to dispersal brought about by the external factors or agents. There are at least four major types of seed dispersal recognized on this basis:

Wind dispersal (Anemochory)

Animal dispersal (Zoochory)

Water dispersal (Hydrochory), and

Dispersal by man (Hemerochory or Anthropochory)

Anemochory (Wind Dispersal) Wind is animportant vector for allochoric seed and fruit dispersal. Plants have developed a number of different adaptations either to help the seeds be released (very small light seeds) or to help the seeds stay in the air for longer, thereby facilitating their transport to greater distances. Such adaptations usually involve hairs or outgrowths which increase the surface area to catch the wind. These adaptations can be broadly grouped into following types:

i Pepper-pot' type

The flower ovary containing the seeds becomes a dry hollow container with one or more openings. The containers are shaken by the wind, scattering the seeds through the openings, dispersing them all around the immediate area. The best example is Red Campion (Silene dioica).

ii Parachute type In this type seeds have feathery hairs which facilitate them to float in air due to the force of wind. They can often be carried long distances in this way, e.g. Ragwort (Jacobaea vulgaris).

iiiWinged type Wing-like outgrowths on the fruit (which contains the seed) make it spin as it falls from the parent plant. This spinning delays its fall so that the wind may carry it some distance away, e.g. Sycamore (Platanus occidentalis).

Iv **Zoochory:** Animal Dispersal Zoochory refers to dispersal brought about by animals. In evolutionary terms, zoochory represents the most important and ecologically most complex form of dispersal. In fact, very close interrelationships between some specific plant and animal species reflect a long co-evolutionary development. Animals facilitate dispersal by either carrying the fruit or seeds on the outside of their bodies, or by eating the seeds and passing them out with their droppings (Endochory). This way seeds are not only transported, but after excretion, they are provided with very fertile starting conditions for germination in the nutrient rich excrement. Some birds eat the fruit and then throw away the seeds. Seeds or fruits carried on the surface of animals often have hooks to attach it to the coat of the animal. Stickybacks and thistles are common examples. Birds, bats and ants are specifically attracted; plants invest in nutrient-rich fruits and attract attention by striking colours or strong smells. Plants, such as burdock (members of biennial thistles in the genus Arctium of family Asteraceae) have hooks to which the seed is attached. These hooks easily get caught in the fur of mammals as they pass by the plant. At some point, the seed will fall, often a

considerable distance from the parent. If conditions are favourable, the seed will germinate and grow into a new plant. In the autumn, blackberries are a common sight in British woodlands and hedgerows. The berries are eaten by birds such as blackbirds and pigeons. Mice, deer and even foxes also eat them. The small hard seed is hidden inside the fruit and passes through the gut of the animal as it can not be digested. The seeds are, therefore, expelled in the droppings of the animal. Some seeds dispersed in this way cannot germinate unless they have passed through the digestive system of an animal.

V **Hydrochory** (Water Dispersal) Water is an important vector for plant dispersal and flowing waters of streams and rivers, especially acts as effective Consortium for Educational Communication corridors for propagule transport. There are many instances wherein the seeds or fruits are dropped from the plant into the rivers, lakes, seas and, being less dense than water, they float and some of them can germinate if, on being washed up on land, the conditions are favourable. Plants, such as Pond Iris grow in or near freshwater. The seed pods break open when they ripen. Those which fall into the water float away. The seeds may be dispersed long distances in this way. They can either germinate in the water or when they become stranded on mud.

Vi Hemerochory (Anthropochory) Man can play, and has in fact played, an exceptionally important role in the recent history of plant distributions, carrying propagules to any distances overcoming all geographical or ecological barriers. Some times, the plants are intentionally transported to different regions for food or ornamental purposes (Ethelochory) and sometimes it occurs unintentionally alongwith other propagules or vectors, e.g. weed seeds in case of cereal crops (Speirochory). An outcome of the anthropochory has corridors for propagule transport. There are many instances wherein the seeds or fruits are dropped from the plant into the rivers, lakes, seas and, being less dense than water, they float and some of them can germinate if, on being washed up on land, the conditions are favourable. Plants, such as Pond Iris grow in or near freshwater. The seed pods break open when they ripen. Those which fall into the water float away. The seeds may be dispersed long distances in this way. They can either germinate in the water or when they become stranded on mud.Hemerochory (Anthropochory) Man can play, and has in fact played, an exceptionally important role in the recent history of plant distributions, carrying propagules to any distances overcoming all geographical or ecological barriers. Some times, the plants are intentionally transported to different regions for food or ornamental purposes (Ethelochory) and sometimes it occurs unintentionally alongwith other propagules or vectors, e.g. weed seeds in case of cereal crops (Speirochory). An outcome of the anthropochory has been the problem of enhanced alien plant invasion, which constitutes the second largest threat to biodiversity after habitat loss. Since the alien plants can have a multitude of impacts on native biodiversity and ecosystem functioning, their management has become immensely costly and a challenging issue.

vii **Atelochory** It is also called as Achory and is a special form of distribution from an evolutionary perspective, because dispersal is prevented due to which reproduction takes place at the site where mother plant grows, which is favourable to the species. Best examples are Arachis hypogaea or Trifolium subterraneum. In these cases after pollination pedicel and ovary penetrate into the ground.

Conclusions

In the present content, we understood the terminology and process of dispersal of seeds and fruits, and also how many possible vectors and mechanisms play a key role in this process. While some plants use the fruit to enable dispersal and other plants use the seed only, some plants use both. Seed dispersal syndromes are the morphological characters of seeds correlated to particular seed dispersal agents, which are basically the result of a mutualistic plant-animal (or dispersal agent) interaction. We learnt that since the origin of fruits of angiosperms many major co-evolutionary innovations greatly enhanced seed dispersal efficiency and triggered rapid diversification of the plant world. In view of the importance of seed and fruit dispersal for plant community dynamics, population structure, and vegetation response to various land use changes as well as climate change, the objective of the e-content module, i.e. to stimulate interest of students in this topic through relevant anecdotes and examples, is genuinely fulfilled.

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