BSC Final Year Notes

Salient Achievements of Crop Biotechnology

Biotechnology is the use of living systems and organisms to develop or make useful products, or "any technological application that uses biological systems or living organisms to make products for specific use". For thousands of years, humankind has used biotechnology in agriculture. Biotechnology has expanded to include new sciences such as genomics, recombinant gene technologies, applied immunology, and development of pharmaceutical therapies and diagnostic tests. Biotechnology has applications in four major areas, such as health care, agriculture, industrial and environmental areas.

The concept of 'biotechnology' include a wide range of procedures for modifying living organisms according to human purposes, such as domestication of animals, cultivation of plants, and "improvements" to these through breeding programs. Modern biotechnology includes genetic engineering as well as cell and tissue culture technologies. Thus in other words, biotechnology can be defined as the mere application of technical advances in life science to develop commercial products.

Agriculture biotechnology includes**:**

1) Plant biotechnology (eg. tissue culture, embryogenesis, genetic markers, genetic engineering, plant breeding, floriculture, forestry);

2) Animal biotechnology (eg. diagnostics, therapeutics, embryo transplantation, genetic markers, genetic engineering, animal breeding, anti-microbials);

3) Biofertilisers, biopesticide, bioherbicides, biological additives, microbial pest control, hormones, pheremones, and other agrichemicals; and

4) Food processing (eg. food products, food components, enzymes, yeasts, bacteria culture).

Applications in Agriculture:

By using biotechnological procedures, the earliest farmers selected and bred the best suited crops, having the highest yields, to produce enough food to support a growing population. As the agricultural sector increased, it was discovered that specific organisms and their by-products could effectively fertilize, restore nitrogen, and control pests. Throughout the history of agriculture, farmers have inadvertently altered the genetics of their crops through introducing them to new environments and breeding them with other plants. This was one of the first forms of biotechnology. For thousands of years, humans have used selective breeding to improve production of crops and livestock to use them for food. In selective breeding, organisms with desirable characteristics are mated to produce offspring with the same characteristics. For example, this technique was used with corn to produce the largest and sweetest crops.

The term "Green biotechnology" is applied to agricultural biotechnology. An example would be the production of plants via micropropagation. Another example is the designing of transgenic plants to grow under specific environments in the presence (or absence) of chemicals. Biotechnology might give more environmentally friendly solutions than traditional agriculture; for example, engineering of a plant to express a pesticide, thereby ending the need of external application of pesticides. However this is a topic of considerable debate.

A) Crop yield

Using the techniques of modern biotechnology, one or more genes may be transferred to a highly developed crop variety to introduce new characters that would increase its yield. However, while increases in crop yield are the most obvious applications of modern biotechnology in agriculture, they are also the most difficult ones. Current genetic engineering techniques work best for effects that are controlled by a single gene. Many of the genetic characteristics associated with yield (e.g., enhanced growth) are controlled by a large number of genes, each of which has a minimal effect on the overall yield. Therefore much scientific work to be done in this area.

B) Reduced vulnerability of crops to environmental stresses

Crops resistant to biotic and abiotic stresses have been developed. For example, a plant gene, At-DBF2, from *Arabidopsis thaliana* shows tolerance to salt, drought and the heat and cold. Using this gene researchers have created transgenic tomato and tobacco plants resistant to these stress conditions. Rice plants resistant to rice yellow mottle virus (RYMV) have been created.

C) Increased nutritional qualities

Proteins in food require modification to increase their nutritional qualities. Proteins in legumes and cereals may be transformed to provide the amino acids needed by human beings for a balanced diet. An example is the work of Professors Ingo Potrykus and Peter Beyer in creating Golden rice. The rice is a result of genetic modification. The genetically modified rice produces beta carotene which is converted to vitamin A. The extra beta carotene content modofied rice to a golden color.

You know that rice is used as staple food almost in every country. The contents of vitamin A are very low in rice. Vitamin A is synthesised from carotenoid which is precursor of vitamin A. Carotenoid is synthesised by three genes. Prof. Ingo Potrykus and Peter Beyer produced genetically engineered rice by introducing three genes associated with biosynthesis of carotenoid. The transgenic rice was rich in pro-vitamin A. Since the seeds of transgenic rice are yellow in colour due to pro-vitamin A, the rice is commonly known as golden rice. Golden rice is an interesting development which could open the way for improving nutritional standards in rice-eating cultures.

Similarly, the work done in India by Ashish Dutta (1992, 2000) on the introduction of amal gene (encoding balanced amino acid-protein) from Amaranthus into potato holds promise for enhancing nutritional value of low protein food. The transgenic potatoes having amal gene are undergoing field trials.

D) Improved taste, texture or appearance of food

Modern biotechnology can be used to slow down the process of fruit, vegetable and oil seed spoilage. Modified fruits can ripen longer and then be transported to the consumer with less risk of spoilage. However engineering soybeans to resist spoilage makes them less suitable for producing tempeh (source of protein) which becomes lumpy, less palatable, and less convenient. Certain varietals of apples which have been bred for appearance often lack the taste qualities and became less visually attractive.

The first genetically modified food product was a tomato which was transformed to delay its ripening. Researchers are currently working on delayed-ripening papaya in collaboration with the University of Nottingham and Zeneca.

About 85 million tons of wheat flour is used every year to bake bread. By adding an enzyme called maltogenic amylase to the flour, bread stays fresher longer. Assuming that 10–15% of bread is thrown away as stale; if it could be kept fresh another 5–7 days then perhaps 2 million tons of flour per year would be saved. Other enzymes can cause bread to expand to make a lighter loaf, or can alter the loaf in a range of ways.

E) Reduced dependence on fertilizers, pesticides and other agrochemicals

Most of the current commercial applications of modern biotechnology in agriculture are on reducing the dependence of farmers on agrochemicals. For example, *Bacillus thuringiensis* (Bt) is a soil bacterium that produces a protein with insecticidal qualities. Traditionally, a fermentation process has been used to produce an insecticidal spray from these bacteria. Crop plants have now been engineered to contain and express the genes for Bt-toxin, which they produce in its active form. When a susceptible insect ingests the transgenic crop cultivar expressing the Bt-protein, it stops feeding and soon thereafter dies as a result of the Bt-toxin binding to its gut wall. Bt-corn is now commercially available in a number of countries to control corn borer which is otherwise controlled by spraying (a more difficult process).

Crops have also been genetically engineered to acquire tolerance to broad-spectrum herbicide. The herbicide-tolerant crops have the potential of increasing yield due to improved weed management and less crop injury. Transgenic crops that express tolerance to glyphosate, glufosinate and bromoxynil have been developed. These herbicides can now be sprayed on transgenic crops without inflicting damage on the crops while killing nearby weeds. Herbicide tolerance is the most dominant trait introduced to commercially available transgenic crops.

F) Production of novel substances in crop plants

Biotechnology is finding novel uses beyond food. For example, oilseed can be modified to produce fatty acids for detergents. Potatoes, tomatoes, rice, tobacco, lettuce, safflowers, and other plants have been genetically engineered to produce insulin and certain vaccines. In future advantages of edible vaccines would be enormous, especially for developing countries. This will help to reduce cost of health care and sources of infections due to contaminations.

G) Glyphosate resistance

One of the most famous kinds of GM crops are "Roundup Ready", or glyphosate-resistant. Glyphosate, (the active ingredient in Roundup) kills plants by interfering with the shikimate pathway in plants.

H) Improved shelf life

The first genetically modified crop approved for sale in the U.S. was the *Flavr-Savr* tomato, which had a longer shelf life. A gene in the fruit has been modified such that the apple produces less polyphenol oxidase, a chemical that manifests the browning.

I) Pathogen resistance – insects or viruses

Tobacco, corn, rice and many other crops, have been generated that express genes encoding for insecticidal proteins from *Bacillus thuringiensis* (Bt). Papaya, potatoes, and squash have been engineered to resist viral pathogens.

J) Production of biofuels

Jatropha has also been modified to improve its qualities for fuel production.

K) Production of useful by-product

a) Drugs

Bananas have been developed that produce human vaccines against infectious diseases such as Hepatitis-B. Tobacco plants have been developed that can produce therapeutic antibodies.

b) Materials

Several companies and labs are working on engineering plants that can be used to make bioplastics. Potatoes that produce more industrially useful starches have been developed as well.

L) Micropropagation

Protocols for micro-propagation of fruit plants, such as Apple cultivars (Golden Delicious, Tydeman's Early Worcester, Red spur), Peach, Cherry, Kiwifruit (Alison and Hayward with male plants), Strawberry (Chandler and Fern); ornamental plants such as Chrysanthemums, Gerbera, Carnations, Gladiolii and Asiatic hybrids of Lily; forest trees such as *Robinia pseudoacacia, Morus alba, Alnus nepalensis, Grevia optiva, Dendrocalanus hamiltoni, D. strictus, Acacia catechu* and *Pinus roxburghii* ; and medicinal plants such as *Valeriania jatamansi, Gentiana kuroo, Inula racemosa* and *Bunium persicum* have been standardized. Cryopreservation following vitrification and encapsulation has been achieved in *Nardostachys grandiflora* and *Inula racemosa*. Protocol for plant regeneration through somatic embryogenesis has been achieved in *Bunium persicum* (Kala jeera).

Controversy

There is another side to the agricultural biotechnology issue. It includes increased herbicide usage and resultant herbicide resistance, "super weeds", residues on and in food crops, genetic contamination of non-GM crops which hurt organic and conventional farmers, etc.

Worldwide use of GM crops:

Country	**Biotech crops**
USA	Soybean, Maize, Cotton, Canola, Squash, Papaya, Alfalfa, Sugar-beet
Brazil	Soybean, Maize, Cotton
Argentina	Soybean, Maize, Cotton
India	Cotton
Canada	Maize, Soybean, Canola, Sugar-beet

Examples of genetically modified crops

Crop	Properties of the genetically modified variety	Modification
Alfalfa	Resistance to glyphosate or glufosinate herbicides	New genes added/transferred into plant genome.
Canola/ Rapeseed	Resistance to herbicides (glyphosate or glufosinate)	New genes added/transferred into plant genome
Maize	Resistance to glyphosate or glufosinate herbicides. Insect resistance via prod ucing Bt-proteins, some previously used as pesticides in organic crop production. Added enzyme, alpha amylase, that converts starch into sugar to facilitate ethanol production.	New genes, some from the bacterium *Bacillus thuringiensis*, added/transferred into plant genome.
Cotton	Kills susceptible insect pests	gene for one or more Bt-crystal proteins transferred into plant genome
Papaya	Resistance to the papaya ring spot virus.	New gene added/transferred into plant genome
Potato	New Leaf: Bt-resistance against Colorado beetle and resistance against Potato virus Y(removed from market in 2001.	New Leaf: Bt cry3A, coat protein from PVY
Potato	Amflora: resistance gene against an antibiotic, used for selection, in combination with modifications for better starch production	Amflora – antibiotic resistance gene from bacteria; modifications to endogenous starch-producing enzymes
Rice	Golden Rice: genetically modified to contain beta-carotene (a source of vitamin A)	Current version of Golden Rice under development contains genes from maize and a common soil microorganism.[118]Previous prototype version contained three new genes: two from daffodils and the third from a bacterium
Soybeans	Resistance to glyphosate (see Roundup Ready soybean) or glufosinate herbicides; make less saturated fats; Kills susceptible insect pests	Herbicide resistant gene taken from bacteria inserted into soybean; knocked out native genes that catalyze saturation; gene for one or more Bt crystal proteins transferred into plant genome
Squash	Resistance to watermelon, cucumber and zucchini/courgette yellow mosaic viruses	Contains coat protein genes of viruses.
Sugar beet	Resistance to glyphosate, glufosinate herbicides	New genes added/transferred into plant genome

Sugarcane	Resistance to certain pesticides, high sucrose content.	New genes added/transferred into plant genome
Sweet peppers	Resistance to cucumber mosaic virus	Contains coat protein genes of the virus.
Tomatoes	Suppression of the enzyme polygalacturonase(PG), retarding fruit softening after harvesting, while at the same time retaining both the natural color and flavor of the fruit	A reverse copy (an antisense gene) of the gene responsible for the production of PG enzyme added into plant genome
Wheat	Resistance to glyphosate herbicide	New genes added/transferred into plant genome

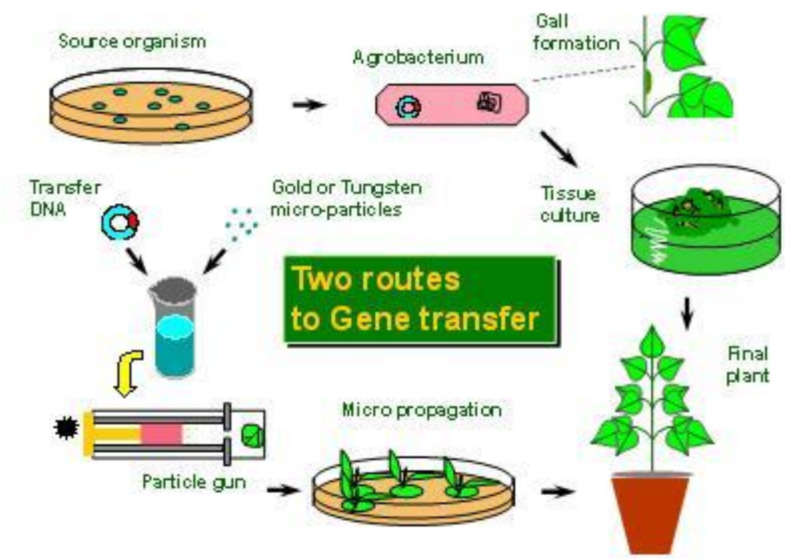
Genetically Modified Organisms (GMOs): Pros and Cons

GMOs are organisms (microbes, plants or animals) which has been modified using genetic engineering techniques. Examples include plants resistant to certain pests, diseases, or environmental conditions, or resistance to chemical treatments (e.g. resistance to an herbicide), or plants able to produce certain nutrient or pharmaceutical agent.

The first genetically modified plant was produced in 1982, using an antibiotic-resistant tobacco plant. In 1987, Plant Genetic Systems (Ghent, Belgium), was the first company to develop genetically engineered (tobacco) plants with insect tolerance from *Bacillus thuringiensis* (Bt). The first genetically modified crop approved for sale in the U.S., in 1994, was the *FlavrSavr* tomato, which had a longer shelf life. European Union (1994) approved tobacco engineered to be resistant to the herbicide bromoxynil. Bt-Potato was approved safe by the Environmental Protection Agency (1995), making it the first pesticide producing crop to be approved in the USA. The following transgenic crops also received marketing approval in the US in 1995: canola with modified oil composition (Calgene), *Bacillus thuringiensis* (Bt) corn/maize (Ciba-Geigy), cotton resistant to the herbicide bromoxynil (Calgene), Bt-cotton (Monsanto), soybeans resistant to the herbicide glyphosate (Monsanto), virus-resistant squash (Asgrow), and additional delayed ripening tomatoes (DNAP, Zeneca/Peto, and Monsanto). In 2000, with the production of golden rice, scientists genetically modified food to increase its nutrient value for the first time.

Genetically engineered plants are generated in a laboratory by altering their genetic makeup. This is usually done by adding one or more genes to a plant's genome using genetic engineeringtechniques Most genetically modified plants are generated by the biolistic method (particle gun) or by *Agrobacterium tumefaciens* mediated transformation. In the biolistic method, DNA is bound to tiny particles of gold or tungsten which are subsequently shot into plant tissue or single plant cells under high pressure. The accelerated particles penetrate both the cell wall and membranes. The DNA separates from the metal and is integrated into plant genome inside the nucleus. This method has been applied successfully for many cultivated crops, especially monocots like wheat or maize, for which transformation using *Agrobacterium tumefaciens* has been less successful. The major disadvantage of this procedure is that serious damage can be done to the cellular tissue.

Agrobacteria are natural plant parasites, and their natural ability to transfer genes provides another method for the development of GM plants. To create a suitable environment for themselves, these Agrobacteria insert their genes into plant hosts, resulting in a proliferation of plant cells near the soil level (crown gall). The genetic information for tumour growth is encoded on a mobile, circular DNA fragment (plasmid). When Agrobacterium infects a plant, it transfers this T-DNA to a random site in the plant genome. When used in genetic engineering the bacterial T-DNA is removed from the bacterial plasmid and replaced with the desired foreign gene. The bacterium is a vector, enabling transportation of foreign genes into plants. This method works especially well for dicotyledonous plants like potatoes, tomatoes, and tobacco. Agrobacteria infection is less successful in crops like wheat and maize.



In research tobacco and *Arabidopsis thaliana* are the most widely used plants for GM, due to well developed transformation methods, easy propagation and well studied genomes. They serve as model organisms for other plant species.

There is broad scientific consensus that food on the market derived from GM crops poses no greater risk to human health than conventional food. GM crops also provide a number of ecological benefits. However, opponents have objected to GM crops per se on several grounds, including environmental concerns, whether food produced from GM crops is safe, whether GM crops are needed to address the world's food needs, and economic concerns raised by the fact these organisms are subject to intellectual property law.

The political discussion of GMOs is focusing on whether these crops should be accompanied with labels identifying them as genetically engineered. Numerous anti-GMO groups have emerged including which warn of the potential health risks of GMO consumption, citing dozens of countries that require labeling of genetically modified crops.
California voters nearly passed a labeling requirement with Proposition 37. The pro-labeling forces achieved 48.6 percent of the total vote and say they will try again on future GMOs. Whole Foods intends to sell products derived from genetic modification techniques with GMO labels.
What then, are the health risks or concerns involved in GMO consumption?

What exactly is a GMO?

Humans have been genetically modifying crops since the advent of agriculture some 12,000 years ago. The process was initially blind and slow. Early humans had little understanding of genetics, cross-pollination and artificial selection processes, but knew what they wanted to achieve larger crop yields, larger fruit, pest and weed reduction, etc. to increase agricultural output.

The common vegetables as broccoli, cauliflower, etc. they all can trace their roots back to a single plant. Through crop hybridization and natural mutagenic principles, several similar kinds of vegetables emerged. By the latter half of the 20th century the kind of genetic modification we are concerned with finally emerged. Genetic modification is the artificial processes of insertion, mutation and deletion of genes in organisms i.e. introduction of desirable genes from one organism to another (transgenic organisms).

Are GMOs safe?

In a word, yes, but that should be qualified. The safety of genetically engineered crops is only as safe as their genetic modification. The "flounder/tomato" is a safe modification. The Winter Flounder is an edible, delicious and highly commercialized fish.

If, however, a gene from the Foxglove plant, which contains a natural, poisonous toxin called digitoxin, were inserted into the same tomato plant, there could be problems. In other words, lumping all GMOs into the same category is not the best idea.

There are numerous studies that demonstrate GMOs are perfectly healthy. So far, the American Association for the Advancement of Science, the American Medical Association, the World Health Organization, the European Union and several other research organizations have provided scientific analyses detailing the safety of GMOs.

Some of the research also suggests GMOs may actually be healthier than non-genetically modified crops. Take, for instance, a transgenic potato that contains a gene from the bacterium bacillus thuringiensis, which provides the potato with an endotoxin safe for human consumption but deadly to the Colorado Potato Beetle, a pest routinely responsible for potato yield reduction. Agriculturalists substituted transgenic potatoes for the pesticide imidacloprid, a pesticide that is adverse to developing mammalian brains.

If GMO's are safe, why is there so much anti-GMO sentiment?

There are several reasons for this. For starters, the term "genetically-modified food" simply sounds terrible. Some hold that mutations, in and of themselves, are unnatural and therefore undesirable. The fact that eating is an everyday event, a deeply personal experience, exacerbates this concern and people want to know why the food supply is being manipulated.

Another reason for these fears involves who is behind GMOs and GMO research. Looking at the groups that provided funding to defeat Proposition 37 is like looking at a who's who of environmentalist bêtes noirs. GMO financiers include Dupont, Bayer Pharmaceuticals and Dow Chemical, with Monsanto topping the list. The thinking goes that any political issue supported by Monsanto can never be a good thing.

To a large extent, Monsanto's public opprobrium is well-founded. The company often is involved in litigation with small farmers who unknowingly use their patented seeds – the most

recent case going all the way to the Supreme Court. The patenting of genetically modified plants has allowed the company to monopolize entire crops, both nationally and internationally. Monsanto controls 90% of the soybean production worldwide, not to mention numerous other crops. The company even has been linked to illegal child labor practices in India.
Currently, Monsanto spends about $6 million dollars every year for lobbying in the United States and gives generously to both parties; in 2012, Barack Obama and Mitch McConnell received $23,000 and $14,000, respectively.

Despite the many reasons to dislike Monsanto, it is important not to confuse the company with the process of genetic modification – the two are distinct. Monsanto's litigious efforts and corporate practices are social and political problems that demand social and political answers; the health and safety of GMOs is a scientific question requiring sound scientific answers. Any policy argument for or against the health risks of GMOs must be couched in scientific analysis.

Is labeling genetically modified food good public policy?
The answer to this question remains unclear, as it goes beyond the scientific analysis of whether GMOs are healthy or not. The question of labeling store-purchased food is fundamentally different because it is concerned with consumer information and the right to know the process behind the foods we eat.

This argument does have some merit; all manufactured foods today already contain a list of ingredients. If you have a right to know that a can of Coke contains some calcium, should you not also have a right to know that the potato you are eating contains a genetic sequence responsible for an endotoxin harmful to potato bugs? Every fast food restaurant in California now lists in bold letters the calorie count for menu items – why not also label GMOs?

On the other hand, people will not purchase GMOs simply because it says GMO, and that may well turn into a problem. Public disdain for the genetically modified potato gave rise to increased use of pesticides, an unhealthier alternative both for human consumption and the environment. World population increases in the next century will require novel and innovative agricultural techniques to keep pace and climate change will require sturdy, resilient plants. These problems may be solved through GMO research and implementation.

Once more, it is important to emphasize the vast majority of scientific research indicates genetically modified food is safe for human consumption. While there may be valid arguments as to labeling foods with a GMO tag, without scientific evidence to the contrary, no one can argue GMOs are inherently, categorically harmful

Health Care: Edible Vaccines

Vaccines are the antigenic proteins that induce B-cells to secrete antibodies. Transgenic crop plants can be constructed which produce vaccines to be eaten i.e. edible vaccines on a large scale at low cost. Moreover, attention has been paid to produce such antigens that can stimulate mucosal immune system to produce secretary immunoglobulin A (S-IgA). In 1990, first report of production of edible vaccine in tobacco at 0.02% of total leaf protein was published in the form of a patent application under the International Patent Co-operation Treaty. Thereafter, production of many antigens in several plants was reported. In 1988, V.S. Reddi at ICGEB produced transgenic tobacco that produced hepatitis B surface antigen (HBsAg) active against hepatitis B virus in uncontrolled way. The plant derived rHBsAg was similar to yeast derived rHBsAg in providing immunity to mice.

The transgenic plants can be eaten as raw for immunisation or vaccination. The transgene expresses antigenic protein in the cells of transgenic plants. After ingestion antigenic protein activates the immune system to produce antibodies. The antibodies provide immunity against the specific pathogens present in human system. Due attention has been paid to produce such transgenic plants which can be used even uncooked as raw such as tomato fruits, carrot, sugar beet, banana, etc. Otherwise after cooking the antigenic proteins may be denatured.There are many advantages associated with edible vaccines such as no problem of storage, easy delivery into system after feeding, low cost of production (as compared to recombinant vaccines produced by bacteria and fungi through fermentation in bioreactors). The edible vaccines provide similar effects as the recombinant vaccines.

Production of edible vaccines

Transgenic plants provide an alternative system for the production of recombinant vaccines. The major advantage of vaccine production in plants is the direct use of edible plants tissue for oral administration. By the use of edible vaccines the problems associated with the purification of vaccines can be avoided. The stable or transient expression system can be used to produce vaccines in plants. Transgenic plants have been developed for expressing antigens derived from animal viruses. The need for use of edible vaccines comes from the fact that larger numbers of people are the victims of enteric diseases. Edible vaccine provides mucosal immunity against infectious agents. Some of the edible vaccines are mentioned in table given below.

Table: Examples of plant edible subunit vaccines

Recombinant Protein	Transgenic Plant	Protection against
Rabies Glycoprotein	Tomato	Rabies Virus
Foot and Mouth Virus	Arabidopsis	Foot and Mouth Virus
Herpes Virus B surface antigen	Tobacco	Herpes simplex virus
Cholera toxin B subunit	Potato	*Vibrio cholerae*
Human cytomegalovirus glycoprotein B	Tobacco	Human cytomegalovirus

Choice of plants for edible vaccines

Most of the vaccines production was carried out in tobacco plant that is not edible. These vaccines are now being produced in edible plants such as banana, tomato and potato. For use in animals the common fodder crops are used. Banana is an ideal system for the production of edible vaccine since it is grown in most part of the world and eaten raw.

Transgenic Plant: Bt-Cotton

Bt cotton is a genetically modified variety of cotton producing an insecticide. It is produced by Monsanto. It is produced by Mahyco in India.The bacterium *Bacillus thuringiensis* (Bt) is a family of over 200 different proteins which naturally produce chemicals harmful to selective insects, most notably the larvae of moths and butterflies, beetles, Helicoverpa armigera and flies, and harmless to other forms of life (Umt.edu, 2013). The gene coding for Bt toxin has been inserted into cotton, causing cotton to produce this natural insecticide in its tissues. In many regions, the main pests in commercial cotton are lepidopteran larvae, which are killed by the Bt protein in the transgenic cotton they eat. This eliminates the need to use large amounts of broad-spectrum insecticides to kill lepidopteran pests (some of which have developed pyrethroidresistance). This spares natural insect predators in the farm ecology and further contributes to noninsecticide pest management.

However, Bt cotton is ineffective against many cotton pests such as plant bugs, stink bugs, and aphids; depending on circumstances it may still be desirable to use insecticides in prevention of such pests. A 2006 study done by Cornell researchers, the Center for Chinese Agricultural Policy and the Chinese Academy of Science on Bt cotton farming in China found that after seven years these secondary pests that were normally controlled by pesticide had increased, necessitating the use of pesticides at similar levels to non-Bt cotton and causing less profit for farmers because of the extra expense of GM seeds

(Bt) cotton was created through the addition of genes encoding toxin crystals in the Cry group of endotoxin . When insects attack and eat the cotton plant the Cry toxins are dissolved. This is made possible due to the high pH level of the insects stomach. The now dissolved and activated Cry molecules bond to cadherin-like proteins on cells comprising the brush border molecules . The epithelium of the brush border membranes role is to separate the body cavity from the gut whilst allowing access for nutrients. The Cry toxin molecules attach themselves to specific locations on the cadherin-like proteins present on the epithelial cells of the midge and ion channels are formed which allow the flow of potassium . Regulation of potassium concentration is essential and if left unchecked causes death of cells. Due to the formation of Cry ion channels sufficient regulation of potassium ions is lost and results in the death of epithelial cells. The death of such cells creates gaps in the brush border membrane. The gaps then allow bacteria and (Bt) spores to enter the body cavity resulting in the death of the organism .

The use of Bt-Cotton in India has grown exponentially since its introduction. Recently India has become the number one global exporter of cotton and the second largest cotton producer in the world. India has also bred Bt-cotton varieties such as *Bikaneri Nerma* and hybrids such as (NHH-44), setting up India to benefit now and well into the future . Socio-economic surveys confirm that Bt-Cotton continues to deliver significant and multiple agronomic, economic, environmental and welfare benefits to Indian farmers and society including halved insecticide requirements and a doubling of yields. However India’s success has been subject to scrutiny. Monsanto's seeds are expensive and lose vigour after one generation, prompting The Indian Council of Agricultural Research to develop a cheaper Bt-Cotton variety with seeds that could be reused. The cotton incorporated the cry1Ac gene from the soil bacterium Bacillus thuringiensis (Bt), making the cotton toxic to bollworms. This variety showed poor yield and was removed within a year and also contained a DNA sequence owned by Monsanto, prompting an investigation. In parts of India cases of acquired resistance against Bt-Cotton have occurred. Monsanto has admitted that the pink bollworm is resistant to first generation transgenic Bt-Cotton that expresses the single Bt gene (Cry1Ac).

Bt cotton has a higher resistance to pests due to the toxic Bt toxin given out by the crop.

In India, Bt Cotton has been enveloped in controversies due to it's links with crop and seed monopolies and farmer suicides. BT cotton accounts for 93% of cotton grown in India. But these BT cotton seeds are expensive and lose vigour after one generation, requiring farmers to buy new stock every year.

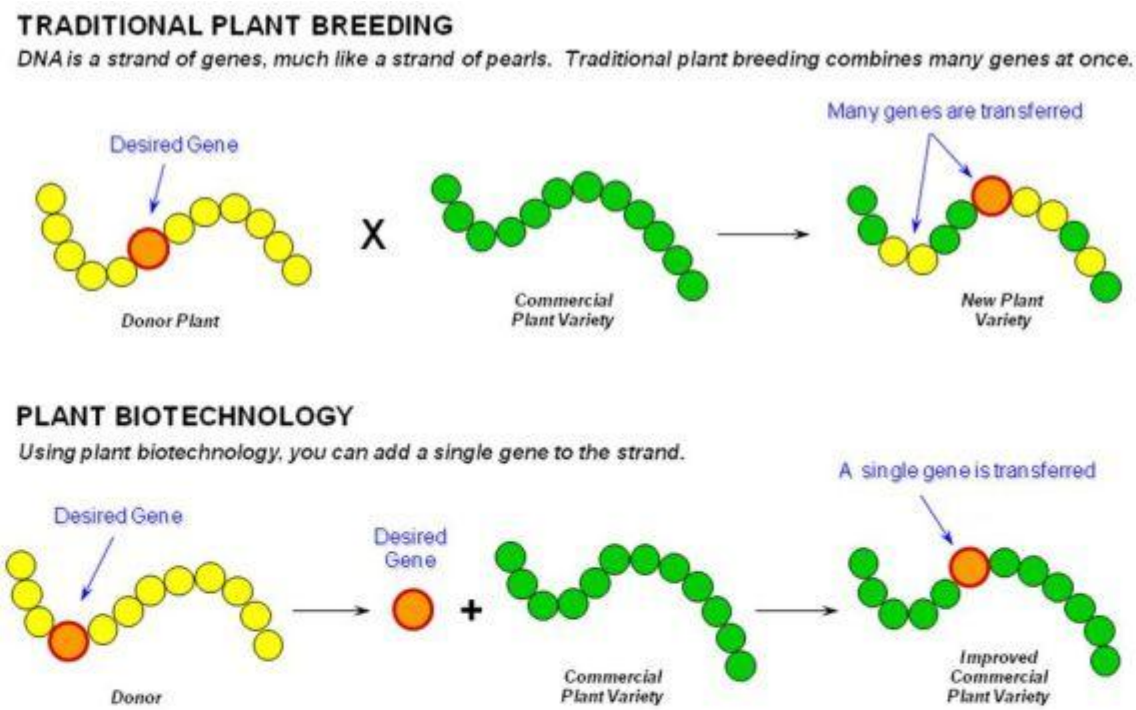


Diagram shows steps for transgenic plant production.

Dr. O.S.Deshmukh

B.Sc.III- Plant Physiology and Ecology

Unit –IV

Plant Responses

Physiology of Flowering

Flowers are the reproductive structures of Angiosperms. Flowering is an important phase of life cycle because the transition from vegetative growth to generative developments involves radical change in the physiology of plant. Flowering is a decisive stage and require a definite period of vegetative growth which varies from plant to plant, eg. A fruiting tree require several years while an annual herb flowers in a few months only.

The physiological mechanism responsible for flowering has been found to be controlled by light period (photoperiod) and temperature (vernilization).

4.1 PHOTOPERIODISM

The plants in order to flower require a certain day length i.e. the relative length of day and night which is called as photoperiod and the response of plants to the photoperiod expressed in the form of flowering is called as **photoperiodism.**

The phenomenon of **photoperiodism** was first discovered by **Garner and Allard** (1920,22) who observed that the Biloxi variety of Soyabean (Glycine max) could be made to flower only when the daily exposure to the light was reduced below a certain critical duration and after many complex experiments concluded that the relative length of a day is a factor of the first importance in the growth and development of plants.

Depending upon the duration of the photoperiod, they classied plants into three categories.

1. Short Day Plants (SDP)

   These plants require a relatively short day light period usually 8-10 hrs. and continious dark period of about 14-16 hrs. for subsequent flowering. These plants are also known as Long –night plants. Eg. Nicotiana , Glycine, Xanthium .

   a. In short day plants the dark period is critical and must be continous. If this dark period is interrupted even with a brief exposure of red light, the short day plant will not flower.
   b. Maximum inhibition of flowering with red light occur at about the middle of critical dark period.
   c. However , the inhibitary effect of red light can be overcome by a subsequent exposure with far red light.
   d. Interruption of the light period with the red light does not have inhibitory effect on flowering in short day plants.
   e. Prolongation of the continuous dark period initiates early flowering in short day plants.

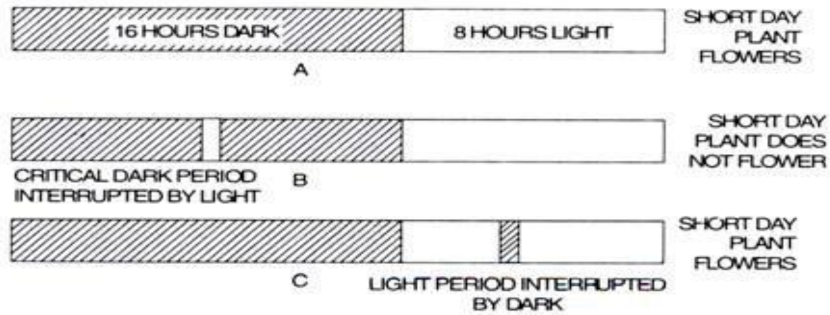


Fig. 18.1. Effect of a brief exposure of red light during dark and interruption of light period by dark on flowering in a short day plant.

2. Long Day Plants (LDP)

These plants require a longer day light period usually 14-16 hrs. in a 24 hrs. cycle for subsequent flowering . eg. Hyoscyamus, Spinacea, Beta vulgaris.

a. In long day plants the light period is critical.
b. A brief exposure in the dark period or the prolongation of the light period stimulates flowering in long day plants.

3. Day Neutral Plants

   These plants flower in all photoperiods ranging from 5 hrs to 24 hrs continuous exposure. Eg. Tomato, cotton, sunflower, cucumber and certain varieties of peas and tobacco.

   During recent years certain intermediate categories of plants have also been recognised . They are-

   a. Long Short Day Plants:- These are short day plants but must be exposed to long days during early periods of growth for subsequent flowering. Eg. Certain species of Bryophyllum.
   b. Short- Long Day Plants :- These are long day plants but must be exposed to short days during early periods of growth for subsequent flowering. Eg. Certain varieties of wheat and rye.

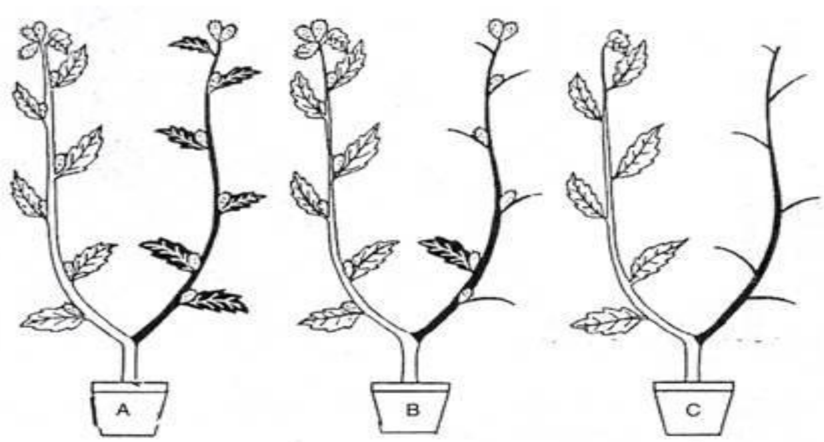
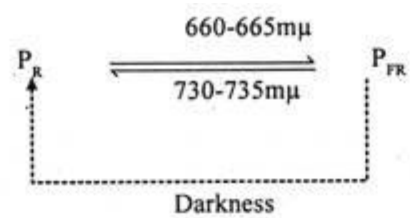


Fig. 18.3. Experiments on cocklebur plants to show that the photoperiodic stimulus can be transmitted from one branch of the plant to another.

Role of Phytochrome

It has already been seen that a brief exposure with red light during critical dark period inhibits flowering in short day plants and this inhibitory effect can be reserved by a subsequent exposure with far – red light. Similarly, the prolongation of critical light period or the interruption of the dark period stimulates flowering in long day plants. This inhibition of flowering in short day plants and the stimulation of flowering in long day plants innvolves the operation of a proteinaceous pigment called as **phytochrome.**

a. The pigment phytochrome exists in two different forms, red light absorbing form which is designated as P_R and far red light absorbing form which is designated as P_{FR}.
b. These two forms of the pigments are photochemically interconvertible.
c. When P_{FR}. form of the pigment absorb red light (660-665 mμ)it is converted into P_R form.
d. The P_{FR} form of the pigments gradually changes into P_R form in dark.



It is considered that during the day the P_{FR} form of the pigment is accumulated in the plant which is inhibitory to flowering in short day plants but is stimulatory in long day plants. During critical dark period in short day plants, this form gradually changes into P_R form resulting in flowering. A brief exposure with red light which convert this form again into the P_{FR} form thus inhibiting flowering. Reversal of the inhibitory effect of red light during critical dark period in SDP by subsequent far-red light exposure is because the P_{FR} form after absorbing far-red light(730-735mμ) will again be convered back int P_R form.

Prolongation of the critical light period or the interruption of the dark period by red light in long day plants will result in futher accumulation of the PFR form of the pigment, thus stimulating flowering in long day plants.

Concept of Florigen

Florigen (or **flowering hormone**) is the hypothesized hormone-like molecule responsible for controlling and/or triggering flowering in plants. Florigen is produced in the leaves, and acts in the shoot apical meristem of buds and growing tips. It is known to be graft-transmissible, and even functions between species. However, despite having been sought since the 1930s, the exact nature of florigen is still a mystery. It is well known that the photoperidic stimulus is perceived by the leaves. As a result a floral hormone is produced in the leaves which is then translocated to the apical tip, subsequently causing the initiation of floral primordia.

The photoperiodic stimulus is perceived by the leaves can be shown by the simple experiments on cocklebur, a short day plant. Cocklebur plant will flower if it has previously been kept under short day condition, if the plant is defoliated and then kept under short day condition it will flower. Flowering will also occur even if all the leaves of the plant except one leaf have been removed. If a cocklebur plant whether intact or defoliated , is kept under long day condition it will not flower. But if even one of its leaves is exposed to short day condition and the rest are under long day photoperiods , flowering will occur.

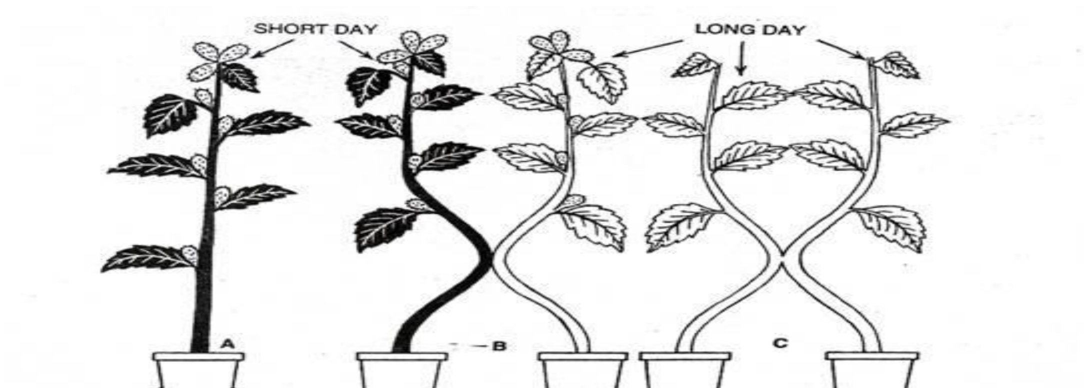


Fig. 18.4. Grafting experiments in cocklebur plants to show the translocation of floral hormone from one plant to another through graft union.

Mechanism

Central to the hunt for florigen is an understanding of how plants use seasonal changes in day length to mediate flowering—a mechanism known as photoperiodism. Plants which exhibit photoperiodism may be either 'short day' or 'long day' plants, which in order to flower require short days or long days respectively, although plants in fact distinguish day length from night length. The current model suggests the involvement of multiple different factors. Research into florigen is predominately centred on the model organism and long day plant, *Arabidopsis thaliana*. Whilst much of the florigen pathways appear to be well conserved in other studied species, variations do exist. The mechanism may be broken down into three stages: photoperiod-regulated *initiation*, signal *translocation* via the phloem, and induction of *flowering* at the shoot apical meristem.

Importance of Photoperiodism

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1. The knowledge of the phenomenon of photoperiodism has been of great practical importance in hybridisation experiments.
2. Although the floral hormone florigen has not yet been isolated , the isolation and characterization of this hormone will be of almost economic importance.
3. The phenomenon of photoperiodism is an excellent example of physiological preconditioning or after effect where an external factor i.e. the photoperiodic stimulus induces some physiological changes in the plant the effect of which is not immediately visible. It lingers on the plant and prepares the latter for a certain process i.e. flowering which takes place at a considerably later stage during the life history of the plant.
4. The knowledge of the phenomenon of photoperiodism has been of great practical importance in hybridisation experiments.
5. Although the floral hormone 'florigen' has not yet been isolated, the isolation and characterization of this hormone will be of utmost economic importance.
6. The phenomenon of photoperiodism is an excellent example of physiological preconditioning (or after-effect) where an external factor (i.e., the photoperiodic stimulus) induces some physiological changes in the plant the effect of which is not immediately visible. It lingers on in the plant and prepares the latter for a certain process (i.e., flowering) which takes place at a considerably later stage during the life history of the plant.

4.3 Plant Movements

Plant Movement

Movements in plants are of 3 types.

A. Movements of Locomotion
B. Movements of Curvature
C. Hygroscopic Movements

The first two types of movements are called as vital movements because they are exhibited only by the living cells or organism.

A. Movements of Locomotion

Those movements in which whole of the plant body or the cells or cytoplasm moves from one place to another are called as movements of locomotion. These movements may occur either spontaneously or in response to certain external stimulus and are called as autonomic and paratonic or induced movements respectively. Paratonic movements of locomotion are known as tactic movements.

a) Autonomic movements of locomotion

1. Ciliary Movements- Such type of movements take place due to the presence of cilia or flagella. Eg. Chlamydomonus, Volvox, flagellated bacteria, flagellated or ciliated reproductive cells.
2. Amoeboid Movements – Such type of movements are exhibited by Myxomycetes whwre the naked plasmodium moves by producing pseudopodia like an Amoeba.
3. Cyclosis- In living cells of many plants the cytoplasm including various cell organelles moves around the vacuoles. This movements of cytoplasm is called protoplasmic streaming or cyclosis. It is of two types- rotation and circulation

In rotation, which is exhibited by plants like chara, Hydrilla, Vallisneria, Elodea etc. the cytoplasm moves either clockwise or anticlockwise around a larger central vacuoles.

While in circulation, which is exhibited by the cells of stamina hairs of plants like Tradeschantia the cytoplasm moves in the clockwise and anticlockwise directions around many smaller vacuoles.

b. Paratonic or Induced Movements of Locomotion or Tactic Movements or Taxes

1. Phototactic Movements or Phototactic – These movements occur in response to an external stimulus, the lightand are exhibited by zoospores and gametes of certain algae. Eg. Chamydomonous, Volvox, Ulothrix, Cladophora etc.

2. Chemotactic Movements or chemotaxis – These movements occur in response to an external chemical stimulus. Such movements are exhibited most commonly by the antherozoids in bryophytes and pteridophytes where the archegonia secreate some chemical substances having a peculiar odors towards which the antherozoids are attracted chemotactically.

3. Themotactic Movements or thermotaxis – Such movements results due to an external heat stimulus. For instance, if a large vessel containing some Chamydomonous in cold water is

warmed on one side, cells move and collect towards the warmer side (positive thermotaxis). However, a negative thermotaxis will occur if the temperature become too high.

B. Movements of Curvature

In higher plants which are fixed , the movements are restricted only to the bending on curvature of some of their parts. Such movements are called as curvature movements and may be either autonomic i.e. spontaneous or paratonic i. e. induced. The curvature movements may be of two types- variation movements and growth movements. In variation movements the curvature or bending of the plant part is temporary while in growth movements it is of permanent nature.

a) Autonomic Movements of Curvature

1. Autonomic movements of variation- Telegraph plant (Desmodium gyrans) is an excellent example of such type of movements. In this plants the compound leaf consists of a larger terminal and two smaller lateral leaflets. During the day time , the two lateral leaflets exhibit peculiar and interesting movements. Sometimes they move upward at an angles of 90o and come to lie parallel to the rachis. Again they move downward at 180o so that they are parallel to rachis. They may again move upward at 90o to come in their original position.. All these movements occur with jerks after intervals, each movements being completed in about 2 minutes.

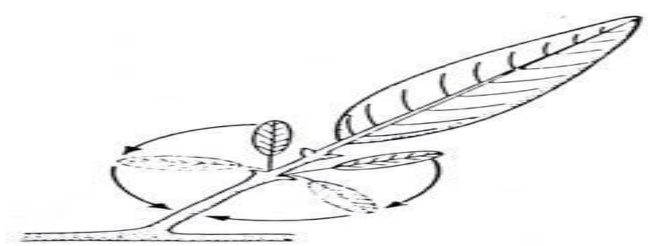

Fig. 21.2. Autonomic variation movements in the leaf of Telegraph plant.

2. Autonomic Movements of Growth
2. Hyponastic and epinastic movements

These moments occurs in bifacial organs like young leaves, flower sepals, petals etc and results due to the differential growth on the two sides of such organs. For instance, if there is more growth on lower side of sepals and petals the flower will close. Such movements are called as hyponastic movements. On the other hand , if there is more growth on their upper side the flower will open. Such a movements are found in ferns where the leaves (fronds) become circinately coiled in young condition (hyponasty) and erect in older condition (epinasty) or in the opening and closing of flowers in many plants such as Crocus.

3. Nutational Movements

Sometimes the growth of the stem apices occurs in zig-zig manner. It is because the two sides of the stem apex alternatively grow more. Such growth movements are called as nutational movements and are common in those stem apices which are not strictly rounded but flattened.

4. Circumnutational movements

In strictly rounded apices the growth occur in a rotational way . It is because the region of maximum growth gradually passes round the growing apex. Such movements are called Circumnutational movements.

b) Paratonic movements of Curvature

1. Paratonic movements of growth tropical movements or tropism

When growth movements occurs in response to an external stimulus which is unidirectional, they are called as tropical movements and the phenomenon of such a movements is called as tropism. Depending upon the nature of the unidirectional external stimulus the tropical movements are of many types.:-

i) Geotropic movements or geotropism (Gravitropism)

The tropical movements which take place in response to the gravity stimulus are called as geotropic movements and this phenomenon as geotropism. The primary roots grow down into the soil and are positively geotropic. The secondary roots growing are rights angles to the force of gravity are called as diageotropic. On the other hand, the primary stems are negatively geotropic.

Geotropism in primary roots and stems can easily be demonstrated by sowing certain maize seeds in the soil so that their radicals lie in different direct ion. After a few days it will be noticed that irrespective of their position radicals in all the seeds always go down while the coleoptiles always grow in upward direction.

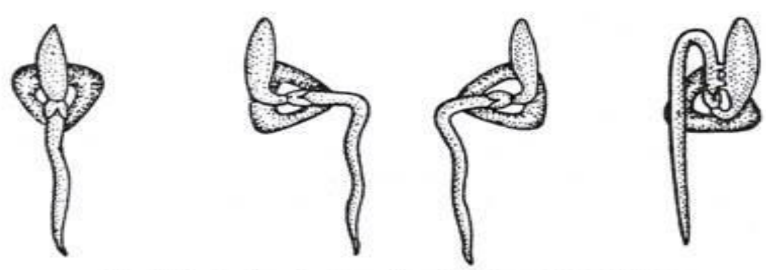

Fig.21.3. Geotropism (gravitropism) in maize seedlings.

In case of roots, the gravity stimulus is perceived only by the root tip. However, the geotropic curvature take place a little behind the root tip, in the region of cell elongation. The effect of unilateral stimulus of gravity causes unequal distribution of growth hormone auxin in the root tip i.e. more auxin concentrates on the upper side and less growth on lower side, and ultimately a positive geotropic curvature is observed.

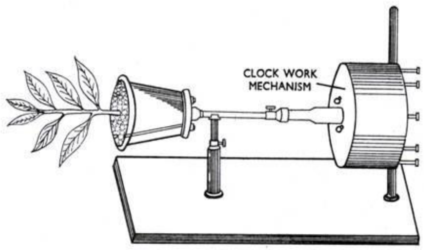

Fig. 21.4. Clinostat.

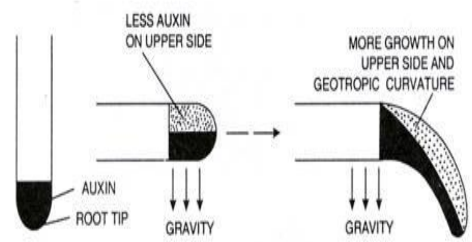

Fig. 21.5. Interaction of gravity and auxin in causing geotropic (gravitropic) curvature in root tip.

But, in case of stem the higher concentration of auxin on the lower side promotes more growth on that side so that a negative geotropic curvature is observed.

iv) Phototropic movements or Phototropism

The tropical movements which occur in response to an external unilateral light stimulus are called as phototropic movements. These movements are commonly found in young stem tips which curve towards the unilateral light stimulus and thus are called as positively phototropic. This can be observed very easily by placing a potted plant in a room near an open window. After a few hours, the stem will be seen bending towards the window, the later being the unilateral source of light. The roots in some plants also exhibit phototropic movements but they are negatively phototropic.

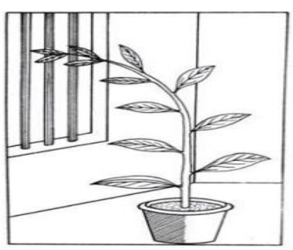
Fig. 21.6. Stem is positively phototropic.

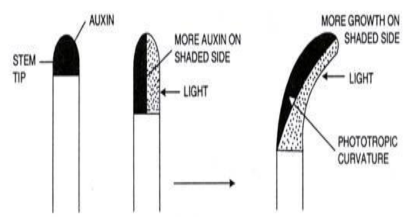

Fig 21.7. Interaction of light and auxin in causing phototropic curvature in stem tip.

When the stem tip receives uniform light all around , the concentration of growth hormone auxin also remains uniform in the tip. But when the tip receives unilateral light , the concentration of auxin becomes more in the shaded side than is the lighted side. Consequently , the higher concentration of auxin in the shaded side causes that side to grow more resulting ultimately in a positive phototropic curvature. If howerer, a small young potted plant receiving unilateral light is fixed on a clinostat in a vertical position and rotated, there will be phototropic curvature in the stem. It is because in this case the stem tip will be receiving unilateral light all round its tip and there will be no unequal distribution of the auxin.

Unilateral blue light is also known to be effective in causing phototropic curvature.

ii) Thigmotropic or haptotropic movements

These movements take place in response to a touch or contact stimulus and are very common in plants which climb by tendrils.

In such plants eg. Passiflora, the tip tendril in the beginging moves freely in the air. But as soon as it comes in contact with a solid object which may provide it support (i.e. it gets the contact stimulus), it twins round the object so that the plants may climb upward. The twining of the tendril around the support is due to less growth on that side of the tendril which is in contact with the support than the more growth on the free opposite side.

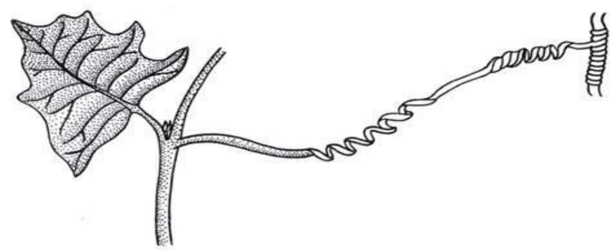

Fig. 21.8. Thigmotropic curvature of the tendril.

iii) Hydrotropic movement or Hydrotropism

The tropical movements occurring in response to water stimulus are called as hydrotropic movements. These are commonly found in young roots and can be demonstrated by the following simple experiments.

Some seeds soaked in water the previous night are kept on a wire gauze covered with saw dust. The wire gauze is then kept slanting in humid condition. After a few days, the radical will be seen bending to towards the moist saw dust.

Chemotropic movements occur in response to some chemical stimulus and are best exhibited by fungal hyphae and pollen tubes.

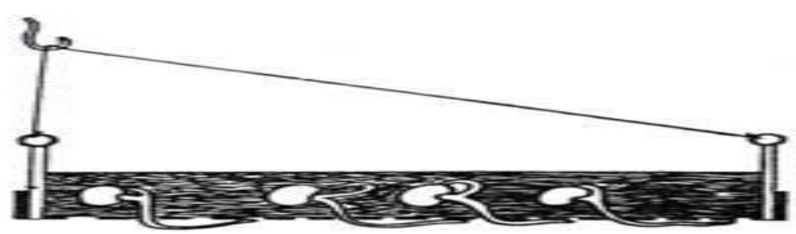

Fig. 21.9. Experiment to show hydrotropism.

iv) Themotropism and Aerotropism

These movements are not very important. When they occur in response to temperature stimulus, they are called as thermotropic movements.

2) Paratonic movements of variation or nastic movements

When growth movements occur in response to an external stimulus which is not unidirectional but diffused, they are called as nastic movements. These movements occur only in bifacial structure like leaves, sepals, petals etc. and may be of many types.

i) Nycytinastic movements or Sleep Movements

In many plants the leaves and flowers acquire a particular but different position during day and at night. Such movements are called as or absence of light, they are called as photonastic movements eg. Oxalis sp. Where the flowers and leaves open in the morning and close at night. In other plants such as Crocus and Perature stimulus are called as thermonastic movements.

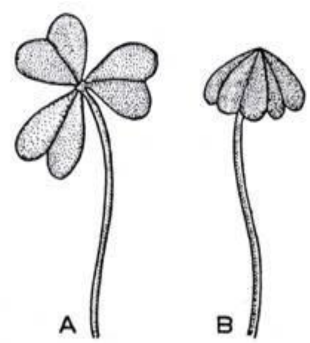

Fig. 21.10. Photonastic movements in *Oxalis* leaf. A. During day; B. During night.

ii) Seismonastic Movements

These are best exhibited by sensitive plant (Mimosa pudica) and occur in response to a touch shock stimulus including shaking or wind , falling of rain drops, wounding by cutting and intense heating or burning.

In this plants the leaves are bipinnately compound with a swollen pulvinus at the bases of each life and similar but smaller pulvinules at the bases of each leaflets or pinna. If a terminal pinnule of a leaflet is touched or given a shock treatments, the stimulus passes downward to the pilvinus and all the pulvinus of that leaflets get successively closed in pairs. Now the stimulus passes to the other pinnae or leaflets so that their pinnules also close down and finally it reaches the pulvinus resulting in drooping of whole of the leaf. Whole of this processes is completed just it few seconds.

The pulvinus contain a number of specialized large thin walled parenchymatous cells called motor cells which undergo reversible changes in turgor in response to the stimulus. When stimulus reaches the pulvinus, the osmotic pressure of motor cells decreased. Consequently, water is realesed from their into intercellular spaces and they suddenly collapse resulting in drooping down of the leaflets and the leaf.

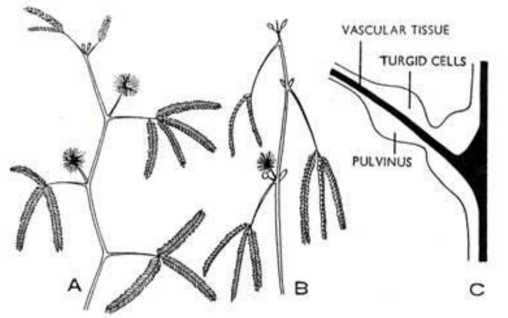

Fig. 21.11. Seismonastic movements in *Mimosa pudica* A. Unstimulated leaf ; B. Stimulated leaf ; C. Diagrammatic section of the pulvinus.

It is now a well established that almost any part of Mimosa plant can perceive the stimulus and transmits it to the pulvinus as electric pluses through phloem sieve tubes at velocities upto 2cms to 1 cms. The action potential is corelated with rapid uptake of proton(H+). When action potential reaches the pulvinus , it stimulates rapid efflux of both K+ and sugar from motor cells into the apoplast(cell walls and intercelluar spaces) decreasing their osmotic pressure. Consequently, water is released from the motor cells which now becomes flaccid due to loss of turgor and collapse resulting in drooping down of the leaf. After sometime, reserve changes occur to restore the turgor of motor cells and leaf comes in its original straight position again.

It is belived that turgorious may give to action potentail in a manner similar to the neurotransmitter acetycholine in animals but at a much lower velocity.

iii) Thigmonastic or haptonastic movements

The movements are found in the leaves of Drosera and Dionaea and result in response to touch stimulus of the insects. In Drosera, as soon as an insect sits on the leaf, the tentacles curve inward to trap the insect. Similarly in Dionaea, the two halves of the leaf curve upward along the midrib. These parts of leaves come to their normal position after the insect has been digested.

C) Hygroscopic Movements

These movements are found only in dead parts of the plants which are hygroscopic in nature and result either due to loss or gain of water by them from the atmosphere. Hygroscopic movements can best be observed in elaters in bryophytes, peristome teeth in moss capsules, elaters of Equisetum spores etc.

4.2 Vernalization

Certain plants require a low temperature treatment during their earlier stages of the life history for subsequent flowering in the later stages. This low temperature or chilling treatments was called as Vernilization by Lysenko(1928). Due to vernilization the vegetative period of the plant is cut short resulting in an early flowering. The effect of the cold stimulus on plant is not immediately visible. It is expressed only at a certain later stage in the form of flowering.

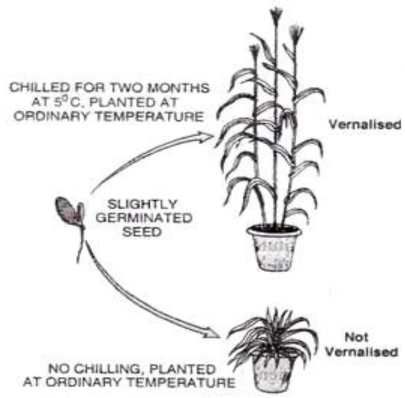

Fig. 15.33. Experiment to show effect of vernalization on Winter Rye.

Fig. 15.34. Effect of vernalization and photoperiods on Henbane.

Presence of floral hormone :

It is believed that the perception of the cold stimulus results in the formation of a floral hormone which is transmitted to otherparts of the plants. This floral hormone has been names as **vernalin,** but it has not been isolated. Even the cold stimulus may be transmitted to another plant across a grafts union. For example, if a vernalized henbane plant is grafted to an unvernalized henbane plant, the unvernalized plant also flower.

Other conditions necessary for vernalization :

1. **Age of the plant:** The age at which a plant is sensitive to vernalization is quite different in different species.
2. **Appropriate low temperature and duration of the exposure :** The most effective temperature for vernalization ranges between 0^{0} c to 6^{0}c . The effectiveness of low temperature treatment decreases from 0^{0}c to -4^{0} c low temperature at about -6^{0} c is totally ineffective. Similarly at higher temperature   from 7^{0} c onwards the response of the plants is decreased. Temperature at about 12^{0} c to 14^{0} c are almost ineffective in vernalizing the plants.
3. **Oxygen :** The vernalization is an aerobic process and requires metabolic energy. In absence of oxygen the cold treatment remain completely ineffective.
4. **Sugar :** Culturing embryo on various media, it has been demonstrated that cold treatments on media without added sugar are not successful.
5. **Water :** Sufficent amount of water is also needed for vernalization. Vernalization of dry seeds is not possible.

Mechanism of Vernilization

The mechanism of vernilization is obscure. The two main hypotheical theories are given below.

1. **Phasic Development Theory**

The main points of this theory which was advanced by Lysenko 1934 are as follow:-

a. The growth(increase in size) and development(the progressive change in the characteristic of new organs) are two distinct phenomenon.
b. The process of development of an annual seed plant consists of a series of phases which must occur in some predetermined sequence.
c. Commencement of any of these phases will takeplace only when the preceding phase has been completed.
d. The phases require different external conditions for the completion such as light and temperature.
e. Vernilization accelerates the thermophases i.e. that phase of development which is dependent upon temperature.

Thus, in winter wheat variety low temperature is required for the completion of the thermophase. After this the next phase which is dependent upon light (photophase) start. Vernilization of winter wheat accelerates the first thermophase so that there is an early swing from vegetative to the reproductive phase or flowering.

2. Hormonal Theory

Vernalization probably involves the formation of a floral hormone called as vernalin. This theory is given by Lang and Melchers(1947).

D higher temp.

↑ Normal temp.

A⟶ cold B⟶ C⟶**vernalin** Flowering

According to this scheme, the precursor A is converted into a thermolabile compound B during cold treatment. Under normal conditions B changes into C which ultimately causes flowering. But at higher temp. B is converted into D and flowering does not take place.(devernilization)

Devernalization :

The effect of low temperature treatment for flowering can be nullified if the plants are immediately given high tempertature treatment. This phenomenon is known as devernilization. During devernilization the product formed during low temperature treatment, is destroyed before it is converted to stable form. The devernalized plants can be vernalized again by subsequent cold treatments.

Significance

1. Vernilization shortens the vegetative period of the plants.

2. Vernilization increases the cold resistance of the plants.
3. Vernilization increases the resistance of plants to fungal diseases.
4. It helps in crop improvement.
5. By vernilization winter varieties of crop plants can be converted into spring varaities.

4.4 Stress physiology

Concept: The basic **concepts** of **plant stress**, acclimation, and adaptation. Energy is an absolute requirement for the maintenance of structural organization over the lifetime of the organism. Abiotic **stress** is a physical (e.g., light, temperature) or chemical insult that the environment may impose on a **plant.** The environmental factor like moisture, temperature, salinity, radiations, air pollution etc. , may as stresses causing injury and death of the plant. Though the plants are well adopted to the stress causing of the environment might be damaged due to reversible or irreversible strains caused by them.

The study of functioning of plants under these stresses or adverse environmental conditions is called as stress physiology. Stress is usually defined as an external environmental factor that exist in environmental influence on the plant.

The concept of stress is closely related with stress tolerance i.e. the plant ability to strive in adverse environment. Degree of tolerance differs with different plant species. Tolerance differ from avoidance. In avoidance, the impact of environmental stress can be reduced. For example plant growing in desert might avoid dry soil by penetrating its roots deep to the water table, while in tolerance the plant just tolerates the adverse condition.

Stresses in adverse soil and other climatic condition may reduce the yield of crops and limit the distribution of plants.

Types of stress

1. Moisture stress:

   Shortage of water results in drought injury while excess of water causes flooding injury. Excess of water results in lack of aeration. The oxygen deficiency affect the all energy consuming processes of the plants. Flooding of water results in lack of growth of the roots and therefore in absence of root hairs, the absorption of water stops and the plant get wilted.

2. Temperature Stress

Plant shows cold and heat injury. The cold injury is of three types.

a. Desiccation
b. Chilling injury
c. Freezing injury

The freezing injury damages the plant irreversibly. High temperature causes coagulation of proteins and causes disorders in protoplasmic structure.

3. Radiation stress

In very high quantity visible light is injurious to the plants. At very high light intensity the atmosphere oxygen oxidizes the entire cell apparatus in to carbon dioxide. This is known as solarization or photo oxidation. Infra-red light causes heat injury. Ultra violet radiation is negligible except in New Zealand due to hole in ozone layer over the Antarctica.

4. Salt stress

The halophytes have xeromorphic characters because of physiological dryness which is caused by excess of salt present in the sea water.

5. Gas stress

The air pollutants are one of the most injurious stress causing strains on the plants. The foliage is badly affected by toxic gases like SO_2 , ozone and PAN.

6. Water stress (Water Deficit and Drought Resistance)

Water deficit is one of the most common environmental stresses encountered by plants during certain periods of the year. Prolonged drought periods and scanty or erratic rainfall causes damage to crop plants.

On the basis of their response to available water, the plants are classified into three categories.

i) Hydrophytes : Hydrophytes are plants growing at a place where there is abundant supply of water i.e. in water or in soils which practically remain saturated with available water throughout the year.
ii) Xerophytes : These are the plants of xeric habitat, where water is scarce at most of the time.
iii) Mesophytes : The plants growing at places where water availability is intermediate.

A. Water deficit and drought resistance in xerophytes

Xerophytes are basically drought resistance. Their protoplasm tolerate extreme desiccation or dehydration without being killed. They bear morphological and physiological characteristics to avoid or postpone lethal level of desiccation.

a.) Desiccation Tolerance : The protoplasm of some xerophytic plants like mosses, lichens, few ferns and some seeds plants can tolerate extreme water stress without being killed. These plants are recognized as desiccation tolerance. The degree of decication tolerance may differ among various species of grasses, shrubs and trees.

b) Desiccation Avoidance or Postponement : Desiccation avoidance may be achieved by various ways.

i) **Drought escapers**: Many annual plants escape drought by copleting their life cycles before severe water stress develops. Seeds of these plants remain dormant during desiccation. These seeds germinate, grow and flower within a few weeks after the rains have wetted the soil.

ii) **Water Spenders :** Some plants develop roots that go deep down to the water table aggressively consume water and avoid drought. Such plants are known as water spenders and infact they never face water deficit.

iii)**Water collectors** : Some of the succulent plant like cacti resist drought by storing water in their succulent tissue. These plant which use water conservatively are known as water collectors. Due to presences of thick cuticle and stomata closure during day time, the loss of water is lesser so that can survive long in dry periods.

iv)**Water savers** : Some nonsucculent xerophytic plants have develop some adaptation to minimize rate of transpiration such as smaller laminar area, sunken stomata, thick hairy covering on surface of leaves and shading of leaves during dry periods such plants are known as water savers.

v)**Osmotic adjustment :** In most of the xerophytes because of water stress certain organic compounds like amino acids, proline and sugar alcohol etc accumulates in the cytoplasm of cells. These substances lower the osmotic potential and also the water potential of cells without damaging enzyme functions. This lowering in osmotic potential helps in maintaining water balance known as osmotic adjustment.

B) Water deficit and drought resistance in mesophytes:

Prolonged drought and scanty rainfall cause wide spread damage tocrop plants all over the world. To cope with this problem, regular irrigation becomes necessary that requires large amount of money.

Some responses shown by the plants have been describe below which helps in resisting the water stress.

1. Decreased cellular Growth and leaf Areas : One of the earliest responses of plants to water tress is lowered cell trugor that results in decreased cellular growth or cell enlargement. As there is remarkable decrease in leaf ares also that transpires less water and is supposed to be first line of defense against drought.
2. Inhibition of protochlorophyll formation and enzyme activities: Increase in water stress causes inhibition of protochlorophyll formation in many plants. The activities of certain enzymes such as nitrate reductase and others dreases. Nitrogen fixation and reduction decreases.. Cell division is also inhibited with water stress.
3. Accumulation of ABA and stomata closure : In water stressed plants increase in level of abscisic acid (phytohormone) in leaf tissue causes closure of stomata. It reduced rate of transpiration, thus it helps resisting water stress. To some extent abscisic acid is also known to accumulate in roots where it increases conduction of water thereby reducing water stress in shoots.
4. Stimulation of leaf abscission : Enhanced synthesis of phytochrome ethylene is known to initiates abscission of leaves in water stress plants.
5. Accumulation of compatible solutes : At relatively mild water stresses organic compound like proline, glycine, betaine and sugar alcohol sorbitol accumulate rapidly in cytoplasm.
6. Decreased photosynthesis, Translocation of Assimilates and Respiration : At higher water stress photosynthesis, translocation of organic solutes in phloem and respiration are inhibited. When water stress is not served and the plant has not been wilted permanently, water stress can be recovered on watering the plants. But the growth and yield of water stress plants is always lower than unstressed plant.

Salt stress and salt resistance :

Salt stress : Plants growing near the seashore and estuaries having higher salt concentratios in the soil. Accumulation of salts in the soil from irrigation water is much more problematic in agriculture. About one third of irrigated land on Earth is affected by salt stress. $Na^{+}CL^{-}$, HCO_3, K^+, Ca $^{2+}$, mg $^{2+}$ and $So_4{}^{2+}$ ions usually contribute to the soil salinity. High concentration of salts are toxic to salt sensitive plants.

The plants are grouped into two categories on the basis of their response to high concentration of salts in the soil.

Halophytes and Non halophytes

Halophytes are native to saline soils where they can grow satisfactorily compete with other species in the same habitat and complete their life cycles. Non halophytes are plants which cannot resist salt to the same degree as halophytes and shows signs of growth inhibition, leaf discoloration and loss of dry weight.

The halophytes which can resists a wide range of salt concentrations are called as euryhaline and those with narrow range of resistance are called as stenohaline.

Salt injury : Higher concentration of salts in the cell sap may affect water relations and metabolism of plants. It reduces activities of some enzymes leading to decreased metabolic rate. Accumulation of chloride ions reduces water absorption and transpiration structure and function of cytoplasm such as leaf edge burns, necrotic spots on the leaves and bleaching of chlorophyll.

Salt resistance :

The plants cope with salt stress or salinity in various ways.

a. Some plants can avoid salinity.

b.Some evade salinity.

c. Few other tolerate it.

a. **Salt avoidance**: This is carry out i) limiting germination ii) growth and reproduction to specific seasons during the year. Iii) by growing roots into non-saline regions and iv) by limiting uptake of salts.

b. Salt evasion: There is an accumulation of salts in specific cells of the plant.

c. Salt **tolerance**: Salt tolerance varies among different organs of the same plant, among tissues and among different stages of development of plants. Various crop plants such as maize, peas, beans, onion, citrus,lettuce etc. are sensitive to salts. Cotton and barley are moderately salt tolerant while sugarbeet and datepalms are salt tolerant species.

Question Bank

i. Fill in the blank:

1. The response of plants to the photoperiod expressed in the form of flowering is known as **photoperiodism.**
2. In **short day** plants the inhibitory effect of red light on flowering during critical dark period can be overcome by far red light.
3. Geotropic movements occur in response to the **Gravity** stimulus.
4. The movement of stem towards light is known as **phototropic** movements.
5. The induction of flowering in plants by cold temperature treatments is called as **vernilization.**

B. Multiple Choice Questions

1. The substance related phototropism in the shoot is

1. Ehanol b) Cytokinin **c) Auxin** d) Gibberellin

2. Some flowers open during the day time and close at night. This is known as

a) Phototaxy b) phototropism c)photoperiodism **d) photonasty**

3. Which of following induces flowering in long day plants ?

a) **Gibberellins** b) Cytokinin c) Auxin d) Ethylene

4. Thigmotropism is best exemplified by

a) Root apex b) Thorns **c) Tendrils** d) Lamina

5. Touch induced closure of leaflets in Mimosa pudica is the case of

a) Thigtropism b) Phototropism c) Thermotropism **d) Siesmonasty**

6. Which hormones promote flowering in long day plants and also control sex expression. ?

a) Cytokinin **b) Gibberellins** c) Ethylene d) Auxin

7. Hormone responsible for preventing seeds during drought is

a) IAA b) NAA c) IBA **d) ABA**

8. The closing and opening of leaves of Mimosa pudica is due to.

a) Thermonastic movements b) Hydrotropic movements **c) Seismonastic movements** d) Chemonastic movements

9. Thigmotropism is the response of the plant to

a) Gravity b) Water c) Light **d) Contact**

10. The plants responsed to photoperiods due to the presence of

a) **Phytochrome** b) Stomata c) Enzyme d) Phytohormone

11. Vernilization is done at

a) **Low temperature** b) Low light intensity c) High temperature d) High light intensity

12. The photoperiodic stimulus is perceived by

a) **Leaves** b) Flowers c) Buds d) Meristem

13. In plants, the induction of flowering , by low temperature treatment is called

a) Peuning b) Cryobiology **c) Vernalization** d) Photoperiodism

14. Phenomenon of photoperidism was first discovered by

a) **Garner and Allard** b) Borth Wick and Hendricks.

c) Filint and Mc Alister d) None of the above

15. Dark period is critical in

a) **Short day plant** b) Long day plant c) Day neutral plant d) All of the above

16. Which of the following is supposed to be precursor for Florigen.

a) Auxin **b) Gibberllin** c) Cytokinin d) All of the above

17. The term vernilization was coined by

a) Gessner **b) Lysenko** c) Chourd d) Lang and Melchers

18. In vernilization the cold stimulus is perceived by

a) Lateral meristem b) Intercalary meristem **c) Apical meristem**

d) All of the above

19. ABA is known to play important role in

a) Phototropism **b) Geotropism** c) Hydrotropism d) All of the above

C. Answer in one Sentences :

1. Give the name of flowering hormone.
2. Who used the term vernilization for a low temperature treatment for promotion of flowering in plants?.
3. Which part of the plant perceives light for flowering.
4. What is vernalin.
5. What is photoperiodism.
6. What is stress physiology.
7. What is vernilization.

Short Answer Question

1. Give an account of photoperiodism.
2. What is photoperiodism? Dicussus the phenomenon with reference to short day plant.
3. Give the significance of vernilization.
4. Describe the Geotropic movements.
5. Describe the concept of florigen.
6. Describe the long Day plants.
7. Describe the Salinity stress.
8. Describe phototropic movements.

9. Explain Seismonastic movements.
10. Explain Day neutral plants.
11. Explain water stress.
12. Explain the role of phytochrome.

Long Answer question

1. What is phytochrome? Describe its role in flowering.
2. What is vernilization? Give practical uses of vernilization.
3. Write a brief account of vernalization. Add a note on its significance.
4. Give a brief account of phototropic movements in plants.
5. Give a brief account of geotropic movements in plants.
6. Write a essay on Nastic movements in plants.
7. What is stress ? Give a detail account of water stress in plants.
8. What is stress ? Give a detail account of salinity stress in plants.

Mahatma Fule Arts, Commerce & Sitaramji Choudhari Science Mahavidyalaya Warud, Dist: Amravati

Class Test

Subject: Botany, Class: B.Sc – I (Semester – I)

Maximum Marks: 30 **Time: 1 Hr.**

Date:

Name: ---Roll. No---------

(Note: All questions are necessary, Draw well labelled diagram wherever necessary)

Q.1: Fill in the Blanks. (1 mark each)

1. Pteridophytes are called -----------------------------
2. TMV Causes disease to ------------------ plants.
3. Bacteria which prepared their own food using light called
4. Phycocyanin is ------------------------------- pigments.
5. Dwarf male in *Oedogonium* is called---------------------------
6. Unicellular multinucleated algae is called-------------------------------------

7. The disease cause by *Albugo* is-------------------------------
8. Fungus show-------------------------------------nutrition
9. Bryophytes lack ---------------------------------------tissue
10. ---------------------cup is present in *Marchantia* thallus

Q.2: Choose correct alternatives (1 mark each)

A. Protein coat in virus enclosing nucleus is called
1. Vector 2. Capsid 3.Plasmids 4.Genome

B. *Albugo* belongs to class
1. Ascomycetes 2.Besidiomycetes 3.Myxomycetes 4.Oomycetes

C. Aplanospores is
1. Motile spore 2.Non motile spore 3.Flagelleted 4. Non of above

D. For growth Viruses requires
1. Living material 2.Bacteria 3. Plants 4.Animal

E. Cap formation is feature of
1. *Oedogonium* 2.*Bactrachospermum* 3.*Sargassum* 4.*Chara*

F. Tuberculate rhizods are presents in
1. *Funaria 2.Anthoceros 3.Marchantia* 4.Non of above

G. Spore producing organ in *Marsilea* is
1. Capsule 2.Strobilus 3.Tuber 4.Sporocarp

H. HIV causes disease
1. Asthma 2. AIDS 3. Cancer 4.T.B.

I. *Equisetum* belongs to class
1. Lycopsida 2.Filicipsida 3.Pteropsida 4.Spenopsida

J. Circinate vernation is found in leaf of plants
1. *Marselia* 2.*Euisetum* 3.*Marchantia* 4.*Psilotum*

Q.3.Define: (1 mark each)

1.Bacteria:--

2.Cryptogams:---

3.Thallus:---

4.Autotrophs:--

Q.4.Draw well leballed diagrams of: 1. TMV **2.** *Oedogonium* thallus **(2x3)**

MAHATMA FULE ARTS, COMMERCE AND SITARAMJI CHOUDHARI SCIENCE MAHAVIDYALAY WARUD

Class Test Examination

B.Sc. – I (SEM – II)

Gymnosperms, Morphology of Angiosprerms, and Utilization

Time: One Hour **(Maximum Marks: 30)**

Date:

Q. A: Fill in the blanks.(Each que carry 1 Marks)

1. *Lyginopteris oldhamia* is the name of --------------------
2. Father of Indian palaeobotany is --------------------------
3. Cycadeoidea is also called as -------------------------------
4. Botanical name of blue pine is --------------------------------
5. Development of many embryo from single zygote is called ---------------------
6. In gymnosperms leaves have ---------------------------stomata.
7. Seed of Lyginopteris is called -------------------------------
8. Common example of conical root is ----------------------------
9. --------------------is the modification of underground stem
10. In Coriander the type of inflorescence is -----------------------------

Q.B. Choose correct alternative (Each que carry 1 Marks)

1. The following era is called age of ferns.
 a.Proterozoic b.Archeozoic c.Paleozoic d.Mesozoic

2. Sphenopteris is the name of organ in Lyginopteris
 a. Stem b. Root c.Leaves d. Ovules

3. Fossil in which entire shape is clearly visible on rock called
 a. Impression b.Petrifaction c. Amber d. Cast

4. Remains of plants & animal life in geological past called
 a. Compression b. Fossil c. Era d. epoch

5. Endopserms in gymnosperm is
 a. Haploid b. Diploid c. Triploid d.Tetraploid

6. Manoxylic wood refer to
 a. Cortex b. heart wood c.Soft wood d. Pith

7. Tap root system commonly found in
 a. Dicot b. Monocot c. Bryophytes d. Algae

8. Root which develop from any part of plants other than radical
 a. Tap root b. Adventitious c. Aerial d. None of these

9. In Pea placentation is
 a. Parietal b. Marginal c. Axile d. Central

10. Stamens is equivalent to
 a. Megasporophyll b. Microsporophyll c. Ovule d.Placentation

Q.C. Define following (Each que carry 1 Marks)

1. What is Palaeobotany? --

----

2. Define Gymnosperms ---

3.Give the function of leaf --

4.Placentation --

----

5. What is flower? ---

Q. D. Describe types of fossil. 5 marks. ---

Mahatma Fule Arts, Commerce & Sitaramji Choudhari Science Mahavidyalaya Warud, Dist: Amravati

Unit Test

Subject: Botany, Class: B.Sc – II (Semester – III)

Maximum Marks: 30 **Time: 1 Hr.**

Date:

Name: ---Roll. No---------

(Note: All questions are necessary, Draw well labelled diagram wherever necessary)

Q.1: Fill in the Blanks. (1 mark each)

1. In *Coriandrum* type of inflorescence is -------------------------.
2. Bentham and Hooker’s system of classification is a ------------------ system.
3. Old name of family Brassicaceae is ------------------------.
4. In India, Royal Botanical Garden is located at------------------------------.
5. --------------------------- is a biodiversity hotspot in India.
6. The outermost layer of the root is called------------------------------.
7. ------------------------------ is a conducting tissue in higher plants.
8. Obliquely placed ovary is a characteristic of family -------------------------------------.
9. Rubber is obtained from a plant of family --------------------------------.

10. Nutritive tissue in anther is called as --------------------.

Q.2: Choose correct alternatives (1 mark each)

A. Which of the following is a meristematic tissue

1. Parenchyma 2. Xylem 3. Cambium 4. Phloem

B. Engler and Prantle's system of classification is

1. Natural 2. Artificial 3. Phyllogenetic 4. None of these

C. Lomentum is a characteristic fruit of

1. Kanher 2. Jaswand 3. Mohari 4. Babhul

D. Which of the following tissue provide strength to the plant body.

1. Collenchyma 2. Sclerenchyma 3. Fibres 4. All of these

E. Epicalyx is a characteristic of family

1. Apiaceae 2. Malvaceae 3. Euphorbiaceae 4. Apocynaceae

F. Which of the following is a largest family of Angiosperms

1. Asteraceae 2. Solanaceae 3. Verbenaceae 4. Poaceae

G. Which of the following is a type of primary meristem

1. Apical meristem 2. Intercalary meristem 3. Lateral meristem 4. All of these

H. Potato, tomato, red paper and brinjal belongs to family

1. Leguminosae 2. Liliaceae 3. Asclepiadaceae 4. None of these

I. In which type of ovule micropyler end and chalazal end lie in straight line.

1. Anatropus ovule 2. Campylotropus ovule 3. Orthotropus ovule 4. None.

J. Development of megaspore is called

1. Megasporogenesis 2. Embryosac 3. Microsporogenesis 4. Endosperm

Q. 3. Define: (1 mark each)

1. Tissue --

----

2. Stylopodium --
----

3. Herbarium:--
----

4. Biodiversity:--

Q.4.Draw well labeled diagrams of: **1.** Pollinia **2.** T. S. Anther **(2x3)**

(Note: Use backside of this paper for diagrams)

Mahatma Fule Arts, Commerce and Sitaramji Chaudhari Science Mahavidyalaya, Warud, Dist. Amravati.

B. Sc. II Sem- IV (Botany), Unit Test

Marks: 30 Time: 40 min.

1. In chloroplast, light reaction occurs in ------------------region and dark reaction occurs in --------------- ---region.
2. Mitosis occur in- a) Germ line cells b) Somatic cells c) Both a & b d) None.
3. Crossing over occur in- a) Diakinesis b) Leptotene c) Pachytene d) All of these.
4. ------------------------------ is the site of protein synthesis in cytoplasm.
5. Phagocytosis is the function of – a) Ribosomes b) Endoplasmic reticulum c) Golgi Complex d) None.
6. Middle lamella, in cell wall of the cell, is made up of --------------------------------------.
7. What is linkage?---
----
8. What is mutagen?---
----
9. The unit of mutation is- a) Codon b) Mutagen c) Muton d) Cistron.
10. What is cell?
----
11. The correct sequence of phages in cell cycle is-a) G_1- G_2- S-M phages b) G_2- G_1- S-M phages
c) G_1- G_2- M-S phages d) G_1- S- G_2-M phages.
12. During cell division, the spindle fibers attached with ------------------------ of the chromosome.
13. The chromosome is made up of – a) Proteins b) DNA & proteins c) RNA & proteins d) All of these.
14. What is the significance of Linkage?---
----
15. Which of the following have bacterial origin- a) Cp-DNA b)Mt-DNA c) Both a & b d) None.
16. Which of the following is a non-ionizing radiation- a) α-ray b) β-ray c) UV-ray d) cosmic ray.
17. Why crossing over is so important in plant breeding programme?
----
18. A process in which a chromosome segment is detached and joined with non-homologous chromosome is called- a) Translocation b) Inversion c) Duplication d) Deletion.
19. What is rough ER?---
----
20. Who proposed "Chromosome theory of Inheritance"?
----
21. What is gene?--
----
22. The term "Genetics" was coined by ---------------------------.
23. In incomplete dominance, one could get 1:2:1 ratio in- a) Test cross b) F_2 generation c) F_1 generation d) R-cross.
24. Complete dominance is absent in –a) *Pisum sativum* b) *Mirabilis jalapa* c) *Lathyrus* d) *Oenothera*.
25. Define Co-dominance.---
----
26. What is complementary gene?--
----

27. What is polyploidy?---
----- ---

28. Genes are located on -------------------------------- like beads in a necklace.

29. The haploid set of chromosomes is known as ----------------------------.

30. What is pericentric inversion?---

B.Sc. III SEM V Unit Test Examination

Botany (Plant Physiology and Ecology)

Time 1.30Hrs. **Max. Marks. 30**

Q. 1. A) Fill in the blacks.

1 The First Stable Compound in C3 cycle is…………………. ½ marks

2 The …………… harmone was first time extracted from fungus Gibbrella Fujikuroi ½ marks

3 The Movement that take place in response to light is called ……………. Movement ½ marks

4 …………. And abiotic components are the main part of ecosystem. ½ marks

5 Highest rate of transpiration take place through……………of the leaves . ½ marks

6 ……….. is photosynthetic cell organelles. ½ marks

7 The percentage of Nitrogen in atmosphere is approximately………….. ½ marks

8 Hydrilla show……………………….. adaptation. ½ marks

9 Gutttation take place through the………………………….. ½ marks

10 The enzymes required for Kreb’s cycle are found in……….. part of mitochondria . ½ marks

11 The movement of stem toward light is known is ………… movement. ½ marks

12 Percentage of oxygen is……………. In atmosphere. ½ marks

13 Swelling of dry seed in water is the processs of……………… ½ marks

14 ………………… movement found in Mimosa pudica. ½ marks

15 Power house of cell is known as…………………………… ½ marks

16 Nymphea and Hydrilla shows……………… ecological adaptations. ½ marks

17 Loss of water from aerial parts of plants in the form of water vapour is called as…………………………………. ½ marks

18 Dark reaction in photosynthesis takes place in region of chloroplast. ½ marks

19 Geotropic movement occur in response to the …………… stimulus. ½ marks

20 CO_2 acceptor in calvin cycle ic…………………………. ½ marks

MCQ

1 Guttation takes place through …………….. ½ marks

a) Hydathode b) Stomata c) Lentcel d) Cuticle

2 CAM pathway was first reported in family ½ marks

a) orchidaceae b) cactaceae c) Crassulaceae d) Verbenaceae

3 Nymphaea, Trapa, Nelumbo show ecological adaptations ½ marks

a) Epiphytic b) Mesophytic c) Xerophytic d) Hydrophytic

4 The Phenomenon of Phtoperiodism was discovered by ½ marks

a) Brain b) Garner and Allard c) Wetlensiek d) Melvin Calvin

5 Green plant are ½ marks

a) Producers b) Primary consumers c) Secondary consumers d) Decompose

6 Avena Coleoptile test was conducted by ½ marks

a) Drawin b) N. Smit c) Paal d) F. W. Went

7 Photolysis of water is associated with ½ marks

a) PS I b) PS II c) Cy. B d) Quinone.

8 Process of water exudation through hydathodes is called ½ marks

a) Guttation b) Transpiration c) Excretion d) Hydrolysis

9 The end product of Glycolysis is ½ marks

a) Acetyl Co-A b) Citic acid c) Pyruvic acid d) $CO_2 + H_2O$

10 Symbiontic nitrogen fixing bacteria in leguminoceae is………….. ½ marks

a) Clostridium b) Rhizobium c) Azotobacter d) Azospirillum

11 Soil is ½ marks

a) Climatic factor b) Biotic factor c) Edaphic factor d) Adiotic factor

12 Presence of aerenchyma is the characteristic of ………………………… ½ marks

a) Hydrophytes b) Xerophytes

c) Mesophytes d) Halophytes

13 Plant absorbs nitrogen in the form of………………………… ½ marks

a) Nitrate b) Nitrite c) Ammonia d) Nitrogen

14 R. Q. of Carbohydrate is…………………… ½ marks

a) less than one b) Infinity c) More than one d) one

15 Kreb Cycle takes place in ………… ½ marks

a) Cytoplasm b) Chloroplast c) Matrix of Mitochondria d) Endoplasmic reticulum

16 Response of plant to cold temperature treatment expressed in the form of flowering is called as ½ marks

a) Phtotoperidism b) Vernalization c) Phtotropism d) Geotropism

17 Producers in the Ecosystem are…………………………. ½ marks

a) Animals b) Microbes c) Plants d) All of the above.

18 Fruit ripening harmone is………………….. ½ marks

a) Ethylene b) Auxine c) Cytokinin d) ABA

19 ………………………… is sdaphic ecological factor. ½ marks

a) Soil b) Light c) Temperature d) water

20 The final product of glycolysis is………………………. ½ marks

a) Pyruvic acid b) Oxalic acid c) Fumaric acid d) Malic acid

Answer in one Sentence

1 Define Osmosis. 1Marks

2 What is Respiratory quotient? 1Marks

3 Define Geotropism 1Marks

4 What is Natality ? 1Marks.

5 What is Kranz anatomy ? 1Marks

6 Define anti transpirants ? 1Marks

7. What is pedogenesis. ? 1Marks

8. Define phtoperiodism. 1Marks

9. Define vernalization ? 1Marks

10. What are xerophytes? 1Marks