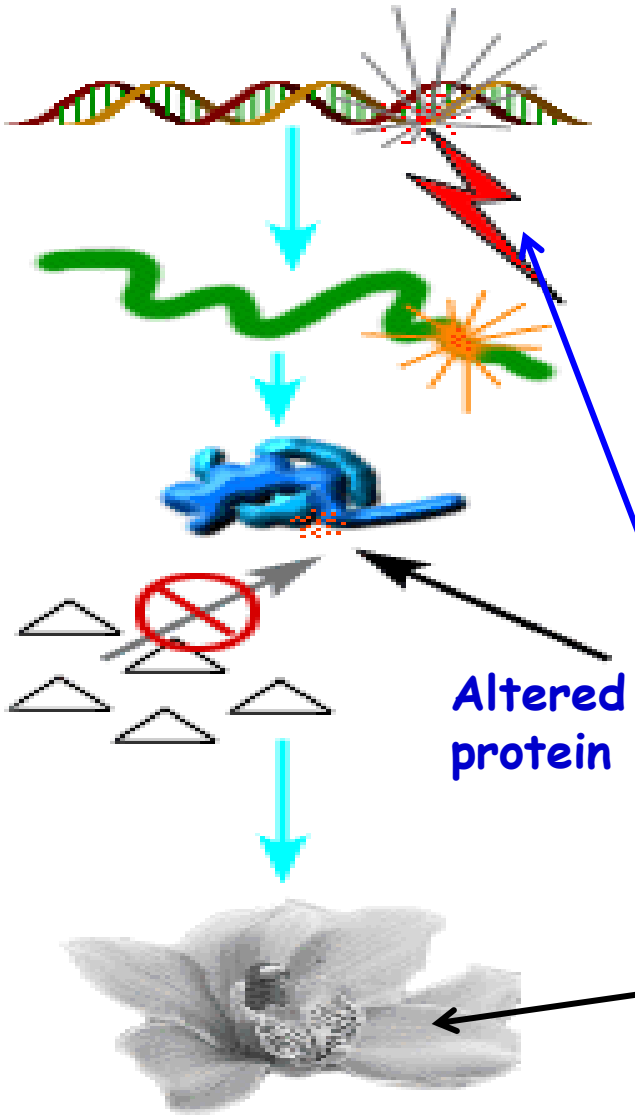
Centurion University

Mutation breeding-methods and uses

Dr. Prabhat Kr. Singh

Assistant Professor,
Department of Genetics and Plant Breeding
MSSSoA, CUTM, Paralakhemundi, Odisha, India

Definitions



- In broad sense mutation is sudden heritable change in genetic material, that is not due to recombination and segregation.
- **It includes chromosomal aberration as well as change in individual gene or even a base pair.**
- **In molecular biology and genetics, mutations are changes in individual gene.**
- **Mutagen:** Any substance that can bring about the mutation.
- **Mutant:** The organism exhibiting a novel phenotype as a result of mutation.

Historical Background

- Derived from the latin word '**MUTARE**' means to change
- Term mutation introduced by **Hugo de Veris (1900)** while studying evening primerose **(*Oenothera lamarckiana*).**
- But the earliest record of mutations dates to 1791 when Seth Wright noticed a male lamb with unusually short legs in his flock of sheep.
- Systematic studies on mutation begain in 1910 with the discovery of **white eye mutants of *Drosophola* by T. H. Morgan**.
- Mutagenic action of X-rays discovered by **H. J. mulier (1927) in Drosophola.**
- **Stadler (1929)** described the mutagenic effect of X-rays in barley.
- Mutagenic effect of mustard gas and some other chemical compound discovered by **Auerbach and Robson in 1946 in *Drosophila*.**

There are three types of mutations based on genetic basis of heritable change :

1. **Gene mutations:** These are produced by change in the **base sequence of genes**. The change may be due to base substitutions, deletion or addition.
2. **Chromosomal mutation:** These arise due to change in **chromosome number** that may leads to polyploidy or aneuploidy or change in **chromosome structure** that result in deletions duplication, inversion and translocation.
3. **Cytoplasmic or plasmagene mutation:** These are due to change in the base sequence of plasma genes. The plasma genes are present in mitochondria/chloroplast. Here the mutant character occurs in buds or somatic tissues which are used for propagation in clonal crops.

Classification of mutations

Based on origin, the mutations are classified as spontaneous and induced mutations.

1. **Spontaneous mutations:** Mutations occur in natural populations at a **low rate (10-6)** but different genes may show different mutation rates. For example : in maize **R-locus** mutates at the frequency of 4.92 x 10-4 i.e. (1 in 20000 population), whereas **Su locus** at 2.4 x 10-6 (1 in 25 lakhs). The **Wx locus** considered to be highly stable. The difference in mutation rate may be due to (a) Genetic back ground i.e. presence of mutator genes (b) Genes them selves (c) Environment.

2. **Induced mutation:** Mutations may be artificially induced by treatment with certain physical or chemical agents. Induced mutations are comparable to spontaneous mutations in their effects and in the variability they produce. Induced mutation occur at a relatively higher frequency so that it is practical to work with them.

Based on magnitude of phenotypic effects mutation as classified as

1. **Macro mutations:** **Oligogenic Mutation** – Large phenotypic effect and recognizable on individual plant basis and can be seen easily in M2 generations – E.g. Ancon breed in sheep, pod maize to cob maize

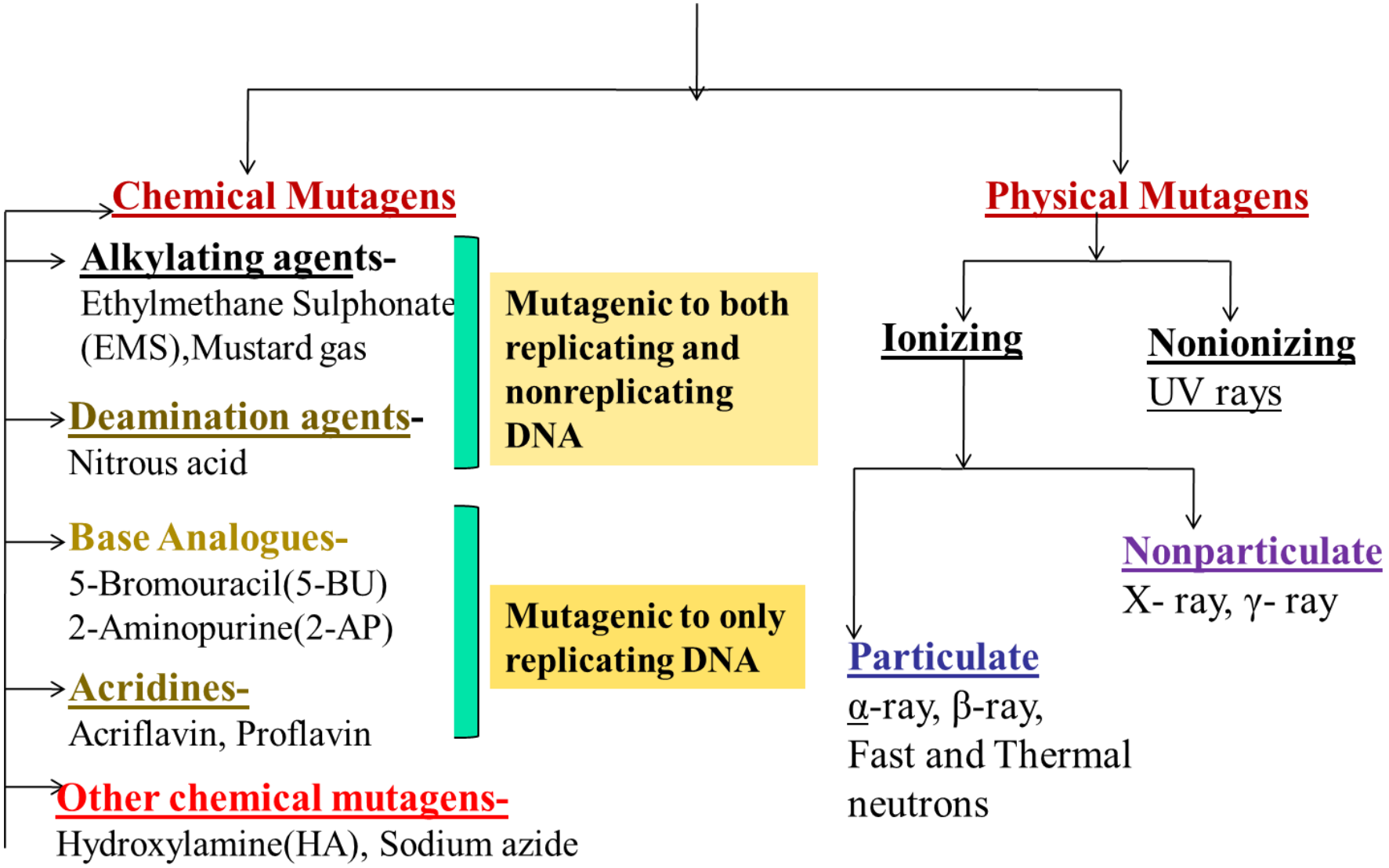
2. **Micro mutations:** **Polygenic mutations** – Small phenotypic effect which can not be recognized on individual plant basis but can be recognize only in a group of plants. Selection should be done in M3 or later generations.

Characteristics of mutation

1) Mutations are mostly **recessive** and very rarely dominant e.g. epiloia in human, *Notch* wing in *Drosophila* etc.
2) Most mutations have **harmful effects** and very few (less than 0.1 %) are beneficial.
3) Mutations are **random event** in term of time of their occurrence and the gene in which they occur.
4) If gene mutations are not lethal, the mutant individuals may survive. However, chromosomal mutations are generally lethal and such mutants do not survive.
5) If mutation occur at both loci simultaneously, the mutants can be **identified in M_1 generation**. However, if it is restricted to one locus only, (dominant to recessive) the effect can be seen only **in M_2 generation**.

6) Many of the mutants **show sterility**.
7) Mutations are random i.e. they can occur in any tissue or cell of an organism. However, some genes show higher mutation rate than others.
8) Mutations are **recurrent** i.e. the same mutation may occur again and again.
9) Induced mutations commonly show **pleiotropy** often due to mutation in closely linked genes.
10) Mutations occur in both **forward** (from wild type allele to mutant allele) and **reverse** (from mutant allele to wild type allele) direction. Generally, the rate of forward mutations are much higher than those for reverse mutations

Mutagens


Chemical Mutagens
Alkylating agents-
Ethylmethane Sulphonate (EMS),Mustard gas
Deamination agents-
Nitrous acid
Base Analogues-
5-Bromouracil(5-BU)
2-Aminopurine(2-AP)
Acridines-
Acriflavin, Proflavin
Other chemical mutagens-
Hydroxylamine(HA), Sodium azide
Mutagenic to both replicating and nonreplicating DNA
Mutagenic to only replicating DNA
Physical Mutagens
Ionizing
Nonionizing
UV rays
Nonparticulate
X- ray, γ- ray
Particulate
α-ray, β-ray,
Fast and Thermal neutrons

Mutation Breeding

- Treating a biological material with a mutagen in order to induce mutations is known as **mutagenesis.**
- Exposure of a biological material to a radiation like X-rays, gamma- rays, etc. is known as **irradiation.**
- When mutations are induced for crop improvement, the entire operation of the induction and isolation, etc. of mutants is termed as **mutation breeding**.
- Commonly used in self-pollinated & asexually propagated species while, rarely used in cross pollinated species
- A mutation breeding programme should be clearly planned and should be large enough with sufficient facilities to permit an effective screening of large populations.

Situations that favorable for mutation breeding/ Applications of Mutation Breeding

1. **When desirable variability is not found** in the cultivated species or in the germplasm of cultivated species .
2. When high yielding variety **has oligogenic defect** such as susceptibility to disease.
3. When there is a **tight linkage** between desirable and undesirable characters.
4. **When particular reaction is to be blocked**. For e.g. Opium, synthesis of morphine by blocking the biochemical pathway at bane level.
5. In those crop where **sexuality is absent**.
6. In those species where **generation cycle is long**, like plantation crop, fruit tree and forest tree.
7. When flower colour and foliage colour have to be developed in ornamental plant. Tuberose mutant pict..docx

The various steps involved in mutation breeding

1. **Choice of material**: Best adapted variety of a crop
2. **Choice of mutagen:** Depends upon the plant parts to be treated various Physical (most preferred for vegetative part) or chemical mutagens (most preferred for seed) are used.
3. **Mutagen treatment:** Three things considered
   a) **Plant species-** In seed propagating species generally seeds are treated and rarely pollen. In vegetatively propagated species, bulb, corm, cutting or suckers are used for mutagenic treatment.
   b) **Dose of mutagens-** Based on LD50 value. Varies from species to species.
   c) **Duration of treatment-** Depends on the intensity of radiation or concentration of chemical mutagen.
4. **Handling of treated material:** Differ in seed propagated species (oligogenic and polygenic traits) and vegetatively propagated species.

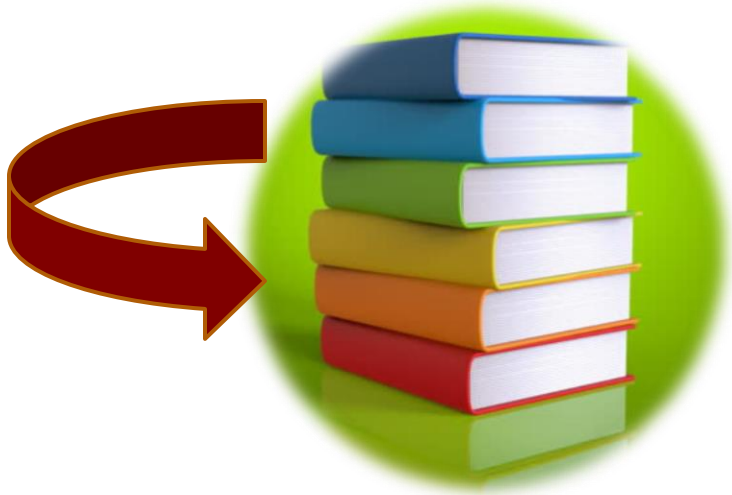
Procedure for irradiation

The plant material may be treated in any of the following source.

1. **Seeds:** Seeds are used after soaking to get greater frequency of induced mutations than air dried.
2. **Seedlings:** At any stage of life cycle can be subjected to radiation but usually seedlings neither too young nor too old are irradiated due to their convenience in handling in pots transportation from nursery easily.
3. **Flowers:** Meiotic cells have been found more sensitive than the mitotic cells and therefore plants are irradiated in the flowering stage in order to affect the developing gametes.
4. **Cuttings:** In case of fruit tree when they are propagated by clones – the desirable cuttings are exposed to irradiation

1. *Mutation Breeding in seed propagating species: Oligogenic traits*
2. *Mutation Breeding in seed propagating species: Polygenic traits*
3. *Mutation Breeding in vegetatively propagating species*

For detail refers to the








Advantages

1. Mutation create inexhaustible variation.
2. When no improvement is possible this method has to be adopted.

Limitations

1. Frequency of desirable mutations is very low about 0.1 percent. To detect the desirable one in M2 considerable time, labour & other resources are to be employed.
2. To screen large population, efficient quick and inexpensive selection techniques are needed.
3. Desirable mutations may be associated with undesirable side effects due to other mutations thus extending the mutation breeding programme.
4. Detection of recessive mutations in polyploids and clones is difficult and larger doses of mutagen have to be applied and larger populations are to be grown.

Achievements

a) Natural mutants:

Rice : GFB 24 – arose as a mutant from Konamani variety
Dee – Gee – Woo –Gen – Arose as a mutant from rice in China
MTU 20 – arose as a mutant from MTU-3
Sorghum: Co. 18 – arose as a mutant from Co. 2
Cotton: DB 3-12 from G. heroaccum variety Western 1

b) Induced mutants:

Rice : Jagannath-gamma ray induced mutant from T.141
Wheat: Sarbati Sonora Gamma radiation from Sonora 64
NP 836 mutants, through irradiation from NP 709
Cotton: Indore 2 Induced from Malwa upland 4
MLU 7 gamma ray induced mutant from culture 1143 EE
MLU 10 gamma ray induced mutant from MLU 4
Mustard: Primax whicte (1950)
Summer Pope seed Regina I (1953)
Sugarcane: Co.8152 gamma ray induced mutant from Co. 527
Groundnut: NC 4
Castor: Aruna (NPH1) – Fast neutrons induced mutant from HC 6