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CHROMOSOMAL ABERRATIONS IN PLANT BIOASSAYS: A REVIEW

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ABSTRACT

Chromosomes are thread-like components found in the cell nuclei of flora and fauna. Each chromosome is made up of a single DNA molecule and a protein. The purpose of the chromosomal aberration test is to determine whether a test substance can cause architectural gene mutations, such as breaks and exchanges. The chromosomal aberrations have been accepted as an indicator of genetic damage and in particular for those alterations which ultimately lead to mutations. The structural changes in the chromosomes are the result of the breaking and reunion of chromatid segments. The breaking and the reunion cycle produces several abnormalities in the chromosome structure. *Allium cepa*, a plant species, has been utilized to assess chromosome abnormalities and mitotic cycle disruptions. Today, it is increasingly utilized in environmental monitoring since it has been used to evaluate a large number of genotoxic and antigenotoxic chemicals. Because it is inexpensive, accessible, and easier to handle than other short-term tests, the A. cepa is frequently utilized as a test organism. The detection of chromosomal abnormalities has been the endpoint most frequently utilized over the years to assess cytotoxic effects and antigenotoxicity among *A. cepa* root chromosomal aberrations. To assess the carcinogenic and mutagenic properties of various plant extracts, the *Allium cepa* chromosomal abnormality assay is frequently used.

Chromosomal aberration in human health has been studied for dates back. Chromosomal aberrations have serious consequences on human health. Many types of human cancer have been found associated with specific and non-specific chromosomal aberrations. In the present review, higher plants have been selected as a monitoring system. Chromosomal aberrations like binucleate cells, scattered metaphase (S_CM), Micronucleus (Mn), nuclear vacuolation (NV), Ring chromosomes at metaphase (RM), Stickiness of Chromosomes at metaphase (STM), Colchicine like metaphase, polarity abolition, laggard formation, Bridge at anaphase have been reported.

Keywords: *Chromosome aberration, plants, mutation, Allium cepa, Genotoxicity.*

Introduction

The thread-like structure also known as chromosomes is present in the nuclei. From one generation to the next, the chromosomes transmit the genetic material. The DNA holds the primary structural and operational elements of heredity, the genes. During cell division, the chromosomes are made up of two parallel strands, called chromatids (Farah, 2004).

Chromosome abnormalities include chromosome number and shape alterations. Chromosome mutations are another name for them. Numerous of these variants can be seen when examining chromosomes with a standard light magnifying tool. These distortions have been linked to changes, physical characteristics, and other attributes and experts have long used them as a criterion for conceptive outcomes in plants(Preston, 2014).

Chromosome aberration in a chromosome's structure can happen naturally or be induced. Genes may be quantitatively altered or rearranged as a result of such modifications. Numerous anomalies in any structure originate from the breakage & reunification of chromatid segments. Therefore, chromosomal breaks are the root cause of structural alterations. Any broken end may link to some other broken end, possibly creating new linkage configurations. A wide range of structural modifications is possible based on the number of breaks and the way that the split ends connect (Jain *et al*., 2017).

Eukaryotic cells have thread-like structures called chromosomes inside the nucleus. Histone-like proteins, which resemble spools, maintain DNA firmly wound around them thanks to the peculiar shape of chromosomes. DNA should reproduce accurately to the daughter cells for there to be continuation of live or for an organism to develop and function correctly. Cells must be split. A chromosome is important to the replication procedure. It took some time for structural & numerical variances to be understood how important they are to human health. Complex effects of chromosomal abnormalities on one or more genes include altered control of gene expression, interference with tests, and the creation of fusion genes.

Different types of chromosome aberrations:

It has been shown that chromosomes can change structurally in four different ways.

- Deletion
- Duplication
- Inversion
- Translocation

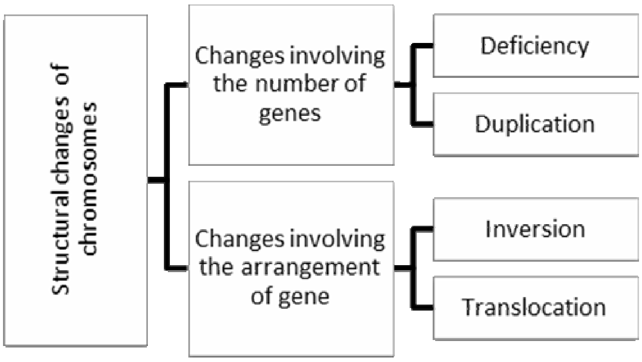

Fig. 1 : Various Structural changes in Chromosomes

The first chromosomal aberration identified by genetic evidence was a deletion, which results in a loss of chromosomal material.

Duplication refers to having more than two copies of a chromosomal section.

Reversible gene order on a chromosome is represented by inversion.

Translocation occurs when a segment of a chromosome pair occasionally separates and connects to a segment of a non-homologous chromosome. Translocations have been described in a variety of plants and have played a significant role in the evolution of species.

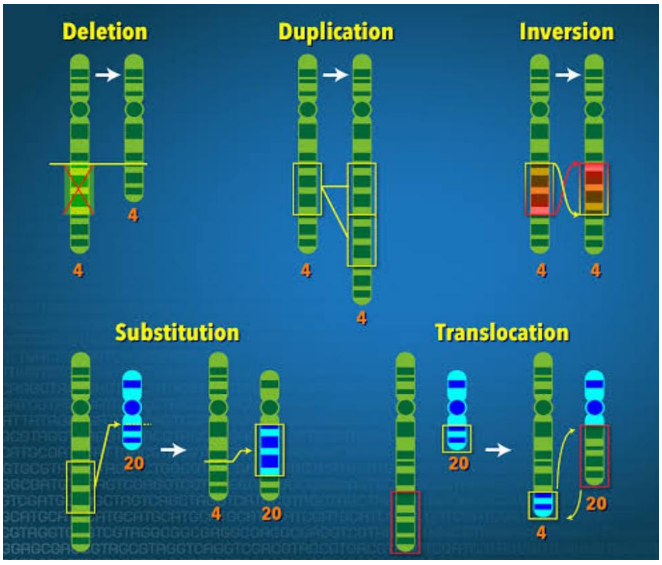

Fig. 2 : Structural Chromosomal Abnormalities

In this particular paper, we'll talk about chromosome abnormalities in several kinds of plants and crops. We will talk about the causes of the plant chromosomal problems and any current solutions that have been put forth.

Effects

In this section, we will discuss the sectors that are responsible for chromosomal aberration effect on the plants and crops

(i) Effects due to Textile industry:

The outflow of both treated and untreated industrial wastes can have a detrimental effect on the creatures that inhabit water ecosystems. Numerous hazardous chemicals are utilized in the production of textiles, and these chemicals are then emitted as wastewater.

The findings of this study suggested that such treated industrial effluents that are directly dumped into the River may contain substances that can damage exposed species' chromosomes. Even trace levels of these substances can have harmful impacts on the ecosystem. It is advised that the effluent be thoroughly cleaned to remove any traces of substances that may disrupt chromosomes before it is released into the canal (Scientists *et al*., 2020).

(ii) Effects due to Chemical Industry:

There are many hazardous substances in the environment, and most of them are released by industrial facilities into the water & air.

Globally several chemical manufacturing units have been established because of the increased use of chemicals. Both natural & artificial processes allow substances to infiltrate our environment. Once they get into our ecosystem, it becomes very difficult to get rid of them because doing so would disrupt several biochemical processes, which might be catastrophic.

(iii) Effects due to Hospital effluents:

Hospital effluents are a serious problem in developing countries and can harm living things if they are not adequately managed.

Bio-monitors, like *Allium cepa* L., which is among the most commonly employed species of plants for testing effluent carcinogenicity, were used to alert the public to environmental degradation &mutagenesis chemicals emission (Bagatini *et al*., 2009).

(iv) Effects by Fertilizers:

The use of fertilizers has risen exponentially due to recent advancements in agricultural technology. The risk that some fertilizers could harm human genetic material makes their widespread usage particularly dangerous. Over 400 substances are being utilized as insecticides. Reading through the literature indicates that, there are still many substances whose mutagenicity hasn't been determined.

In agricultural systems, synthetic fertilizers are used to amend the soil and provide the vital nutrients needed for plant growth. Magnesium sulfate is used to make nutritional solutions for in vitro techniques in addition to being a fertilizer. It has not been thoroughly explored how the application of fertilizers application affects cytological changes in the soil. Chromosome breaks and other abnormalities in onion cell divisions were caused by fertilizers such as $(NH_4)_2SO_4$, $(NH_4)_3PO_4$, (NH_4NO_3), and KCl. Urea causes cytological alterations in onions, according to other studies (Bhatta & Sakya, 2009).

Literature Review

Various crops and plants, including legumes, rye, barley, and a lot more were shown to have chromosomal abnormalities.

Around the world, grains and pulses are seen as complementary aspects of agriculture and are believed to have coevolved at the same time in a mutually beneficial manner. Because they make up a substantial portion of the agricultural food crops that are frequently consumed in undeveloped countries, pulses are an essential grain for ensuring food security and nutrition for both impoverished producers and consumers (Ights & Olice, 2002).

In Southern Italy's Campania province, samples of eight different grapes varieties and 21 treated vegetables were taken from various markets and examined for the presence of toxic substances. Using plant tests— the chromosomal abnormality check in *A. cepa* roots-the extracts were examined for pesticides by using chromatography as well as for genotoxicity. There were to be around 33 carcinogens, some of which were not authorized. Some of the examined veggies and grapes were shown to be genotoxic. Tests on the *Allium cepa* plant have shown to be accurate at detecting carcinogenicity in food components(Feretti *et al*., 2007).

According to cytological investigations on meiotic cells of barley plants produced after seed treatment, all 15 pesticides were capable of generating chromosome abnormalities and, in certain cases, abnormal cellular behavior, such as cytoplasmic furrowing. Some of the chromosomal abnormalities seen included stickiness, coalescence, chromosome bridges, fragments, and micronuclei. Additionally, parallel nuclear and cellular divisions were observed (Grover & Tyagi, 1980).

Plant cytological abnormalities make for an effective Screening system for the recognition of environmental contaminants that could be dangerous to genetic health. Recently, (Grant, 1978) examined the plant systems that have been demonstrated to be the most useful for this goal.

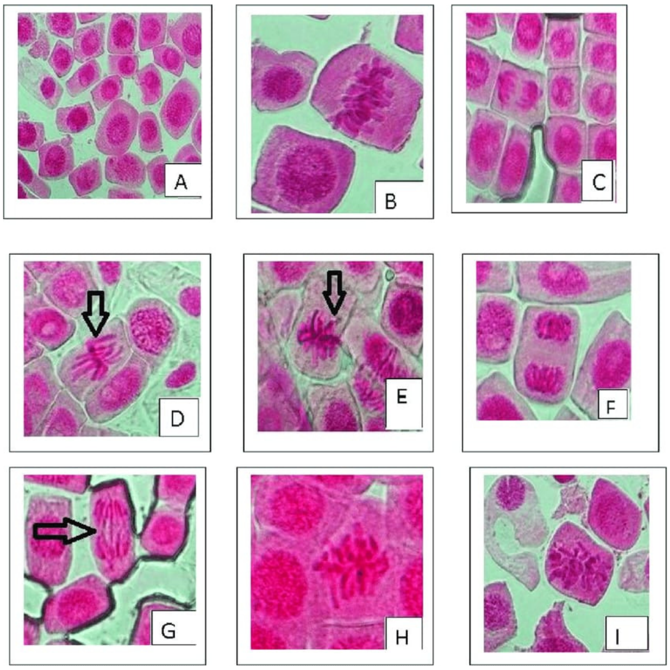

Fig. 3 : A-Normal prophase; B-Normal metaphase; C-Normal anaphase: D-Disorientation at metaphase; E-Stickiness at metaphase; F-Anaphase stickiness; G-Anaphase bridges; H-C-mitosis; I-Chromosomal break

Table 1 : Chromosomal Aberrations in an ecosystem

Reference	Year	Topic	Study
(Bhatta & Sakya, 2009)	2009	Fertilizers	Magnesium sulfate-induced cytological shifts were examined in the root of the onion. Different types of chromosome aberrations were visible at various magnesium sulfate concentrations. The current investigation found that magnesium sulfate has cytotoxic and clastogenic properties.
(Jabee *et al*., 2008)	2008	Herbicides	On root tips and other vegetative, the maleic hydrazide has a harmful impact. This toxicity causes a variety of genetic and chromosome alterations, accelerates the rate of change in physical appearance and produces traits that vary to select improved qualities, and quickens the pace of evolution.
(Bagatini *et al*., 2009)	2009	Hospital waste	Hospital wastewater genotoxicity was assessed using the *Allium cepa* test. Chromosome abnormalities, bridges, and micronuclei during telophase were found during the investigation, indicating a possibility of environmental contamination.
(Mangalampalli *et al*., 2018)	2018	Presence of MgO in plants	The cytotoxicity of MgO Nanoparticles and Micro particles was assessed in the plant system by using *A. cepa* bioassay.
(Palani Kumar & Panneerselvam, 2007)	2007	Food Preservatives	Chromosome aberrations are caused by potassium metabisulfite, and their frequency rises with concentration. When compared to the untreated control, the discrepancies between the amounts have been substantial. Breaks, gaps, and repeated breaks are the most common anomalies.
(Ragunathan & Panneerselvam, 2007)	2007	Curcumin	According to the study, curcumin has the ability to prevent chromosomal abnormalities caused by sodium azide in *A. cepa* root tissues. Additionally, clearly shows slight cytotoxicity by lowering the percentage of the mitotic index in all groups that received curcumin treatment, but the exact mode of action is yet unknown.

The three coded compounds induced a large and concentration-dependent increase in gene mutations in the Broad Beans chromosomal aberration bioassay data from the six laboratories, which led us to conclude that they are clastogenic in the publication (Kanaya *et al*., 1994).

Plants, animals, and humans all experience chromosomal abnormality. Chromosomal aberrations that have previously been discovered by researchers are included in (Table 1).

A way to screen the chromosome aberrations:

For many years, *Allium cepa* bioassay has been used to evaluate toxicants and the harm they cause to both the environment and human health (Mangalampalli *et al*., 2018).

An efficient test for toxicological screening and for keeping track of the cytotoxic effects of environmental contaminants is the *Allium cepa*. The assay has frequently been used to examine the carcinogenicity of several pesticides, proving that these chemicals can result in chromosomal aberrations in *A. cepa* root stems. Pesticide traces in fruits & vegetables could be dangerous to human health. The effects of chemical fertilizers on experimental animals are known to be detrimental to human health and are known to be as carcinogenic(Feretti *et al*., 2007).

Conclusion

Plant chromosomes are sensitive markers of environmental contaminants, as shown by numerous researches. We talked about several chromosomal abnormalities in plants and crops in this review research. We also talked about the most used test for detecting chromosomal abnormalities in plants and other organisms. The *Allium cepa* test is a quick, and highly sensitive assay to identify environmental genotoxicity of chemicals and natural plant products, it can be inferred from the information presented in the review. This test relates to the study of the genetic effects of substances, which takes into account both cellular and subcellular factors.

Chromosomal irregularity has been occurring naturally as a strategy to address the problem of food security by enhancing breeding possibilities to raise environmental tolerance, boost biomass, and more as climatic instability becomes more serious than ever. Humans also need to understand chromosomal anomalies since doing so may lead to ways to ensure the security of our food supply. Because they create a variance in a natural population, chromosomal anomalies are crucial for success in ecosystem adaptation and play a crucial role in evolution.

Recommendation

The research that began with chromosomal aberration in plants has now been expanded to include animals (including humans).Thus, it is essential to allow for the precise detection and quantification of chromosome aberrations of various types. As cytology has progressed, the simplicity and precision with which researchers can identify and measure chromosomal abnormalities have increased.

- Identifying individual chromosomes in mammals such as humans and other mammals using various band methods like G banding, R banding, etc.
- Using banding methods, the karyotypic analysis allowed one to trace the links between various species of plants and animals.
- By analyzing the shape and pairing behavior of chromosomes during meiosis in cross-species mating

Aegilops speltoides was definitively identified as the ancestor of wheat's B genome although plant chromosomes just weren't susceptible to excellent banding.

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