

Forward and Reverse Breeding Cum Genetics

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Abstract

Plant breeding and genetics are fundamental to the sustainable development of crops, ensuring the production of vital resources such as food, feed and fiber. These fields focus on enhancing desirable traits in plants, including yield, disease resistance, environmental tolerance, nutritional content and overall adaptability. Genetics, the study of heredity, forms the basis for understanding how traits are transmitted through genes in plants. Here exploration of the basic forms of genetics and breeding—forward and reverse genetic and their application in breeding programs studied. Forward genetics initiates from phenotype and identifies responsible DNA segments or genes. This approach involves creating mutagenized populations, selecting mutants with specific traits and employing tools like genetic mapping and positional cloning to identify and characterize genes associated with the observed phenotype. Reverse genetics is advantageous in its targeted and efficient exploration of known gene functions. However, it requires more time compared to forward genetics. Both approaches contribute to advancing plant breeding by providing insights into gene functions and their roles in trait expression. Understanding these methodologies is crucial for the success of breeding programs focused on improving crop characteristics for global food security and sustainability.

Keywords: - Genetics, Breeding, Forward, Reverse, Improvement.

Introduction: -

Plant breeding and genetics play pivotal roles in the development and improvement of crops, ensuring the sustainable production of food, feed, fiber, and other essential resources. These fields are integral components of agriculture that aim to enhance desirable traits in plants, such as yield, resistance to diseases and pests, tolerance to environmental stress, nutritional content, and overall adaptability. Genetics is the study of heredity and the variation of inherited characteristics in living organisms. In plants, genetics provides the foundation for understanding how traits are passed from one generation to the next through genes. Genes are



segments of DNA that code for specific traits and functions. The principles of Mendelian genetics, discovered by Gregor Mendel in the 19th century, form the basis for understanding the inheritance of traits and are fundamental to plant breeding. Plant breeding is the intentional manipulation of plant species to create new varieties or cultivars with desired characteristics. This process involves selecting and crossing plants with desirable traits to produce offspring with improved qualities. Over time, repeated cycles of selection and breeding lead to the development of new plant varieties that exhibit improved performance, yield, and resilience.

Despite of various breeding methods here we discuss about basic form of genetics and breeding *viz.* Forward and Reverse genetics/breeding that can provide local understanding about such field and how to move forward for any breeding programme.

Forward Breeding/Genetics:

Forward genetics starts from phenotype and ends with which DNA segments or genes responsible for this phenotype development.

The approach known as forward genetics, or a forward genetic screen, is employed to pinpoint the genes, or a set of genes, accountable for a specific phenotype in an organism. The primary objective of forward genetics is to uncover the genetic foundation underlying a particular trait or phenotype. Classical or traditional genetics traces its origins back to humanity's initial efforts in the domestication of plants and animals. Mutation plays a significant role in both forward and reverse genetics, serving as a primary factor. Consequently, the initial step in both forward and reverse genetics involves creating a suitably mutagenized population. Within forward genetics, gene mapping stands out as the crucial process. The sequential steps in forward genetics encompass: (1) obtaining mutants, which can arise from natural variation or induced mutations, (2) selecting the phenotype of interest and (3) identifying the gene and elucidating its function.

Forward genetics involves the identification and characterization of the gene accountable for a mutant phenotype. The process begins by pinpointing intriguing mutants with the goal of uncovering the function of genes that exhibit defects in these mutants. This methodology is rooted in a "phenotype to gene approach." In the forward genetics approach, the researcher opts for a mutant plant displaying a modified phenotype and proceeds to ascertain the gene responsible for that specific phenotype. To induce random mutations, mutagenesis techniques such as ethyl methane sulfonate (EMS), other mutagens, radiation, or

T-DNA insertion are employed on a plant population. Subsequently, the mutants undergo screening for a particular phenotype through mutant screening. The chosen mutants are then subjected to PCR analysis to identify gene alterations leading to the observed changes in phenotype.

Tools used to study forward genetics:

- Generation of mutants by chemical, radiant, transposon insertional mutagenesis or genome wide mutagenesis.
- Genetic mapping
- Positional or Map based cloning
- Mapping by sequencing
- Expression analysis by microarray
- Candidate gene approach

Pros and cons of forward genetics/breeding: -

It effectively operates in phenotypes that are easily discernible, such as the color of flowers or grains, the shape of plants, fruit size, etc. Additionally, its unbiased nature stems from its random characteristics. This method allows for the swift identification of mutant alleles in model organisms and the exploration of genes associated with quantitative traits like heightened disease resistance, increased yields, tolerance to abiotic stress such as drought and salinity, improved nutritional quality, and more. However, it tends to be more time-consuming compared to reverse genetics.

Reverse Breeding/Genetics:

Reverse genetic starts from DNA or genes and goes to find out what is expected phenotype from this gene.

Reverse genetics aims to identify the phenotypes that emerge from specific genetic sequences. The revelation of DNA as the hereditary material paved the way for the evolution of reverse genetics, allowing the targeted manipulation of the genome to assess and harness functional variations in genes. Mutations play a significant role in both forward and reverse genetics. The initial phase in both forward and reverse genetics involves creating a suitably mutagenized population. Crucial tools for reverse genetics include in vitro mutagenesis and gene disruption, commonly referred to as gene knockout.

Reverse genetics employs a "gene to phenotype" approach commencing with a known gene sequence. The objective is to modify the gene's function to elucidate its role, gauged by the effects manifested in plants. The primary goal of reverse genetics is to scrutinize the consequences of induced mutation or altered expression within a specific gene sequence, unraveling the gene's function. This methodology is tailored to focus on a singular gene, the function of which is yet undetermined. A gene sequence lacking known function or phenotype is chosen, subjected to mutagenesis, and then assessed for its in vivo function, resulting in a discernible phenotype that can be unequivocally attributed to the gene under investigation.

Tools used to study reverse genetics:

- Homologous recombination
- Gene silencing
- Ectopic expression
- Zinc-finger nucleases
- TILLING (Targeted Induce Local Lesions In Genome)
- Insertional Mutagenesis
- Deleteagene

Pros and cons of forward genetics/breeding: -

Requires less time compared to traditional genetics. No need for knowledge about gene function. Single allele mutations may lead to misleading results and also Limited in its scope.

Conclusion: -

The dynamic fields of plant breeding and genetics are fundamental to the sustainable development of crops, ensuring food security and resource optimization. Despite the diverse breeding methods, this discussion emphasizes the fundamental concepts of forward and reverse genetics/breeding. Forward genetics, starting from phenotype and moving towards gene identification, employs mutagenesis and gene mapping to uncover the genetic basis of traits. In contrast, reverse genetics starts with DNA or genes to elucidate expected phenotypes, utilizing tools like homologous recombination and gene silencing. Both approaches have their pros and cons, offering unique insights into trait inheritance and gene function, thereby shaping the future of plant breeding programs.

References

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