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Study on Plant Breeding Methods to Enhance the Crop Yield

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ABSTRACT-*Genetic principles are used to grow plants that are healthier for people. This is done by choosing plants that are aesthetically pleasing, economically beneficial, or both, managing the mating behaviour of those individuals, and then choosing particular offspring from the ensuing offspring. Such approaches have the potential to drastically alter the hereditary content and value of a plant population when applied over several generations. The biological aspects of plant breeding are covered in the page on heredity; this one concentrates on using genetic principles to improve plants. In this paper ,author shed the light on plant breeding methods and their different characteristics with the increasement in the crop yield.*
Keywords- *Plant breeding methods, offsprings, genetic principles ,hereditary compositions etc.*

I. INTRODUCTION &HISTORY-

People have been breeding plants since the dawn of agriculture. People reportedly started identifying different levels of plant excellence in their fields not long after the first cereal grains were domesticated, and they started saving seed from the best plants to grow new crops. These hesitant selection techniques served as the foundation for early plant breeding techniques. Plant breeding techniques used in the past generated observable outcomes. Because they are so different from their natural ancestors, the majority of modern species cannot thrive in the wild. Because the created forms differ so greatly from their wild counterparts, it can sometimes be challenging to even determine their ancestors. From an evolutionary perspective, these amazing changes were made by early plant breeders in a relatively short period of time, and the rate of change was certainly faster than for any other evolutionary event. Gregor Mendel created the groundwork for scientific plant breeding in the middle of the nineteenth century by using pea plants to develop the basic theories of heredity. In the early 20th century, as plants were further characterised, a first step was taken toward utilising genetic inheritance patterns for plant enhancement. One of the most important discoveries from the brief history of scientific breeding is the enormous genetic diversity present in plants all across the world, and the fact that only a small portion of their potential has been realised.

GOALS FOR PLANT BREEDING

Plant breeders frequently view an ideal plant as one that possesses the most desired characteristics. Tolerance to heat, soil salinity, or frost, proper size, shape, and time to maturity, as well as a variety of other general and specialised properties that assist enhanced climate adaption, ease of growth and handling, higher yield, and superior quality, are just a few examples of these traits. Horticultural plant breeders must also take aesthetic attractiveness into account. Therefore, the breeder must consider the different traits that make the plant more efficient in attaining the aim for which it is cultivated rather of focusing attention on a single attribute, which is rarely attainable. One important strategy for enhancing global food security is plant breeding. In order to better endure the extreme climatic circumstances brought on by global warming, such as drought or heat waves, several staple crops have undergone modifications.

1. **A rise in output**

Almost all breeding initiatives have as one of their goals raising yield. The most common method for achieving this is via selecting obvious morphological variants. One example is the selection of dwarf, early-maturing rice varieties. These resilient dwarf varieties yield more grain. Furthermore, because they reach maturity early, the field is cleared quickly, frequently allowing for the subsequent planting of rice or another crop the same year.

Another way to increase productivity is by breeding cultivars that are resistant to pests and diseases. The only effective pest management method has frequently been the development of resistant cultivars. Perhaps their most important characteristic is the stabilising effect resistant cultivars have on output and, thus, on a steady supply of food. Varieties that are tolerant of heat, cold, or drought offer the same benefit.

2. Changes in scope and constitution

Plant breeding frequently aims to increase a crop species' production area. A good example is how grain sorghum has changed since it was brought to the United States in the 1750s. Although earlier-maturing cultivars have since been developed, grain sorghum, which has a tropical origin, was historically mostly farmed in the southern Plains and the Southwest.

Recently, one of the main goals of plant breeding has been to create crop kinds that are suitable for automated agriculture. Plant character uniformity is essential for automated agriculture because it simplifies field operations when individuals of a variety have the same germination durations, growth rates, fruit sizes, and other traits. The uniform maturity of crops is obviously essential when mechanically harvesting crops like tomatoes and peas.

Plant breeding can significantly improve nutrient content. For example, kinds of corn (maize) that are significantly higher in lysine than the existing variety could be developed. For regions of the world where maize is the primary source of this nutritionally significant amino acid, plant breeding has given the development of high-lysine maize cultivars major emphasis. The "biofortification" of food crops—a word that sometimes refers to genetic modification—has been shown to enhance nutrition. It is especially useful in developing countries where there may be gaps in the infrastructure for medical care and recurrent dietary shortages.

When creating attractive plants, longer flowering periods, greater flower preservation skills, general thriftiness, and other characteristics that encourage usefulness and aesthetic appeal are all taken into account. Since novelty is frequently a value in ornamentals, the spectacular and even the odd are occasionally desired.

3. Evaluation of plants

The appraisal of the value of plants so that the breeder can decide which individuals should be discarded and which allowed to produce the next generation is a much more difficult task with some traits than with others.

4. Qualitative characters

The most straightforward cases are traits or characteristics with discrete, qualitative distinctions that are governed by one or a small number of important genes. Such genetic variants are abundant, and they frequently have substantial effects on plant value and utility. Examples include green beans' determinate versus indeterminate development patterns and the starchy versus sugary kernels of sweet versus field corn (determinant varieties are adapted to mechanical harvesting). Regardless of the environment in which the plant grows, the expression of the traits is constant, and such variations may be quickly and easily noticed. These characteristics are known as highly heritable.

5. Quantitative characters

It is impossible to categorise some plant traits into distinct classes since they grade gradually from one extreme to the next in a continuous succession. We refer to these deviations as quantitative. Height, cold and drought resistance, time to maturity, and yield are examples of this type of characteristic that are typical. These traits are influenced slightly by a large number of genes. Although the distinction between the two sorts of traits is not rigid, it is helpful to think of qualitative characters as those that have discrete distinctions and quantitative characters as those that entail a graded series.

Quantitative traits are more difficult for breeders to control for three main reasons: (1) the sheer number of genes involved makes hereditary change slow and difficult to assess; (2) the variations of the involved traits are typically only detectable through measurement and exact statistical analyses; and (3) the majority of the variations are caused by the environment rather than genetic endowment. For instance, the heritability of some traits is lower than that of others.

DIFFERENT METHODS FOR PLANT BREEDING

1.Mating systems

The process of pollination, or the movement of pollen from flower to flower, controls the evolution of angiosperm mating systems. Instead of being self-pollinated, a flower is said to be cross-pollinated (also known as "outcrossing" or "outbreeding") if the pollen originates from a flower on a different plant (also known as a "selfer"). Natural cross-pollination occurs in about half of the more significant cultivated plants. These plants have a variety of mechanisms in their reproductive systems that encourage cross-pollination, including protandry (the release of pollen before the ovules are mature, as in the case of the carrot and walnut), dioecy (the bearing of male and female parts on different plants, as in the case of the date palm, asparagus, and hops), and genetically determined self-incompatibility (inability of pollen to grow on the stigma of the same plant, as in white clover, cabbage, and many other species).

Most other plant species self-pollinate, including many of the most important domesticated plants including wheat, barley, rice, peas, beans, and tomatoes. Only a few reproductive mechanisms, such as the inability of some violet flowers to open (cleistogamy), are beneficial for self-pollination. Pollination takes place after flower

opening in barley, wheat, and lettuce, but the stamens surround the stigma in a cone. Pollination takes place before the tomato bloom opens. In these species, unwanted cross-pollination is always a possibility.
During controlled breeding operations, only the pollen from the desired male father should come into contact with the female parent's stigma. When stamens and pistils are present in the same flower, the anthers of the flowers designated as females must be removed before pollen is expelled. For this, scissors or forceps are typically employed. In addition, protection against "foreign" pollen is necessary. The most common method is to cover the bloom with a plastic or paper bag. When the stigma of the female parent becomes receptive, pollen from the chosen male parent is transferred there, frequently by shattering an anther over the stigma, and the protective bag is then replaced. Such hybridization is time-consuming and expensive since it typically calls for a series of delicate, exact, and precisely timed physical tasks. When male and female reproductive organs are situated in separate flowers, as in corn, controlled breeding is made simpler (maize).
Because each of its two parents is likely to have different gene compositions, cross-pollination produces a diverse population of plants that are heterozygous (hybrid for many traits). A single-parent, self-pollinated plant produces a more uniform population of plants that are homozygous (pure breeding) for a number of traits. Therefore, self-breeders are more likely than outbreeders to be highly homozygous, making them true breeders for a particular trait.

2. Breeding self-pollinated species

The breeding methods that have proved successful with self-pollinated species are: (a) mass selection; (b) pure-line selection; (c) hybridization, with the segregating generations handled by the pedigree method, the bulk method, or by the backcross method; and (d) development of hybrid varieties.

Mass selection

In mass selection, desirable-looking individuals in a population are selected from a stock of mixed seed that has been collected from (typically a few dozen to a few hundred) individuals. This procedure, sometimes referred to as phenotypic selection, is predicated on how each individual looks. Mass selection is widely used in horticulture to improve old "land" cultivars, which are cultivars that have been passed down from one farmer generation to the next over a significant amount of time.

Eliminating undesirable types from the field is a different tactic that has probably been employed for thousands of years. The results are the same whether superior plants are left alone or inferior plants are eliminated: the seeds of the superior plants are used as the planting material for the upcoming season.

A contemporary advance over bulk selection is to harvest the best plants separately, grow and contrast their progeny, and then compare them. After the inferior offspring are culled, the remaining progeny's seeds are collected. It is important to emphasise that selection now considers not only the appearance of the parent plants but also the performance of the progeny. Phenotypic selection usually outperforms progeny selection when confronting quantitative variables with low heritability. However, progeny testing requires an extra generation, thus to achieve the same rate of growth per unit time, the gain from each selection cycle must be twice as large as the gain from conventional phenotypic selection.

Mass selection, whether it includes or does not involve progeny testing, is possibly the most straightforward and least expensive plant breeding approach. A few forage species that are not commercially significant enough to merit further examination are bred using it frequently.

Selecting only lines

Three more or less different steps commonly make up pure-line selection: A large number of better-looking plants are selected from a genetically diverse population, their offspring are grown and evaluated by straightforward observation, often over the course of several years, and when selection is no longer possible solely on the basis of observation, extensive trials are carried out with careful measurements to determine whether the r is still significant. Any progeny that performs better than an existing variety is then made available as a new "pure-line" variety. The success of this approach in the early 1900s was largely a result of the accessibility of ready-to-use genetically varied land varieties. They provided an abundant supply of premium pure-line varieties, some of which can still be found in modern commercial cultivars. The above-described pure-line strategy is still often used with less significant species that have not yet undergone considerable selection, although having lately lost some of its value in breeding key farmed species.

A centuries-old method of pure-line selection is the selection of single-chance variants, mutations, or "sports" in the original variety. A very large number of varieties that are distinct from the original strain in terms of features like colour, the absence of thorns or barbs, dwarfism, and disease resistance have emerged as a result of this process.

Hybridization

Since the turn of the 20th century, self-pollinated species have been bred mostly by intentional hybridization between carefully selected parents. To produce pure-breed kids that are superior in many ways to their parents, hybridization aims to combine favourable genes from two or more distinct kinds.

However, genes always reside alongside other genes in a collection known as a genotype. The fundamental difficulty facing plant breeders is efficiently controlling the vast number of genotypes that emerge in the generations after hybridization. The potential of hybridization in producing variety is shown by the fact that a hypothetical cross between two wheat varieties with only 21 gene changes can produce more than 10,000,000,000 different genotypes in the second generation. While the bulk of these second-generation genotypes are hybrid (heterozygous) for one or more qualities, 2,097,152 different pure-breeding (homozygous) genotypes may exist, each potentially a new pure-line variety. These data emphasise the importance of hybrid population management techniques, a function for which the pedigree approach is most frequently used.

Pedigree breeding begins with the union of two genotypes that each have one or more desirable features that the other lacks. If the two original parents do not provide all of the required features, a third parent can be added by crossing it with one of the hybrid children of the first generation (F1). The pedigree technique involves selecting superior kinds over time and maintaining a database of parent-progeny links.

The F2 generation, which is produced when two F1 people are mated, has the first chance to be selected in pedigree programmes. This generation is focused on eliminating people with hazardous primary genes. Natural self-pollination causes the hybrid state to finally give way to pure breeding in succeeding generations, and families descended from different F2 plants begin to express their unique traits. From each outstanding family, one or two superior plants are normally selected in these generations. The level of homozygosity among the F5 generation's pure-breeding condition has almost entirely shifted the attention to selection inside families. The pedigree information aids in these deductions. In order to yield the larger numbers of seed needed to evaluate families for quantitative traits, each selected family is now frequently mass-harvested. This study is often conducted in plots that have been planted as similarly to commercial planting practises as is practical. Once the number of families has been reduced to manageable levels through visual selection, frequently by the F7 or F8 generation, precise performance and quality evaluation begins. Promising strains must first be monitored, often across a number of years and locations, followed by exact yield testing, quality testing, and further observation in order to find any defects that may not have previously arisen. Many plant breeders test new varieties for five years at five representative sites before making them available for industrial production.

The bulk-population strategy to breeding differs most from the pedigree system in how it handles generations after hybridization. The F2 generation is planted on a big area at typical commercial planting rates. When the crop has fully grown, it is collected in large quantities, and the seeds are then sown to grow the subsequent crop on the same plot. No ancestry data is saved. During the bulk propagation period, natural selection has a tendency to reject plants with low survival value. Two other methods of artificial selection are also widely used: (1) eliminating plants with undesirable primary genes, and (2) mass strategies such harvesting only portion of the mature seeds to favour plants that mature earlier or the use of screens to favour larger seeds. After that, single plants are chosen and evaluated in a manner akin to pedigree-based breeding. The fundamental advantage of the bulk population strategy is that it enables the breeder to inexpensively handle enormously huge numbers of individuals.

It's often possible to improve a fantastic variety by giving it a certain desirable quality that it is now lacking. In order to achieve this, you must first cross a plant of the superior variety with a plant of the donor variety that exhibits the desired trait, and then you must mat the resulting plant with a plant that carries the genotype of the superior parent. This movement is referred to as backcrossing. After five or six backcrosses, the offspring will be hybrid for the trait being transferred yet similar to the superior parent for all other genes. There will be some children that are pure breeding for the inherited genes after selfing the most recent backcross generation and choosing. Backcrossing has the advantages of being rapid, requiring fewer plants, and producing predictable results. The method's primary flaw is that it lessens the likelihood of genetic combinations that can occasionally lead to noticeably increased performance.

Hybrid plants

In contrast to hybridization, the process of creating hybrid varieties merely seeks out F1 hybrid plants; no effort is made to produce a pure-breeding population. The F1 hybrids produced by crosses between various genotypes typically outperform their parents in terms of robustness. These characteristics of heterosis, or hybrid vigour, include quicker growth, greater uniformity, earlier flowering, and larger yields—the latter of which is essential for agriculture.

Because its male flowers (tassels) and female flowers (incipient ears) are distinct and controlled, making it practical for the production of hybrid seed, corn (maize) has by far experienced the greatest advancement in hybrid types. Other plants, most notably attractive flowers, whose hand-made F1 hybrid seed has been developed, have only been able to do so economically because greenhouse farmers and home gardeners are willing to pay high rates for hybrid seed.

However, in recent times, a number of plants, including some that self-pollinate, like sorghums, have been able to develop hybrid varieties thanks to an internal cellular system of pollination management. This system, also known as cytoplasmic male sterility or cytosterility, prevents the male sex organs (stamens) from maturing or functioning normally. The result is limited pollen production, or none at all. It does away with the need for mechanical or hand stamen removal. Cytosterility is brought on by an interaction between male sterile genes (R + r) and elements found in the cytoplasm of the female sex cell. Only the egg can supply the cytoplasm (and its constituent parts), hence the female parent determines whether cytosterility will be inherited. According to the standard Mendelian theory, the genes are inherited from both parents. All plants that have fertile cytoplasm make viable pollen, as do all plants that have sterile cytoplasm but at least one R gene; however, a plant with two R genes is male sterile (produce defective pollen).

It is possible to produce F1 hybrid seed between the two strains by interplanting a fertile version of one strain (let's say A) with a sterile version of another strain in a solitary field (B). Because strain A doesn't produce any viable pollen and can only be pollinated by strain B, all seeds produced by strain A plants must be F1 hybrids between the strains. The F1 hybrid seeds are then used to plant the commercial crop. By using this method, the breeder can begin producing hybrid seeds by investing a lot of time in developing pure-breeding sterile and fertile strains.

3. Breeding cross-pollinated species

The most important methods of breeding cross-pollinated species are (1) mass selection; (2) development of hybrid varieties; and (3) development of synthetic varieties. Since cross-pollinated species are naturally hybrid (heterozygous) for many traits and lose vigour as they become purebred (homozygous), a goal of each of these breeding methods is to preserve or restore heterozygosity.

Mass selection

Similar to self-pollinated species, cross-pollinated species undergo mass selection, in which a large number of better-looking plants are chosen, harvested in huge numbers, and their seeds used to create the following generation. Despite the low heritability of such traits, mass selection has been shown to be quite efficient in improving qualitative characters. When used over many generations, it is also capable of improving quantitative characters, including yield. Mass selection has long been a key technique for breeding cross-pollinated species, particularly in the species that are less economically significant.

Hybrid varieties

The best example of utilising hybrid vigour has been corn, which uses F1 hybrid varieties (maize). Selecting excellent plants, selfing them over several generations to produce a number of inbred lines that are all pure-breeding and remarkably uniform, and finally crossing the selected inbred lines are the three steps in the creation of a hybrid corn variety. During the inbreeding process, the vigour of the lines gradually decreases, often to less than half that of field-pollinated kinds. However, vigour is restored when any two unrelated inbred lines are crossed, and in some cases, the F1 hybrids between inbred lines are noticeably superior to open-pollinated varieties. Every inbred hybrid will always have the same traits because inbred lines are homozygous. Once the inbreds that generate the best hybrids have been identified, any necessary quantity of hybrid seed can be produced.

Pollen is transported by the wind from the tassels to the styles (silks) that protrude from the tops of the ears when corn (maize) is pollinated. Controlled cross-pollination on a field size is thus economically possible by interplanting two or three rows of the seed parent's inbred plants with one row of the pollinator's inbred plants and removing the former before it sheds pollen. The bulk of hybrid corn is actually produced by "double crossings," which entails mating two F1 hybrids from each pair of the four inbred lines (A, B, C, and D) twice. Instead of using an inbred with low yields, the double-cross approach produces commercial F1 seed from the highly productive single cross A B, which lowers seed costs. In recent years, it has been possible to produce hybrid seed at even lower cost by using the previously stated cytoplasmic male sterility to prevent the seed parent from getting detached.

The majority of the hybrid vigour exhibited by F1 hybrid types is lost in the subsequent generation. So, instead of using seed from hybrid types to grow stock, the farmer purchases fresh seed from seed firms each year.

Of all the biological science advancements, the discovery of hybrid corn may have had the biggest influence on boosting the number of food sources available to the world's population (maize). Thanks to the application of male sterility, the adoption of hybrid types in other crops has also been extremely successful, and it looks that this success will continue in the future.

Synthetic varieties

Several genotypes with proven superior combining ability—i.e., genotypes that are known to produce superior hybrid performance when crossed in all combinations—are intercrossed to create a synthetic variety. (In contrast, a mass-selected variety is built up of genotypes that have been bulked together without first being tested to establish how well they function in a hybrid combination.) For their hybrid vigour and capacity to yield useful seed for future seasons, synthetic cultivars are well-known. Because of these benefits, synthetic varieties are increasingly preferred when cultivating various species, such as forage crops, where the cost of developing or using hybrid types prevents it.

II. SUMMARY AND CONCLUSIONS

It should go without saying that unless sufficient seed has been produced to enable commercial production, better new varieties cannot fully benefit. The primary responsibility of a plant breeder is to create new species, but he also often oversees a modest initial seed expansion. In this technique, breeders seed is produced. The next phase involves multiplying breeders seed to produce foundation seed. Usually, seed organisations or institutions that are governed by the government create foundation seed. The third step entails the large-scale manufacturing of certified seed, a product of foundation seed that is widely distributed to farmers and gardeners by specialised seed growers. The requirements set forth by the certifying organisation must be followed in the production and processing of certified seed (usually a seed association). Seed associations are frequently in charge of maintaining the purity of new varieties after they have been licenced for commercial use.

Seed associations routinely distribute new varieties developed by commercial plant breeding organisations, however many trustworthy companies sell their products without following the official certification process. In some countries, new varieties can frequently be patented for up to 15 years or longer, during which time the breeder has exclusive rights to produce and promote the type.

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