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Reverse breeding and its uses in marker assisted breeding.

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Plant breeding has traditionally been an investigation process in which new kinds are created by crossing parental plants or self-pollination. The method involves selecting a desirable property in one plant for example increased disease resistance then crossing it with another plant, allowing the desired trait to arise in the progeny. However, a number of undesirable features are also conveyed, which will require several additional breeding cycles to be replaced by desired qualities. This type of breeding takes many years to complete, which is a lengthy period given the urgency with which climate change and food security challenges must be addressed. New methods are required to speed up the process while also allowing for more precision and efficiency. Reverse Breeding is one of the New Breeding Techniques (NBTs) that have already been established.

Reverse breeding could be used in a variety of situations

Reverse breeding, in practise, produces novel heterozygous hybrid plant kinds with hybrid vigour ('Hybrid vigour') that would be difficult and time-consuming to generate by traditional breeding. Due to natural genetic recombination of the chromosomes, breeders are unable to produce stable heterozygous hybrids. Breeders have traditionally created exceptional hybrids by crossing homozygous parental lines (forward breeding). Reverse breeding allows for the creation of homozygous parental lines that, when mated, completely recreate the desired heterozygous hybrid plant. Breeders can perpetuate these homozygous parents indefinitely.

In several crops, hybrid vigour is required to develop high-yielding cultivars [1]. Maize (Zea mays ssp. mays) breeding has advanced rapidly in recent decades, with genetic gain accounting for more than half of the yield increase. Maize breeding relies heavily on germplasm. Homozygous inbred lines have been generated through selfing, and current hybrid varieties acquire a high level of heterosis by merging lines from diverse heterotic groupings. However, because parental chromosomes may recombine when passed down to descendants, a good heterozygous genotype cannot be perpetuated through hybrid seeds [2]. Crossover recombination, which generates new allele combinations by reciprocal exchange of chromosome segments, and the orientation of homologous chromosomes on the metaphase plate, which generates novel combinations of parental chromosomes, are two interrelated events that influence allele recombination during meiosis.

Although recombinant DNA is used in the Reverse Breeding process, the selected homozygous parental lines and their progeny are not transgenic. The plant types that come from this application are similar to those that can be created using traditional breeding approaches.

Benefits

Reverse breeding speeds up the breeding process and expands the number of genetic combinations accessible, allowing breeders to respond to the requirements of farmers and growers with superior varieties much faster.

Reverse breeding is used in marker-assisted breeding

When reverse breeding heterozygous hybrids, it is feasible to develop the same hybrid variety with two different sets of parental lines, potentially improving repeatability for crops like cauliflower, where seed production issues can make hybrid types difficult to commercialise [3]. This method is referred to as parental line substitution. Chromosome substitution lines can also be created through reverse breeding. One or more chromosomes from one parent are present in the genetic background of the other parent in these lines. This method can be used to strengthen parental lines or to conduct genetic research, for example.

Reverse breeding allows researchers to investigate gene interactions in the heterozygous inbred families that can be created by crossing and backcrossing reverse breeding products. When genotyping is paired with, for example, transcriptome or metabolome analysis, screening of populations that segregate for features on a single chromosome allows for fast discovery of QTL. These heterozygous inbred families also make it easier to create chromosome-specific linkage maps and fine-map genes. As a result, reverse breeding can provide extremely useful information about the nature of heterotic effects [4].

The rapid development of MARB in maize is supported by our success in breeding homozygous parent lines, as well as the ever-increasing need for innovative crop enhancement approaches [5]. As a result, we believe that MARB's enhanced capabilities for selecting and improving favourable genotypes will help to boost future crop yield.

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