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# PLANT BREEDING STRATEGIES FOR THE FUTURE

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### What is breeding?

Plant breeding is a numbers game. The production of a good variety from any cross cannot be guaranteed, and instead, plant breeding involves choosing strategies that increase the probability of identifying new varieties. This requires data on the performance of individuals and their offspring, so that parents can be crossed in combinations most likely to produce suitable progeny.

One of the fundamental tools of plant breeding is the progeny test. This involves crossing individuals in different combinations, and using the performance of the offspring to assess the worth of the parents in breeding, also referred to as the breeding value (BV) of the parent.

In order to illustrate some concepts in plant breeding, a character of an individual, e.g. yield, may be represented as:

$$Y = G_A + G_I + E$$

$G_A$ is the component due to the additive genotype. This can be predicted from the parents, and is equivalent to the breeding value.

$G_I$ is the component due to the interactive genotype. This is due to chance combinations of genes that cannot be predicted.

E is the environmental effect, that can be controlled by selecting on appropriate sites, and by planting the right variety on the right site.

In short term breeding, the aim is often to make many crosses, and select the superior individuals with fortuitously good combinations of genes, i.e. the $G_I$ component of the character is being exploited, which is due to chance and cannot be predicted. For long term breeding, the objective is to increase the additive portion of the genotype in each generation, so as to increase the base level of the population.

### Breeding strategies for long term gain

A sugarcane clone requires many attributes, such as resistance to several diseases, high sucrose content, high cane yield, and the ability to perform well under a range of conditions, in order to be accepted as a new commercial variety. A fundamental principle of plant breeding is that the more traits that are selected for, the lower the probability that a variety that satisfies all the selection criteria will be found. Multiple population breeding (MPB) offers a flexible strategy to overcome some of the problems associated with breeding for many traits.

In multiple population breeding, different groups are formed for each selection criterion. For example, populations for high sucrose, eldana resistance, smut resistance, high yield, etc. can be assembled. Each group has 10 to 12 parents in it, chosen on the performance of their offspring, rather than on their own value for that particular trait. For breeding purposes, each group is treated as a closed unit, and in each generation, crosses are only made between individuals in the same group.

This accumulates the genes responsible for the additive genotype in each generation. For selection purposes, when the objective is to identify varieties suitable for commercial release, crosses between the groups can be made, to combine different traits, and also to force interactions that increase the $G_I$ component. In essence, there are two programmes running concurrently – a breeding programme to ensure that the right kinds of genes are available, and a selection programme to optimise the combinations of those genes in commercial varieties.

This system is very flexible, in that if a new disease or a new selection criterion becomes important, a new population for that trait can be formed. Selection for the new trait then does not affect gains already achieved by selecting for other traits in other populations.

The breeding strategy has implications for the way trials are conducted, and also has an impact on other departments. As mentioned earlier, there is a need to gather information on the performance of the progeny of crosses, to estimate the breeding value of their parents. For example, in the eldana resistant population, offspring of the parents in that population need to be tested in eldana resistance trials, to assess their parents' breeding values. These would have to be controlled inoculation trials, as opposed to field screening trials, because the breeding programme needs the most reliable information to estimate breeding values to make the programme work. The same applies to diseases such as smut and mosaic; it requires additional controlled resistance trials to assess the parents for the breeding population.

Strategy used for breeding is one aspect of breeding. The type of variety to breed for is also a strategic concern. It is often left up to the plant breeder, but is actually an issue for the industry as a whole. The types of issues involved include the cutting cycle, self-trashing varieties, and varieties suitable for mechanised harvesting. The more traits that are added to the breeding programme, the less efficient selection becomes.

### New technologies to aid breeding

Breeding is about manipulating genetics, and the new technologies developed under the umbrella of biotechnology that enable one to examine and manipulate DNA offer exciting possibilities to aid breeding.

*Molecular markers*: Markers are small segments of DNA that are correlated with a particular trait. For example, a marker may be linked to smut resistance. This marker can then be used to screen a group of individuals, and to select those that have the marker, which would be more likely to be smut resistant than plants without the marker.

With the present selection system, the use of markers will allow one to eliminate all the seedlings that do not have the marker before they go into the first selection stage. In other words, it will reduce the number of varieties that go into field trials, which makes the evaluation of these varieties more precise. However it does not increase the probability of finding a new variety.

In order to utilise markers to increase the probability of selecting a new variety, one must increase the number of seedlings raised. This would increase the number of plants with the marker going into the first stage of selection. Practically, it means raising and screening up to one million plants a year, which would require extra seed being produced each year, and a facility dedicated to mass screening for markers.

Another way of using markers would be to screen the parents before crosses are made. By ensuring that at least one of the parents in each cross has the marker, the proportion of progeny in the population carrying the marker would be increased. In the long term, this would be a more efficient strategy, and would require the screening of only a few hundred parents a year.

*Genetic engineering*: This involves adding new characters to plants, by introducing DNA segments coding for desirable attributes. For example, eldana resistance may be engineered into existing varieties by adding the appropriate resistance genes. Selection and breeding for traits that can be added in this manner then becomes unnecessary. Genetic engineering thus has the potential to reduce the number of traits to select for in the breeding programme, making selection for the remaining traits more efficient. It also offers the potential to introduce desirable traits from other organisms that are not found naturally in sugarcane.

**Variety release strategies**

The variety release philosophy affects the way that promising varieties are tested in the final stages of selection, and so is worthwhile to review this when considering breeding strategy in the broad sense.

At present, for a variety to be released commercially, it has to perform well across several sites. Varieties that do well over several crops at one site, but fail at other sites, are not released. In other words, the system favours those varieties that are fairly stable, and can grow in a range of environments, and it works against varieties that are site specific and will only grow in special environments.

One thing to remember, is that as yields increase, it becomes more and more difficult to find stable varieties adapted to a range of sites, and that the biggest yield increases will be as a result of identifying specific varieties for specific sites. In order to exploit these potential gains, it may be necessary to adapt the variety release procedure to accommodate site specific varieties. Although the current release procedure would remain for the environmentally stable varieties, growers would have to be more involved in testing site-specific varieties on their own farms at their own risk. In principle this would be a good idea, but it would have to be established whether this is both practical and acceptable to growers before such a system is implemented.