MUTATION BREEDING

A promising tool for sugarcane improvement

Over evolutionary time, spontaneous mutations have played an important role in the adaptation of plant species to their environments. However, a low rate of occurrence strongly limits their usefulness in plant breeding programmes, which must meet present-day demand for the speedy release of varieties adapted to rapidly changing pests, diseases and climate. Mutation breeding seeks to accelerate the accumulation of mutations on which directed selections can be made.

Over the past 75 years, more than 3000 crop plant varieties derived from mutation breeding programmes have been released, as listed in the Food and Agriculture Organisation/ International Atomic Energy Agency mutant variety database, including 816 rice lines, 285 wheat lines, 96 maize lines; but only 13 sugarcane lines. This approach has clearly been successful, with more than 60% of mutant varieties being released after 1985, despite limitations such as difficulties in identifying a small number of individuals with improved characteristics within a large unselected population. Only a small proportion of mutants, approximately one in 25,000 (0.004%) are found to be at least comparable to their respective 'parent' lines. Consequently, mutagenesis must aim to produce as many variants as possible. The larger the total number of variants obtained, the more likely that a few may be useful.

Conventional sugarcane plant breeding and selection programmes operate with a similar constraint. At SASRI, 250,000 different genotypes from multiple parental crosses are propagated annually. Of these, some 15 years later, one or two selected genotypes (less than 0.001%) are found to be at least comparable to contemporary cultivars and are released to growers.

It can be argued that a parallel process of mutation breeding can be used to improve specific desirable traits in highly adapted parental material. However, due to the presence of many copies of each gene in sugarcane, most mutations have no detectable effect on the sugarcane plant. This can also be an advantage since sugarcane can tolerate a high mutation load allowing for an increased likelihood of detecting new characteristics arising from mutations.

Figure 1: Leaf symptoms six weeks after the foliar application of imazapyr to seven selected N12 mutants and control N12 in the field.

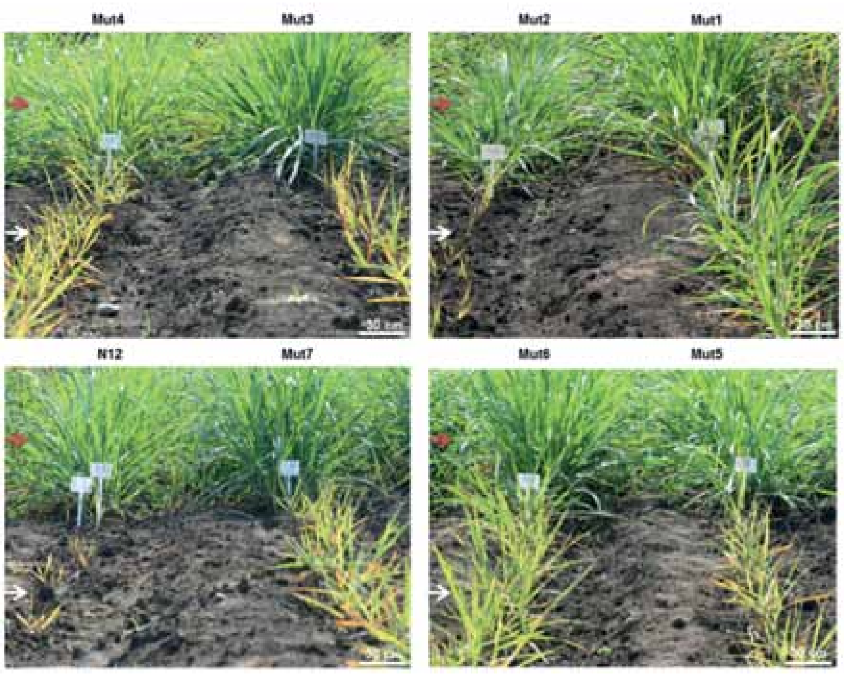


Figure 2: Germination of mutant lines in imazapyr treated soil.

The targeting of mutations conferring new characteristics by imposing a selective pressure is an approach that SASRI scientists consider likely to succeed in sugarcane. For example, resistance to imidazolinone herbicides is conferred by single amino acid substitutions in the enzyme targeted by this class of herbicide.

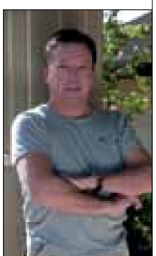
Weeds and input costs are identified by small-scale growers as being their major production constraints. Due to low levels of inputs in general, sugarcane is slow to canopy allowing weeds a competitive advantage. The variety N12 is known for its superior tolerance of acid soils (in the absence of liming) and for its ability to take up phosphorous when this nutrient is limiting. N12 is therefore often the variety of choice for small-scale growers.

The herbicide imazapyr is effective against problem grass weeds, with residual soil activity up to 4 months. The planting of a resistant mutant sugarcane line could allow the cane to canopy during the residual period of weed suppression, resulting in improved weed control. To this end, in a project involving two MSc students based at SASRI with academic supervision from Prof MP Watt (School of Life Sciences, UKZN), N12 has been mutated through the use of a chemical mutagen and tolerant mutants have been selected by exposure to imazapyr in tissue culture.

Seven mutants were planted out in the field following the tissue culture selection process. Five of these showed no visible symptoms when imazapyr was applied as a foliar spray (Figure 1).

Seedcane was also planted into soil just three weeks after the planting area had been treated with imazapyr. Mutants 1 and 6 appear to be the least affected by the soil imazapyr treatment (Figure 2). Although growth appeared slower and percentage of buds germinating was slightly reduced compared to planting in untreated soil, the result was vastly superior to planting un-mutated N12. The mutant plants achieved thirteen weeks of growth during the time period in which it would not have been safe to plant a non-tolerant variety.

Preliminary results suggest that the mutant lines are similar to their 'parent' variety N12 in terms of yield and quality traits. Further trials to confirm this, as well as to confirm that disease resistance levels have not been compromised, are being planned. If all goes well consideration could be given as to the release into the industry of this novel trait.



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