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Techniques for acceleration of mutation breeding in crop plants

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Abstract

Plant mutation breeding involves the processes of mutation induction, mutation detection, mutation fixation, mutant line development and release of new mutant cultivars. The length of the process depends largely on the nature of propagation of the crop (for annual crops this normally takes 7 to 12 years), the targeted trait, the ability to recognize and select individuals carrying traits of interest in segregating populations and developing selected lines. Advances in plant propagation, phenotyping, genotyping and supporting technologies provide several opportunities to enhance the efficiency of selection and accelerate the delivery of mutant cultivars. In addition to mutation induction and mutation detection the PBGL of the Joint FAO/IAEA Division has active R&D projects in speeding up plant mutation breeding through rapid generation cycling and doubled haploidy.

Recently, a procedure for rapid generation cycling in wheat and barley was published. This procedure has been adapted for a wider range of wheat genotypes and has been extended to sorghum. Ten wheat and 7 sorghum cultivars from Kenya and Sudan were propagated in different pot sizes, day length and watering regimes.

Embryos were rescued at 10, 15 and 20 days after flowering and germination rates and growth in culture studied. The aim is to provide conditions for immediate germination, sampling and seedling development for transplant. The *in vitro* plantlets produced offer ideal materials for DNA sampling, genotyping and marker assisted selection. Thus only preferred genotypes may be advanced to the next generation. Plants propagated in small pots (8×8×8.5 cm) under continuous lighting flowered in less than 40 days. With embryo rescue, an average of 48 and 60 days were sufficient to complete the generation cycle for the wheat and sorghum cultivars tested, respectively. Sufficient seed (5-20 for small pots and 15-45 for medium sized pots) were produced for the next generation cycle. This enables up to 6-7 generations to be produced in one year which is enough to reach sufficient homozygosity to advance a mutant line for bulking for field evaluation and progression to eventual official testing.

Doubled haploidy is another biotechnology that can speed up mutant line development. It enables the production of homozygous lines from any generation and recessive mutations can be exposed and fixed in one generation. Simplified protocols for anther and microspore culture in wheat, sorghum and barley are being developed. Genotype, growing condition of donor plants, stage of spike collection, pre-treatment of spikes/anthers, media composition and culture condition are among main factors influencing success in anther/microspore culture. Pollen irradiation for doubled haploid production is also being investigated both as a pre-treatment to stimulate microspore development *in vitro* and to stimulate *in vivo* haploid embryo development after pollination via parthenogenesis.

Integration of such biotechnologies together with *in vitro* selection and molecular markers for mutant assisted backcrossing offer potential in speeding up the delivery mutant cultivars and allowing rapid plant breeding responses to new challenges to food production such as changing climate.

Keywords
Barley, breeding cycle, embryo rescue, doubled haploidy, wheat

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