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CROP HEALTH
Augmenting National Income

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Breeding and Biotechnological Applications FOR SUSTAINABLE CROP HEALTH MANAGEMENT

On average, GMOs have increased crop yields by 22% and reduced chemical pesticide quantities by 37%.

Plant Breeding has always played a pivotal role in human history from revolutionizing agriculture to feed the ever-growing population. However, longer time invested in variety development and breeding cycles presents a stumbling block to an accelerated response of plant breeders to the growing demand for food production. Breeding and biotechnological approaches for crop health management is aimed at increased substantially agricultural production with enhanced nutritional content and enhanced tolerance to abiotic and biotic stresses.

Pre-breeding with Crop wild Relatives

Pre-breeding is an opportunity to introgression of desirable genes, from wild species (primary, secondary and tertiary gene pools) into elite breeding lines/ cultivars/ genotypes, to overcome the linkage drag. Crop wild relatives (CWRs) are good reservoir of untapped genetic diversity, which may not exist in the cultivated gene pool that can be used to improve the numerous trait of interest including resistance/ tolerance against diseases, insect-pests, drought, salinity, cold, heat and good agronomic adaptation with quality improvement.

Resistance Breeding

Host plant resistance need to be integrated into a crop management system. This will not only have to take into account the availability of plant resistance genes but also other factors affecting crop phenotype such as agronomy, breeding system, alternative control measures and most importantly the potential of the pathogen to evolve new pathotype.

Resistant varieties are the only solution to various viral diseases in crop plants threatening its cultivation. Recently, Anand Agricultural University has developed highly resistant varieties through resistant breeding approach that includes GAO 5 and GAO 8 in Okra, GAU 4 in Black gram, GAM 5 and GAM 8 in Green gram.

Considering the various direct and indirect impacts of climate change on food production and agriculture along with rapid deterioration of arable land and perplexity of rainfall patterns, all these factors triggering various abiotic stresses such as drought, heat stress and biotic stresses like pest and disease attacks, the sophisticated techniques laden biotechnology toolkit has potential to address these immense challenges.

Transgenic Crops

Transgenic /Genetically modified (GM) crops have been developed since the 1980s and were first

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commercialized in a few countries in the mid-1990s. According to PRS India, transgenics has been commercially released in about 32 crops and flower species with a total of 439 different transgenic events. In 2018, GM crops were grown in 26 countries on an estimated 474 million acres of about 14% of the world's arable land.

The most widely used GMO traits thus far involve herbicide tolerance and insect resistance. India is both the world's largest cotton producer and largest Bt cotton producer with an adoption rate of 95% for Bt cotton. On average, GMOs have increased crop yields by 22% and reduced chemical pesticide quantities by 37%. Within less than 10 years after its first commercialization, more than 90% of the cotton growers had switched to GMO seeds showing that Bt cotton adoption has significantly and sustainably reduced chemical pesticide applications, leading to large health and environmental benefits.

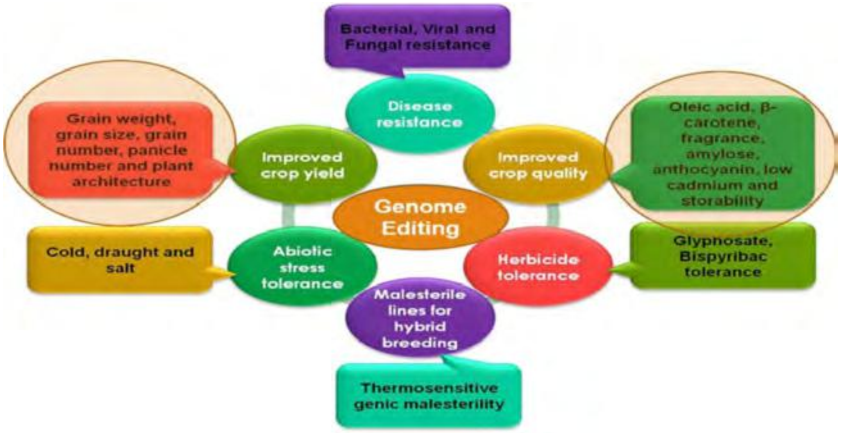
Marker assisted breeding

Genetic markers associated with agronomic traits can be introgressed into elite crop genetic backgrounds via marker assisted breeding (MAB). It allows stacking of desirable traits into elite varieties to make them better adapted to climatic changes. The ultimate goal of crop breeding to develop super-varieties by assembling multiple desirable traits, such as yield related, superior quality, tolerance/ resistance against biotic and abiotic stresses and good environmental adaptation. It is very challenging, difficult and time consuming to combine all traits in single genotype by traditional breeding.

Genome editing

Clustered regularly interspaced short palindromic repeat (CRISPR)/CRISPR-associated protein (Cas) system from Streptococcus pyogenes developed in last decade has been most versatile tool in breeder's toolkit to introduce desirable or novel traits and accelerate development of new crop varieties. A recently invented technique is gene editing, a much more precise form of genetic modification which often uses CRISPR technology.

On 30 March 2022, the Government of India released the Office Memorandum for Exemption of the Genome Edited plants falling under the categories of SDN1 and SDN2 from the provisions of the GMO Rules, 1989. If validated to be free of transgenes, they will be exempted from the current GMO regulations and can be released as a new variety and used for further development and evaluation. Many major countries like USA, UK, Mexico, Brazil, Argentina, Canada, India, China, Japan have implemented legislation that regulates genome edited crops, and now also two African countries have followed suit.



Speed Breeding

Speed breeding can potentially accelerate the discovery and use of allelic diversity in landraces as well as in CWR to be further used in developing improved crop varieties. The current pace of yield increase in staple crops like wheat, rice and maize is insufficient to meet the future demand in the wake of rising population. A major limiting factor in plant breeding is the longer generation times of the crops, typically allowing 1 to 2 generations in a year. Several 'speeding breeding' protocols, using extended photoperiods and controlled temperatures have enabled breeders to harvest up to 6 generations per year by reducing the generation time by more than half. Such protocols have been reported in several important crops such as spring wheat, rice, barley, chickpea and canola.

Food security and nutritional security of human being are dependent on effective crop health management wherein, crop breeding and biotechnology played key role in the past, present and future. Breeding resilient varieties is the best solution for crop health management as it is the cost effective, durable, ecofriendly and free from health hazards.