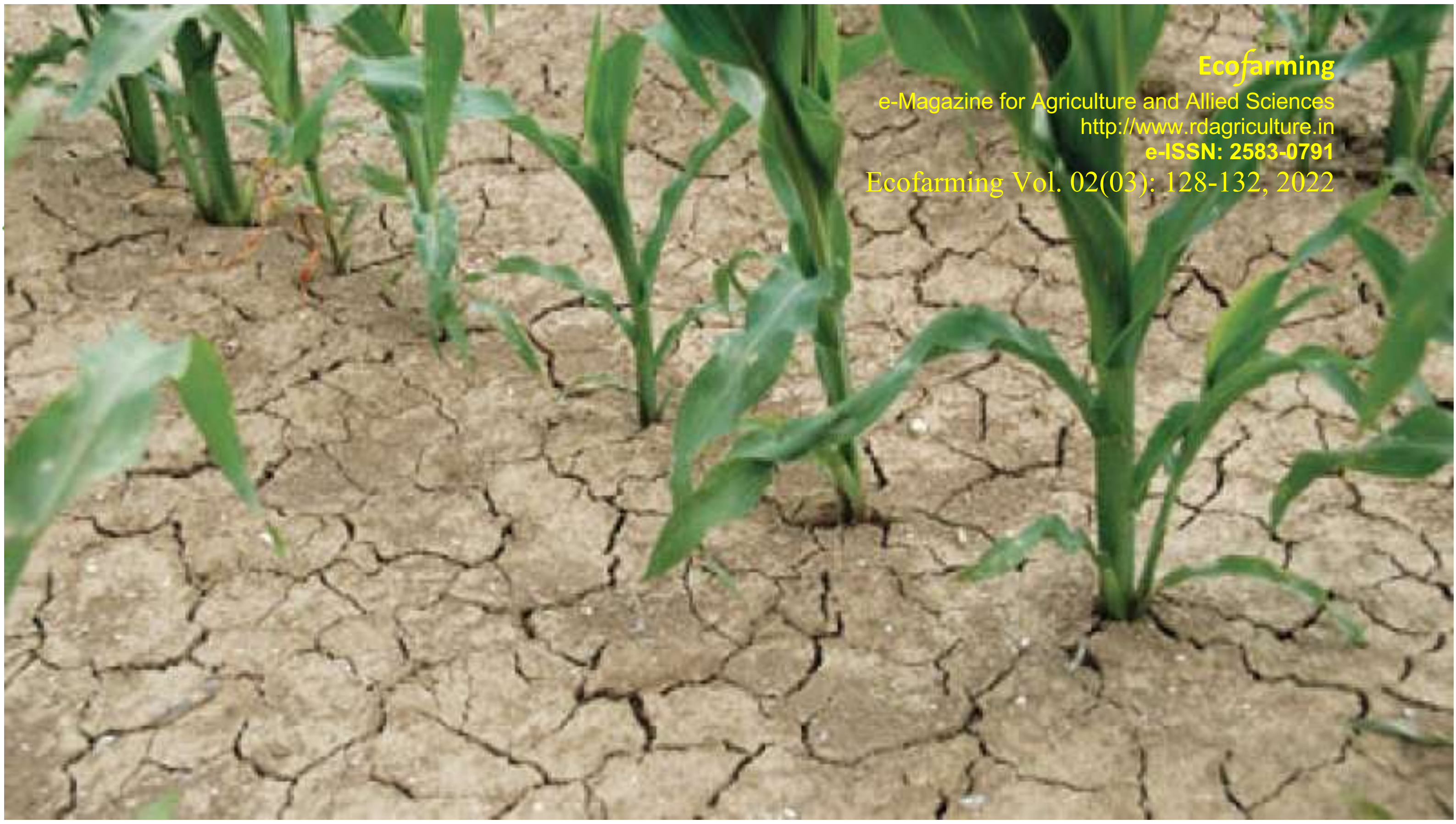

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Breeding for Drought Resistance: Need of the hour

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The global climate change has resulted in the serious decline in the availability and productivity of the cultivated arable land. Different types of abiotic stresses such as drought and heat, salinity and heat, etc., has been known to be even more destructive to crops in their combinations than the individual stress alone. These stresses also increase the occurrence and spread of biotic stresses like insect pests, pathogens, weeds, etc. Reduced plant growth due to drought or heat stress is a frequent and common phenomenon over the world. The stresses due to drought and heat are major issues for crop growth, development, yield, and sustainability of agriculture all over the world. In the rainfed areas, effective rainfall and its distribution throughout the season are becoming highly variable causing frequent and severe water stress in agricultural fields. The increased soil temperature due to increase in air temperature, becomes more severe when combined with drought stress. Under field conditions, water-deficit (drought) stress often occurs concurrently with high air temperature (heat stress), and now this has a become threat to agriculture and the sustainable food production world over. Severe stresses always negatively affect the crop yield and quality.

Among all abiotic stresses, drought stress is considered to be a major threat to sustaining food security under current and more so in future climates. About 58 per cent (80 M ha) of the net sown area in India continues to be rainfed which contributes for about 40 per cent of the total food grain production and supports two-third of the livestock population. India has witnessed more than 25 drought years in the last 130 years; with 1987 and 2002 and 2012 being the major one in recent times. The drought of 2002 led to decrease in acreage of more than 15Mha for kharif crops which resulted in the loss of about 10 per cent in production.

Effect of drought in plants

The drought *i.e.* low moisture availability for plants affects the plant growth, chemical constitution, photosynthesis level and growth regulators composition. Some effects of the drought on plant are discussed.

Plant growth

Dry soil and the loss of water through a high transpiration rate makes the plant experience drought stress, which leads to the loss of turgor. This stress results in the slow growth and under development of different plant parts. Thus, plants of drought climate are generally of short stature. The genotype of plant is highly affected by the environment for the quantitative traits so, the environment plays an effective role in growth.

Photosynthesis

The main effects of high temperature on photosynthesis result from changes in thylakoid physical-chemical properties (Gilmore and Govind, 1999) besides inducing an increase in lipid matrix fluidity (Raison *et al.*, 1982), with the consequent formation of a single-layer structure. High temperature causes the following disturbances to the organisation of the photosynthetic apparatus:

a) destruction of the oxygen evolution complex;

b) dissociation of the light harvesting complex of PSII accompanied by variations in energy distribution between PSII and PSI;

c) inactivation of the PSII reaction centre (P680), which disturbs grana stacking (Yamane *et al.*, 1998)

The result of all these events is the loss of photochemical and carboxylation capacity as well as serious metabolic restrictions in the Calvin cycle, such as the inactivation of ribulose-1,5-bisphosphate carboxylase/oxygenase and variations in the metabolic pool, especially ATP and NADPH availability (Pastenes and Horton, 1996).

Sources of Abiotic Stress Resistance

There are several informations on the sources of abiotic tolerance in crop plants. The major sources of drought tolerance are the land races, wild relatives, high yielding varieties, initial breeding materials and advance breeding materials. Land races from dry habitats have been used successfully in breeding toward developing

OPVs or hybrids for moisture stressed conditions. Wild species and progenitors of our cultivated crops were always the possible donors of the tolerance/resistance genes for abiotic stress. The choice of genetic resource to use as donor for abiotic stress tolerance depends on the probability of discovering the required genes as well as the expected difficulties. Biotic and abiotic stress genes may also be introduced by genetic engineering.

Breeding methodologies

The mode of pollination *i.e.* self or cross pollination is the key factor for a breeder for selecting the most appropriate breeding method for any crop. The cultivar type associated to the genetic control of the traits since individual plants react so differently to similar abiotic stress factors, it can be difficult to breed a species for more than one resilient trait at a time, but that is precisely what plant breeders are looking to do.

Conventional approaches

Selection and Introduction

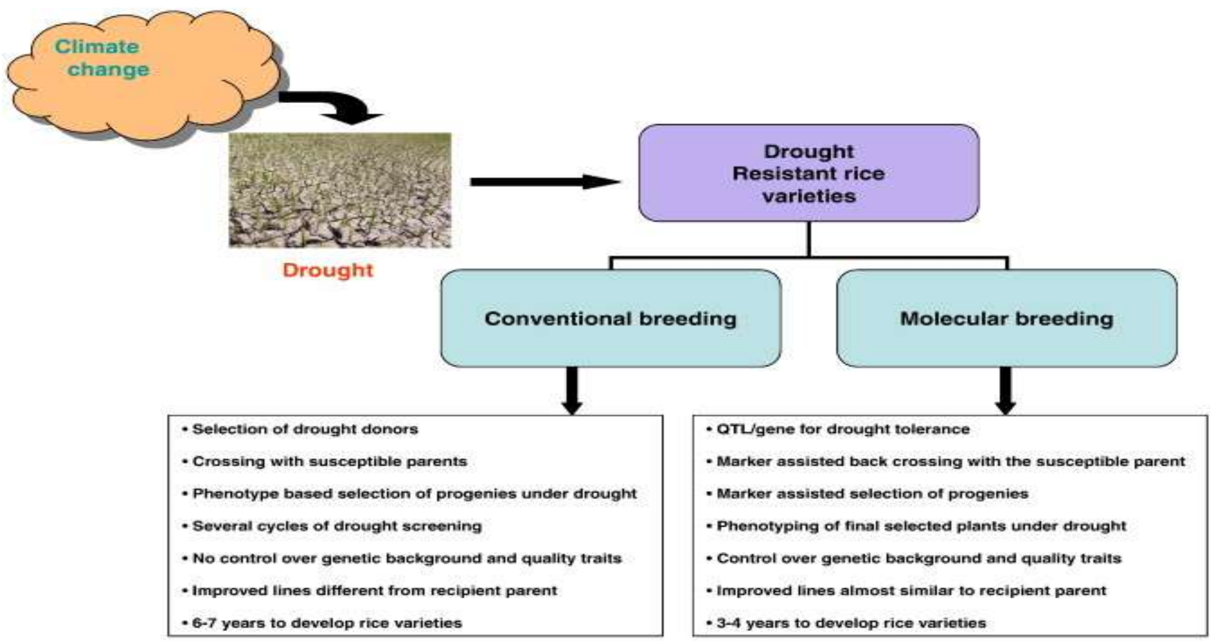
Breeding for any trait start with the assembly of genetic variation through the collection and evaluation of the available germplasm. If the desirable variability is not available within a locality or species, introduction of the exotic germplasm can be resorted to. This classical approach is still very relevant in all breeding strategies.

Pedigree method

Pedigree selection method can be used to identify superior genotypes for grain yield in a cultivar development program. Pedigree method is a genetic improvement method in which superior genotypes are selected from segregating generations and proper records of the ancestry of selected plants are maintained in each generation. Varieties *viz.,* CSR0-10, CSR-13, CSR-23, CSR-27, CSR-30, CSR-36, CR Dhan-402, CR Dhan-403, TRY-1, TRY-2, TRY3, White ponni, CO-43 etc. were developed by this method.

Shuttle Breeding

In the shuttle breeding approach, pre-breeding or advanced breeding materials are evaluated at two locations for their adaptability and the best selected materials are mated again and evaluated at another site in replicated trials.



Mutation Breeding

Mutation breeding is mostly used for creating the genetic variability in the existing gene pool of a species. Chemical mutagens like Ethyl methyl sulfonate (EMS) provide broad spectrum genetic changes with lesser sterility effects, as compared to other mutagens like X ray or particulate mutagens. Mutation is used when the desired genes are not available in the germplasm.

Diallele Selective Mating System Supplemented by MAS

The biggest problem in breeding of self-pollinated crops is the narrow genetic base in the upcoming generations as plant breeders can perform crossing in only two individuals for a single cross, on three and four way cross, and at the four most for a double cross. So, for increasing the parental control, broadening of the genetic background, and break up linkage blocks, Scientist of IRRI employed diallele selective mating system (DSMS), which is modified from the DSMS suggested by Jensen (1970). This modified DSMS has become a permanent breeding scheme for developing multiple abiotic stress tolerance genotypes with wider adaptability. Basically, this method is a type of recurrent selection scheme in which only the alleles of interest are taken in next generations for further intermating.

Recurrent Selection Method

Crosbic *et al.* (1981) suggested that photosynthetic rate could be improved by recurrent selection and thereby drought tolerance. Eight cycle of recurrent selection for improved drought tolerance in a tropical maize population resulted in a yield gain of 500-800 kg/ha (Edmeades *et al.*, 1992). Recurrent selection for drought tolerance for three to eight cycles has increased grain yield under drought at flowering by 30-50 per cent in three low land tropical maize populations (Chapman and Edmeades, 1999).

MAS for Drought Tolerance

In 2007, MAS 946-1 became the first drought tolerant aerobic rice variety released in India. To develop the new variety, scientists at the University of Agricultural Sciences (UAS), Bangalore, crossed a deep-rooted upland japonica rice variety from the Philippines with a high yielding indica variety (Chandrashekar, 2007). The new variety consumes up to 60 per cent less water than traditional varieties. It saves 3,000 litres of water for every kg of rice.

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