Preface

Plant breeding is defined as the art and science of changing genetic architecture of plants for the benefit of mankind and it has been in practice for thousands of years, since the beginning of agriculture. However, it is being practiced more scientifically ever since the rediscovery of Mendel's laws in 1900 and has become increasingly precise by the use of new molecular tools. In addition to simple selection methods, crop improvement involves sexual hybridization of desirable parents followed by selections in the segregating populations so as to select desirable combinations and eliminate the undesirable ones. Even today, this is the predominant practice in crop improvement, although various tools like mutation induction, wide hybridization, exploitation of somaclonal variation, genomic tools, and genetic transformation are also employed. Thus plant breeders have been largely engaged with creation of variation and selection to improve the crop plants over decades.

Plant breeder's task is to select the plants that most likely meet the breeding objectives. Selecting a desirable combination and rejecting the undesirable one remains a challenging task given the fact that selections have to be exercised on a large number of plants/progenies with due consideration to a large number of traits, both qualitative and quantitative. The greatest apprehension haunting a breeder is the loss of superior plant/progeny during selections. As a consequence, the number of selections increased, sometimes by selecting the undesirable combinations, which burdens both time and resources required to handle them. Thus, success of a breeding program largely depends on use of an appropriate phenotyping method enabling a breeder to make judicious selections. Plant breeders have been using new tools like trait selection and use of markers to select gene(s) (marker-assisted selection) and/or genomes (genome-wide selection) to enhance the speed, accuracy, and scope of selection process. These techniques complement the selection process in breeding but cannot replace phenotyping for two reasons: first the design of these tools itself needs high-throughput phenotyping and second the need for the genotyped selections be confirmed by phenotypic data. Thus even the application of new tools essentially requires appropriate phenotyping systems.

A phenotype is any measurable characteristic or trait of a plant and is a result of combination of genes expressing in the plant (referred to as genotype), environmental influence, and their interactions. Phenotyping to a plant breeder means characterizing the performance of the plants for desired trait(s). Phenotyping is central to plant breeding to carry out selections; in addition, it is also done to study genetics of the traits, to associate markers with traits, to understand trait diversity, etc. Although routinely used, it still remains a factor of paramount importance for the success of breeding programs and to derive valid conclusions from genetic studies. In fact generating reliable phenotype data is now considered as a major limiting factor in breeding programs. Even in this era of genomics where state-of-the-art genotyping techniques and bioinformatics tool are available, the progress and validity of the results are largely constrained by the generation of reliable and reproducible phenotype data.

The objectives of a crop-breeding program in general are to develop improved varieties/hybrid parents with specific adaptation, high yield potential possessing pest and disease resistance, abiotic stress tolerance, enhanced nutritional content, high quality, market preferred traits, etc. These additional traits are as important as increasing yield and are often of critical significance as they offer protection from yield losses, improve quality, and thus enhance the economic returns. Plant breeding is often a painstakingly slow process; therefore a breeder often has to look many years ahead of the requirements of farmers and consumers to prioritize crop-breeding objectives. These objectives are location specific and depend on the economic importance of the trait.

We have therefore in this book discussed the phenotyping techniques for prioritized traits in some of the agriculturally important crops. This book broadly discusses various established methods of phenotyping for important biotic and abiotic constraints and other traits of interest. Thus it serves the requirements of a practical plant breeder who is often perplexed with the selection process requiring a good phenotypic method. A large number of reviews and books are now available on the use of molecular and genetics tools in plant breeding, although not many breeders have access to use them in their breeding programs. On contrary, we don’t find comprehensive information on phenotyping of plants which indeed can be routinely used in breeding programs, and a large number of breeders even in developing counties can use such phenotyping techniques. A crop breeder has to pull information from many different publications before she/he chooses an appropriate screening method. This book is also important in the context of dwindling numbers of plant breeders who can guide students and younger generations on practical issues of selections, and a majority of students now consider plant breeding an old-fashioned science where modern tools are not applied. While the fact remains that plant breeding has played an important role in increasing the crop production through improved cultivars and will continue to play a key role in future in meeting future food, fodder, fiber, and fuel demands.

This book is intended to serve as a useful guide to practicing plant breeders to use appropriate phenotyping methods for improving the major traits in selective crops. This also helps the teachers and students in plant breeding to better understand the phenotyping and its importance in plant breeding.

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