Preface

Plant breeding is a discipline that has evolved with the development of human societies. Similar to the rapid changes in other disciplines during the twentieth century, plant breeding has changed from selection based on the phenotype of individuals to selection based on the information derived at the deoxyribonucleic acid (DNA) level in molecular genetic laboratories and data from replicated field experiments. The initial beginnings of plant breeding occurred when humans made the transition from a nomadic hunter–gatherer lifestyle to the development of communities, colonies, tribes, and civilizations. The more sedentary lifestyle required that adequate food supplies (both plant and animal) were available within the immediate surrounding areas. The plants available within the immediate areas became very important to sustain the food, fuel, fiber, and feed needs of the local settlements. Hence, the greater the grain and forage yields of the native plants, the greater the sustainability of the needs of the local settlements. They recognized the relative importance of some plant species that could meet the needs of the settlements and practiced selection of individual plants that had greater grain and/or forage yields. Seed was saved from desirable plants to perpetuate the plants in the next growing season. By present-day standards, the methods of selection would seem simplistic because selection was based only on the phenotype of individual plants. But the selection methods were effective to develop landrace cultivars that provided substance for the local settlements to prosper and expand into regional civilizations. The landrace cultivars also were the germplasm resources for future generations of plant breeding. The original plant breeders, therefore, provided the plant resources for the development of human societies and the germplasm resources to sustain modern human societies. The major contributions of the early plant breeders were to develop domesticated crop species, dependent on humans (in some instances for survival) from their wild progenitors.

Domestication of our major crop species from their wild progenitors occurred over broad areas and time frames. The extent and rapidity of the distribution of the different domesticated crops depended on human movements within and among different areas of the world. It is estimated, for example, that maize (*Zea mays* L.) was domesticated 7,000–10,000 years ago in southern Mexico and Guatemala. Maize, however, was unknown outside the Western Hemisphere until Columbus

(1493) brought maize seed upon his return to Europe. The potential of maize was recognized and spread rapidly throughout the world. Similar patterns occurred for the other domesticated crop species. Because of the different needs of the different societies and the different environments inhabited, the next stage of plant breeding occurred. The selection techniques of the domesticators were used to develop cultivars adapted to their specific environments. Within the domesticated crop species, different landraces were developed that had the desired traits for the local needs and customs and environmental conditions. By 1900, it was reported, for example, that more than 800 distinctive open-pollinated cultivars were available in the United States. Until 1900, the plant breeding selection methods emphasized selection of individual phenotypes, but modifications were being made to improve selection effectiveness, such as the progeny test suggested by Vilmorin in 1858. Although the early plant breeders did not have a knowledge of Mendelian genetics (and his predecessors, they did observe that progeny tended to resemble their parents) and scientific methods to separate genetic and environmental effects (i.e., heritability) in trait expression, the early plant breeders were effective in domestication of wild, weedy plants for human use and the development of improved strains and cultivars that provided the germplasm resources for twentieth century plant breeders.

Plant breeding is often described as the art and science of developing superior cultivars. Art is defined as the skill in performance acquired by experience, study, or observation, which were certainly strong traits of the early plant breeders, whereas science is defined as the knowledge attained through study or practice. The distinctions between art and science are not always clear because even with experimental field and molecular data, subjective decisions are often necessary in choices of parents, progenies to consider for further testing, choices of testers, stage of testing, etc. But the relative importance of the art and science of plant breeding was reversed during the nineteenth and twentieth centuries with the emphasis on science (data driven) replacing emphasis on art (phenotypic appearance). The scientific basis of plant breeding was enhanced in the early part of the twentieth century by several developments, including the rediscovery of Mendel's laws of inheritance; a greater understanding of Darwin's theory of evolution based on Mendelian genetics; development of field experimental methods (randomization, replication, and repetition) to make valid comparisons among cultivars; theoretical basis for the inheritance of complex traits designated as quantitative traits; integration of the concepts of evolution, Mendelian genetics, and quantitative genetics to provide a basis to understand (and predict) response to selection; the importance of recycling of germplasm (both via pedigree selection within crosses of related lines and genetically broad-based populations) to enhance consistent genetic advance; and the advances made during the latter part of the twentieth century in molecular genetics on qualitative trait loci. Each of the developments impacted plant breeding methods in different ways, but collectively, all have been important to provide a firm and valid genetic basis for developing superior cultivars for the producers. Each of the advances was made to give greater emphasis to selection based on genotypic differences. During the past 100 years, plant breeding has changed from selection based on individual phenotypes to selection at the DNA level for selection for primarily genetic differences. This trend will continue in the future with greater emphasis at the DNA, gene, and phenotypic levels.

This volume is a summary and an update on the breeding methods that have evolved for our major cereal crop species, especially those based on breeding experience, often not presented in books. Similar to other research disciplines, rapid changes occur annually for the scientific basis of plant breeding. Although the basic genetic information and techniques of plant breeding continue to evolve, the basic concepts of plant breeding to develop superior cultivars remain the same; integrate all the available information to enhance the effectiveness and efficiency of our choice of parental materials, genetic enhancement of germplasm resources, estimate breeding values of progenies with greater levels of precision, and develop genetically diverse cultivars with greater tolerances to pest and environmental stresses as well as greater quality for a healthier diet. There is documented evidence that significant genetic improvements for greater yields have been made in cultivated crop species during the twentieth century. Similar genetic improvements are needed to meet human needs (e.g., biofuels) during the twenty-first century. Genetic information at the DNA level will continue to provide basic scientific information and will, hopefully, have a greater role in the future. Similar to other scientific disciplines, the science of plant breeding will continue to evolve for development of superior cultivars with the necessary traits to continue to provide adequate nutritional food supplies to sustain continued population expansions in a world of finite dimensions. Plant breeders have and will continue to develop cultivars. Plant breeding has and will continue to have important roles to ensure the future health of the world's human societies.

Fargo, ND Marcelo J. Carena
Ames, IA Arnel R. Hallauer

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