CHAIRS' SUMMARY PAPER: Conventional and Novel Methodologies for Plant Improvement

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Forage breeding is rapidly evolving to efficiently and effectively utilize numerous recent technological advancements. Forage breeding of the future will continue to evolve toward a greater dependence on interdisciplinary collaboration, particularly with molecular biologists and geneticists. Existing and potential collaborations have created the possibility of new and previously unimagined genetic combinations in forage crops. Forage breeders and geneticists face the dual challenge of incorporating such novel genetic combinations into superior genetic backgrounds and convincing the public that these germplasms will not have undesirable side-effects on society.

PLANT BREEDING VS. PLANT GENETICS

Because of the diversity among delegates to the International Grassland Congress and the various implications of new technology, distinction must be drawn between the two sub-disciplines of forage breeding. Plant breeding refers to the development of new cultivars, while plant genetics refers to research with a goal of advancing our understanding of plant genomes, genetic inheritance systems, mating systems, and/or plant breeding methodology. In many countries these activities are clearly compartmentalized between the private and public sectors, respectively. In others, they are inextricably intertwined, sharing funding sources, personnel, and facilities within a single program. The distinction between the two sub-disciplines becomes most important when the relationship between conventional and novel technologies is examined.

CONVENTIONAL PLANT BREEDING AND GENETICS

In his plenary paper, Dr. M. O. Humphreys compared the progress made toward improving forage crop biomass (mean of 4%/decade) vs. that made in improving grain yield in cereal crops (mean of 12%/decade). He gave four reasons for this lag in progress: (1) a longer breeding cycle for forage crops, (2) greater exploitation of heterosis in grain crops, (3) improvements in harvest index of grain crops, and (4) a focus on other traits in forage crops (eg. seasonal growth vs. total growth, various stress tolerances, and forage nutritive value).

There was some discussion of both the numerical values and their causes. The 4%/decade value may be an underestimate of the actual gains due to forage breeding, because old cultivars, representing true historical yield levels, may not have been included with sufficient frequency in evaluation studies. As they become more susceptible to pests, they are phased out and comparisons to new cultivars often become moot.

While the reasons for reduced progress toward increased yield of forage crops compared to grain crops are valid, they nevertheless suggest considerable opportunity for improvement of germplasm per se and plant breeding methods. First, breeding cycles can be reduced through imaginative selection and intercrossing systems, although there has been very little research done in this area.

Second, there has been considerable research done on the utilization of heterosis in forage crops, with little progress. Unreduced gametes, self-incompatability systems, and strain crosses between complementary lines all show promise, but have yet to be commercially utilized. Genetic mapping technologies offer considerable promise as tools to gain an increased understanding of the genetic basis of heterosis and its utilization in forage crops. The challenge is to overcome the difficulty of selfing in most outbreeding forage crops and to fix heterosis in a commercially viable product. Progress in this area will likely occur only through a mixture of plant breeding and plant genetic research and a combination of conventional and novel tools. The ability to characterize the molecular makeup of individual genotypes and their hybrids may be one of the most valuable contributions of molecular biology to the field of plant improvement. These techniques allow plant breeders to more accurately quantify the genetic effects of hybridity and predict the consequences of hybridization.

Third, forage crops have no harvest index per se. However, there has been considerable research on morphological modifications to both above- and below-ground portions of forage crops. Many of these modifications have led to the development of new germplasm with improved tolerance to stresses such as competition from neighboring plants and drought.

Finally, the posters of this session demonstrate considerable activity in three themes related to plant improvement. First, breeding and genetic variation for stress tolerances, including cold, aluminum, acid soils, and various diseases. Second, the use of interspecific hybrids for introgression of desirable genes between species. Third, selection methodology, including the use of grazing animals, genotype x environment interaction, selection for self-fertility, apomixis, the use of strain crosses, and co-existence between neighboring plants.

NOVEL PLANT BREEDING AND GENETICS

In his plenary paper, Dr. G. Spangenberg summarized a range of molecular tools that can be used to augment plant breeding and plant genetic programs. These techniques include *in vitro* plant regeneration, tissue culture, molecular markers, genome characterization, gene cloning, and plant transformation. Many of these procedures have been instrumental in the development of forage crop cultivars, particularly in the development of interspecific hybridization techniques that have allowed the successful introgression of genes between species. Other techniques, such as plant transformation have the potential to contribute both to new cultivars (new and useful genetic combinations) and plant genetic research (rapid generation of pseudo-isogenic lines).

Posters of this session reflected considerable interest in a wide range of species and tools, including tissue culture and *in vitro* plant regeneration in wide hybridization, identification of quantitative trait loci by molecular markers, and plant transformation.

The discussion of this session focused on the use and adoption of plant transformation in practical plant breeding programs. Although new cultivars which include transgenes are prohibited in many countries, the overwhelming sentiment of the delegates was that this policy will change as education programs begin to take effect. Public opinion and fears need to be understood and scientific knowledge needs to be interpreted and disseminated in a positive and effective manner. There are still many issues that relate to the best strategies to move transgenic plants into practical breeding programs. For example, how many copies of the transgene are present, what is the stability of the transgene, what regulations govern the official testing and release of transgenics, and what are the possibilities of hybridization with wild relatives?

Delegates raised some concerns about classification of breeding tools as conventional vs. molecular. There was some sentiment that the product of the work is important, not the method of achievement. Indeed, the interest among delegates from both practical plant breeding and basic plant genetics for using molecular genetic tools attests to their place in the plant breeding/genetics toolbox.