CHAIRS' SUMMARY PAPER: Plant Physiology and Growth

G. Bélanger[1] and P. G. Jefferson[2]

[1] Soils and Crops Research and Development Centre, Agriculture and Agri-Food Canada, 2560 Hochelaga Boul., Sainte-Foy (Québec), Canada G1V 2J3

[2] Semiarid Prairie Agricultural Research Centre, Agriculture and Agri-Food Canada, P.O. Box 1030, Swift Current, Saskatchewan, Canada, S9H 3X2

Forage crops and pastures often grow under abiotic and biotic stresses such as drought, low temperature, nutrient deficiencies and defoliations. This contrasts with annual crops for which maximizing grain yield under optimum environmental conditions is a high priority, and defoliation rarely occurs. Understanding the effect of stresses acting either alone or in combination on the herbage production of forage crops and pastures is essential to manage them efficiently and to improve them genetically.

The physiological responses of forage and pasture species to three environmental stresses in relation to the genetic variability were discussed in the first plenary paper by C.F. Eagles. The second plenary paper by C.J. Nelson focused on growth mechanisms at the plant level. Poster papers covered a wide diversity of stresses encountered by forage crops and pastures, and many of the growth mechanisms involved in the response to environmental stresses.

PHYSIOLOGICAL RESPONSES TO STRESSES AND GENETIC VARIABILITY

In the first plenary paper, the methods required to identify genetic variability for physiological responses were discussed in relation to the development of selection criteria. The emphasis was placed on perennial grasses and white clover, and on three environmental stresses: cold, heat and drought. In his oral presentation, C.F. Eagles focused on cold stress which is of particular importance in Canada. Significant advances in our understanding of the physiological basis of cold hardening and dehardening, and its genetic control have been achieved over the last few years. As indicated by the plenary speaker, however, much remains to be done. The possibility of dissociating the negative relationship between dormancy and plant growth (survival vs growth strategy) remains a challenging task. It can only be achieved by a greater understanding of the mechanisms involved in the relationship between dormancy, winter survival and plant growth at different levels of plant organization, and the genetic control of those mechanisms. A good example of this type of study is reported by Volenec et al..

The study of low temperature response mechanisms depends on the LT_{50} artificial freezing technique to predict field results. As C.F. Eagles pointed out, a good correlation between field and laboratory responses is essential for progress to be made. The temperature threshold for these mechanisms are species specific. Therefore, results from *Lolium spp.* cannot be extrapolated to other species. Dr. Eagles also pointed out the interference of photoperiod to the temperature-based hardening mechanism. This may have major implications for species such as *Phleum pratense* because plant breeding has become consolidated at very few locations.

The genetic variability in physiological responses to cold, heat, and drought which is available for selection was also discussed in the first plenary paper. Examples of genetic variability for other stresses such as N deficiency in tall fescue (Gastal et al.), timothy (Bélanger et al.) and perennial ryegrass (van Loo et al.); and salinity, defoliation and aluminium were presented in this session and in the session on "Conventional and novel methodologies for plant improvement". Genetic variability is extremely useful to the field of plant physiology in that it provides tools to study the mechanism of stress response.

Mechanisms associated with water and high temperature stress tolerance are not as well understood as those related to low temperature stress. Is this related to the lack of a physiological screening technique for drought stress that is correlated to field response? The lack of correlation between leaf water potential status and stomatal conductance or the observations that chemical signals from roots in drying soils affect stomatal conductance both indicate that a new paradigm is required. This new model of drought stress response will provoke the development of physiological screening techniques for genetic adaptation to drought stress. Examples of research reports with only two levels of water stress (i.e. droughted and control) can be found in this proceedings. Future research requires more precise control of water stress, especially in the evaluation of contrasting genetic materials.

Selection for specific traits to improve tolerance to environmental stresses will continue, and most likely benefit from the tools of molecular biology. Nevertheless, the agronomic and ecophysiological evaluation of selections for specific traits and other important traits will be required. As examples, posters were presented on the effect of selections for different white clover morphologies on drought tolerance (Karsten et al.), and the effect of white clover populations with different nodulation patterns on the partitioning of phosphorus (Crush).

The plenary paper and many posters confirmed that genetic variability exists for many traits of interest. Combined efforts of physiologists and breeders are required to make good use of this variability. The study of divergent genetic materials has produced important hypotheses for further study of cold hardening processes (Volenec et al.). This illustrates the scientific value of integrating plant breeding and physiology research efforts.

PLANT CONSIDERATIONS

In his plenary paper, C.J Nelson focused on the growth of grasses at the tiller and phytomer level, and reviewed the utilization of C and N resources. The phytomer concept is useful for understanding grass sward response to environmental conditions. However, phytomers can exhibit tremendous plasticity in response to the environment and do not describe legumes nearly so well. Nitrogen concentration in intercalary meristem region of C_3 grasses is correlated with leaf elongation rate but soluble carbohydrate concentration is not. Tillering control in grasses is a complex mechanism involving auxin, cytokinin and phytochrome mediated responses. Interesting comparisons of C_3 and C_4 grasses, and legume and grasses were also provided by C.J. Nelson.

Numerous posters dealt with the issue of morphological development. Leaf appearance rate or phyllochron may be a useful regrowth indicator for management of rotational grazing systems as mentioned by Frank et al. and Laplace et al.. The use of quantified scales of morphological development for the characterization of swards was highlighted in two posters by Mitchell et al.. The effect of stresses (N, water, defoliation, salinity) and species/cultivars on different aspects of morphological development were discussed (Fisher et al.; Gomide and Gomide; Klich et al.; Lattanzi et al.; Taleisnik et al.). The hormonal control of bud development after defoliation (Nojima et al.) and the effect of light quality (Hay et al.; Jefferson and Muri; Varlet-Grancher et al.) were also presented and mentioned in the discussion. The plenary paper and numerous posters illustrated the significant progress made in our understanding of the mechanisms controlling leaf appearance, tillering, and root development.

The importance of research on roots was illustrated by the number of posters and the discussion. It has been shown that root N reserves play a significant role in the regrowth of legumes and grasses (Ourry et al.; Volenec et al). Root N reserves would also be involved in cold tolerance (Volenec et al.). The morphological and functional relationships between shoots and roots were discussed in posters by Moser and Smart, and Barker and Dymock. A significant proportion of C is invested in the root system, and this proportion varies according to the level of stress encountered by the crop. The importance of the plant C investment to the root system under stress and non-stressed conditions was discussed, and good examples were the studies that determined the best C investment strategy under defoliation presented by Birch and Thorton, and Matthew and Kemball.

Most forage crops and pastures are grown in mixtures and competition frequently interacts with other stresses in the field environment. The introduction of species into monocultures was discussed by Porter et al.. Relationships between species grown in mixtures were discussed in terms of N transfer from legume to grass (Tow), allelopathic interactions (Souza Filho et al.). and competition between palatable and unpalatable grasses when subjected to grazing (Distel and Moretto). Further research should focus on stress responses in competitive environments.

CONCLUSION

The plenary papers and posters presented some interesting avenues of research such as the role of N reserves in regrowth and winter survival, and the role of light quality in morphogenesis. At the previous Congress in New Zealand and Australia, A.J. Parsons in his summary of the session on Plant growth which focused on defoliation, justifiably stated that " the challenge for the future is for grassland scientists to combine the concepts of physiology with those of ecology". It is apparent that plant physiologists are meeting this challenge. This was highlighted by C.F. Eagles in his plenary paper when he discussed the relationship between plant growth and plant survival in relation to cold and water stresses. To that, however, both plenary speakers and many posters added the dimension of genetic variability. Combining the concepts of ecology and physiology needs to be done in the context of the genetic variability.