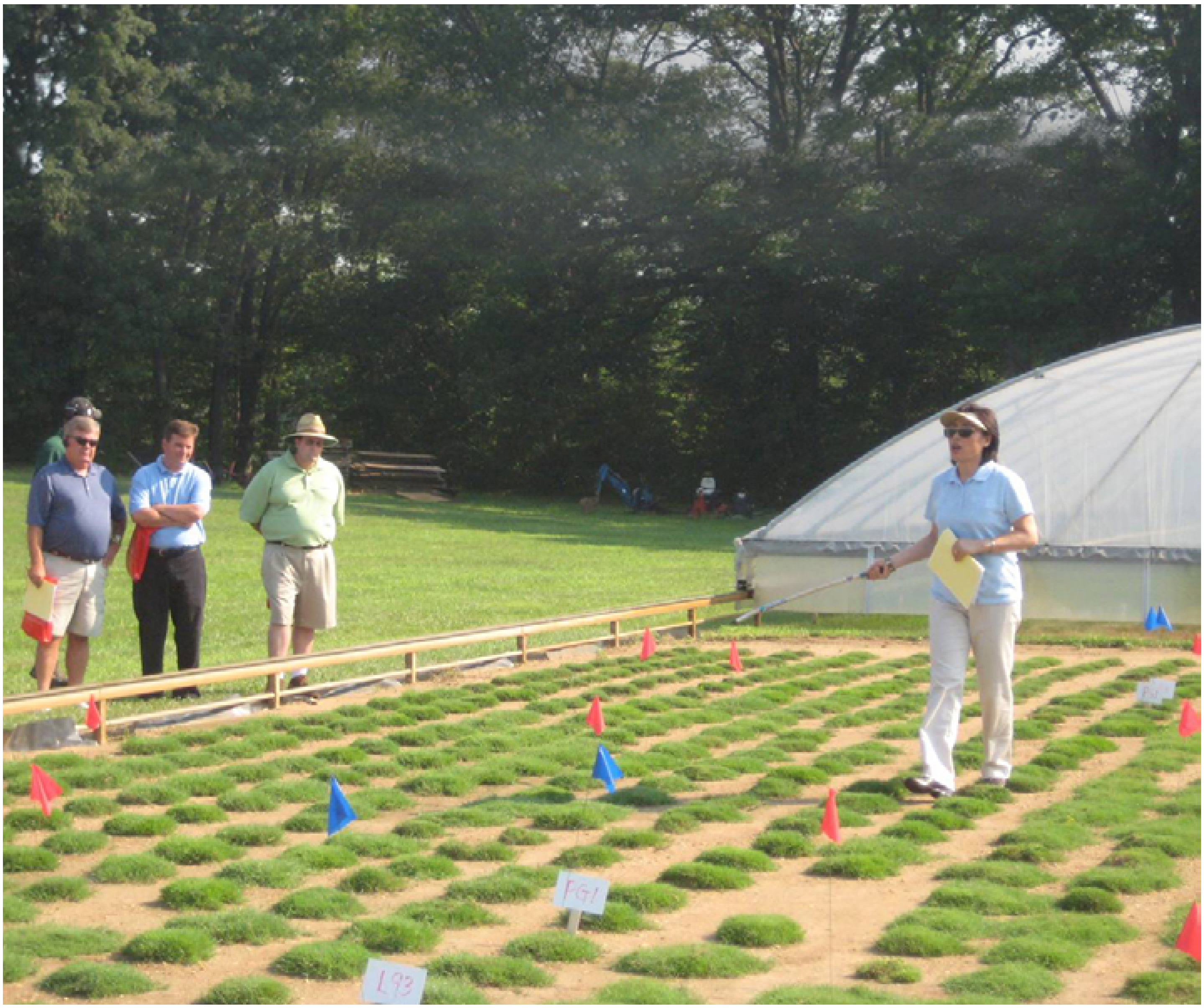
Searching for the Right Stuff: Tolerating Hot and Dry

Rutgers University scientists examine genetic clues to improve heat and drought tolerance of creeping bentgrass cultivars.

BY JEFF NUS, PH.D.



Dr. Bingru Huang at Rutgers University discusses a field trial evaluating the heat and drought performance of creeping bentgrass breeding materials.

Rutgers University has established itself as one of the nation's premier universities for turfgrass research. The essential connection between plant physiology and plant breeding is well developed within the community of turfgrass scientists at this northern New Jersey university. One project that benefits from an interdisciplinary approach is working to improve the heat and drought tolerance of creeping bentgrass. Dr. Bingru Huang, who leads the project, explains why this work is both relevant and vital.

"Heat and drought are the two most detrimental and most widespread abiotic stresses limiting the growth of turfgrasses, particularly for cool-season species," Dr. Huang explains. "It is costly to manage stressed turf, as more water, fertilizer, and fungicide may be required to control the decline in turf quality due to heat or drought. Improving heat and drought tolerance can result in significant savings in management costs and reduced environmental impacts."

Dr. Huang's project involves functional genomics (how the plant's DNA controls vital plant functions) of heat and drought tolerance of creeping bentgrass. To do that, her team is identifying quantitative trait loci (QTLs) associated with heat and drought. "Quantitative trait loci (QTLs) are stretches of DNA, or DNA regions, that contain or are linked to the genes underlying a quantitative trait," she explains. "QTLs are useful for identifying and sequencing the actual genes underlying trait variation."

Genetic variation among plants is vital for improving any trait. Simply put, there must be enough variation among plants for plant breeders to select plants that exhibit superior levels of a particular trait. Conventional plant breeders have depended on that axiom for decades. In recent years, however, molecular genetics has enabled plant breeders to speed plant improvement with a process called marker-assisted selection.

Through a series of laboratory techniques involving replicating the DNA of plant selections and evaluating the banding patterns produced on special gels, molecular geneticists are able to identify plants with the necessary DNA for certain traits of interest. The spots showing up on the banding patterns of gels are called markers, since their presence denotes or "marks" the presence of the necessary DNA for that trait. Identifying markers and using them to select for better and stronger plants is the basis of marker-assisted selection.

Developing useful markers can speed up a breeding program dramatically. "Traditional breeding for new varieties can take five or more years. The integration of molecular markers in breeding programs enhances the effectiveness and efficiency of traditional breeding," says Dr. Huang. "Molecular breeding, or marker-assisted selection, is able to efficiently select for high numbers of crosses based on molecular markers linked to the target traits (genes). The technique may shorten the screening process by at least a year. This linkage helps breeders to predict whether a plant will have a desired trait based on the presence of the markers. The ultimate goal of this project is to identify molecular markers and genes for heat and drought tolerance to develop new creeping bentgrass cultivars with improved heat and drought tolerance."

To reach this goal, it is absolutely necessary to understand the processes that occur as turfgrasses react to drought and heat, and to relate the control of those processes to the genetic makeup of the plant. "Various physiological processes affect heat and drought tolerance. Among them, maintaining leaf turgidity or hydration, active photosynthesis, nutrient and water uptake by developing extensive root systems, as well as active protective and antioxidant defense systems are major physiological traits for turfgrass tolerance to heat and drought stress," says Dr. Huang. "We have now identified QTLs for some of these traits and are currently screening for specific molecular markers for these traits."

Some physiological responses of turfgrasses to abiotic stresses can overlap. In other words, turfgrass response to drought may involve processes that are also involved in response to other abiotic stresses, such as heat or soil salinity. This possibility may benefit Dr. Huang's goal to increase both heat and drought tolerance of creeping bentgrass.

"Heat and drought commonly occur simultaneously during summer months in many regions. Some heat tolerance traits are highly correlated to drought tolerance traits, such as stay-green leaves, cellular turgor maintenance, and root growth," says Dr. Huang. "Therefore, some QTLs identified for heat or drought tolerance may be used for improving turfgrass tolerance to either stress alone or in combination."

In addition to the response overlap to heat and drought, turfgrass responses may also be similar to drought and salt stress. Most plants, including turfgrasses, accumulate and concentrate both inorganic and organic solutes within their cells in response to both salinity and drought stress. This process is called osmotic adjustment, and it enables plants to absorb and retain more water during periods of drought or salinity stress.

"One of the primary effects of salt stress is the induction of osmotic stress that can cause plant dehydration. Drought stress also causes dehydration," says Dr. Huang. "Improving salt tolerance through dehydration protection mechanisms, such as osmotic adjustment, may also enhance drought tolerance, although not necessarily heat tolerance."

As Dr. Huang and her colleagues continue their research, one is left with the overwhelming impression that this work is very important for the future of golf courses. Its importance lies not only in the basic information it is revealing and the transferring of that knowledge to other turfgrass species, but also in the demonstrated synergy of combining breeding and physiology.

ADDITIONAL INFORMATION

Identification of Quantitative Trait Loci (QTL) Associated with Drought and Heat Tolerance in Bentgrass Species

Confirmation and Utilization of Candidate Gene Markers for the Selection of Heat-Tolerant Bentgrass

Evaluation of Perennial Ryegrass, Creeping Bentgrass, and Kentucky Bluegrass Cultivars for Salt Tolerance

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