Scientists and practitioners already get how critical genetics × environment (G × E) interactions are to realizing further gains in global crop yields and ensuring future food security. But will a focus on G × E by itself be enough to feed nine billion people by 2050? In a review published in the July–August 2015 issue of *Agronomy Journal*, USDA-ARS scientists Jerry Hatfield and Charles Walthall say no, arguing for inclusion of a third factor: management, or M. This is especially true, Hatfield says, given our changing climate and decreasing land base for agriculture. Learn what else he had to say on the subject in a recent interview with CSA News magazine.

**CSA News:** You argue in your review article that focusing on boosting actual farmer yields is a more feasible approach to feeding nine billion people than is trying to boost potential yield. Why is that?

**Hatfield:** Understanding the limitations to producers’ yields will help stabilize yields among years and provide more options for moving forward with yield improvement.

**CSA News:** So, if that’s the goal, then emphasizing G × E × M, rather than classic G × E interactions, is the foundation for moving forward?

**Hatfield:** That’s correct.

**CSA News:** How do you explain G × E × M in a nutshell?

**Hatfield:** The G × E × M concept is based on the idea that yield is a function of genetics, environment, and management options. The reason we made M a part of this is that if we want producers to increase their yields (point 1) they need to realize they have management options that will allow the genetics to more fully express their potential.

G × E × M does several things. First of all, it emphasizes the need to increase land productivity through improved management because expanding agriculture onto new land is not an option at this point. It offers a more integrated approach to addressing yield gaps and ensuring food security. And it provides a foundation for building a climate-resilient agriculture to offset the impacts of increasing variability in weather during a growing season.

**CSA News:** How does it achieve the last goal?

**Hatfield:** If you examine yield variation over time or within a field, you begin to see that the variation in production depends on seasonal weather patterns. And when we examine why yields fail to reach their potential, weather also tends to be the dominant factor. However, weather interacts with soil management or with nutrient management, giving us opportunities to counteract its effects. Increasing organic matter content to improve soil quality can have a positive impact on water conservation, for instance.

**CSA News:** Can you give an example?

**Hatfield:** We saw some anecdotal support for this approach during a recent severe drought in Iowa: Traditional crop varieties were able to outperform new drought-resistant varieties because of differing soil management practices. We also observed that fields with enhanced soil water availability produced very good yields—far in excess of the county average yields—because of the extra stored water in the soil profile. Those are some of the observations we’ve made during the past few growing seasons with the more variable weather. Improved soil management was able to sustain yields much more than improved genetics.

**CSA News:** What does a focus on G × E × M mean for the research community?

**Hatfield:** We list several implications in our paper. We need to develop methods of quickly screening genotypes for responses to different combinations of environmental and management factors. We need to focus on soil improvement (via management) to improve both water supply characteristics and nutrient cycling. As temperature and precipitation...
become more variable with climate change, the availability of water and nutrients will become more critical to achieving high yields.

Transdisciplinary teams of scientists are also needed to address these problems, and we should take a more site-specific focus to increasing yields that involves farmers more in applied research.

CSA News: So, more on-farm research would be one solution?

Hatfield: I think we need to foster more evaluation by producers. The reason we put the M in G × E × M was to show producers that they have more options than just selecting the “right” seed to increase their yields. A lot of the innovative producers are conducting strip trials on their farms. We need to be working with them to ensure that these trials are providing useful and correct information to evaluate different management practices.

CSA News: Anything else you’d like to add?

Hatfield: To address the challenges of feeding the world, we’ll have to take a holistic approach that integrates crops, soils, and management (sounds like agronomy) with pests, diseases, and weeds, not only to determine how these aspects interact to affect yield, but also to overcome the barriers to yield gains.

Another aspect that I think is important is that we need to focus on the quality of the product. Food security is not just about the mass of food or feed that we produce. It’s also about the quality of that product from a nutritional point of view: protein, micronutrients, or starch.

View the open access review article, “Meeting Global Food Needs: Realizing the Potential via Genetics × Environment × Management Interactions” online at http://dx.doi.org/doi:10.2134/agronj15.0076

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