'Darwinian Agriculture' explains how evolution can improve agriculture

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The largest drought in 50 years has severely damaged much of the nation's "corn belt" and is threatening the viability of Minnesota's 2012 corn crop. While an extreme, this summer's condition is a reminder of a larger challenge facing agriculture – to use limited resources like water in an effective and sustainable manner.

R. Ford Denison, an adjunct professor at the University of Minnesota, seeks to address these challenges through the dual prism of science and nature in his new book, Darwinian Agriculture: How Understanding Evolution Can Improve Agriculture.

"The need to produce a higher yield is continually growing, yet natural resources are becoming increasingly scarce," says Denison. "Improving crop genetics – and avoiding costly dead ends in the process – is paramount to the long term sustainability of agriculture. This requires a comprehensive approach, one that incorporates the lessons of nature when applying modern science."

Linking evolution to agriculture was natural for Denison, who researches evolutionary biology in the university's College of Biological Sciences and helps to plan long-term field research for the College of Food, Agricultural and Natural Resource Sciences. He discusses how both biotechnology and traditional plant breeding can – and should – benefit from considering past evolutionary improvements in traits like drought tolerance when identifying promising routes for further genetic improvement.

Analyzing the implications of evolutionary tradeoffs, Denison argues in Darwinian Agriculture that biotechnology and breeding efforts should sometimes reverse the results of past evolution that are inconsistent with present goals. For example, the ratio of photosynthesis to water use is greater for a plant in the morning when humidity is higher; it would therefore sometimes be better for crop yield if plants simply shut down in the afternoon. Why then, Denison asks, have plants not naturally evolved to do so? The answer, he states, is competition among plants: if one plant sacrifices its water intake for an afternoon, a neighboring plant will use water saved by the former. As a result, past natural selection favored individual growth at the expense of the plant community.

"Drought resistance is great when needing to get through a week without rain," Denison says. "In agriculture, however, simply surviving is not enough – a crop actually needs to produce a grain or fruit. What we need is a plant able to produce more with a given amount of water. This is much more difficult, but that also means there may be more opportunity for us to improve on what evolved naturally."

The first of Denison's three proposed principles of Darwinian Agriculture: "Prolonged natural selection rarely misses simple, tradeoff-free improvements," predicts that simply increasing drought resistance may have negative tradeoffs. His second principle indicates that, "Competitive testing is more rigorous than testing merely by persistence." So "nature's wisdom" may be found more in individual trees (whose ancestors competed) than in even ancient forests. The final principle is a call to action: "We should hedge our bets with a greater variety of crops – and ideas!"

In a review, Kenneth G. Cassman, professor of agronomy at the University of Nebraska, states: "Darwinian Agriculture is a very important contribution to our understanding of the links between nature and agriculture, and to the future of our human race. Denison underpins

his arguments with an incredible wealth of insight and knowledge about plants, animals, physics, chemistry, biology and ecology."

Darwinian Agriculture is published by Princeton University Press and is available now.

As the state's only public research university, the University of Minnesota is guided by its ongoing land-grant mission of learning, discovery and engagement for the common good. Denison's work is just one example of how U of M researchers are driven to discover solutions to real and significant challenges facing Minnesota, the nation and the world.

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