AGRICULTURE

Infusing Evolutionary Perspectives

Allison A. Snow

Taking a cue from Darwinian medicine (*1*), *Darwinian Agriculture* offers an engaging and bold explanation of why agricultural research must take better advantage of insights from evolutionary biology. A provocative and companionable author, agronomist R. Ford Denison (University of Minnesota) spent much of his career at the University of California, Davis. His writing varies from scientifically rigorous to casually anecdotal and from caustic to empathetic, as he describes the mistakes and successes of crop breeders, molecular biologists, and agroecologists who have taken on agriculture's great challenges. He has a deep interest in plant physiology, organic farming, and evolutionary biology, all of which contribute to the originality of his views on agriculture.

Darwinian Agriculture
How Understanding Evolution Can Improve Agriculture
by R. Ford Denison
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Denison argues that current efforts to improve agriculture are "risking failure" if core principles of Darwinian thinking are ignored. Noting that rapid evolution in weeds, pests, and pathogens is already well documented, he explores other terrain, offering fresh perspectives on how to improve crop breeding and agronomic practices. He examines food security and sustainable farming issues through an evolutionary lens, probing and searching for missed research opportunities that could enhance crop yields.

Among these is the development of crop traits that would not be favored by natural selection, such as Norman Borlaug's low-stature wheat and other crops that produce very high yields by allocating more resources to grain at the expense of height and competitive ability. Denison believes that additional opportunities for "reversing" past natural selection and thereby breeding more "cooperative" plants that boost crop yields could help alleviate global deficiencies in agricultural production. In other words, crop breeders should take note whenever traits that favor individual fitness under natural conditions—such as aggressive root growth or horizontally positioned leaves—can be jettisoned in favor of traits that improve overall yield by enhancing the performance of the entire crop population.

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Ever skeptical of biotech's silver bullets, Denison contends that using genetic engineering to enhance tradeoff-free photosynthetic efficiency or water-use efficiency may be extremely challenging because millions of years of natural selection may have already experimented with mutations that enhance plant fitness through these traits. Likewise, agroecologists who attempt to select for high grain yields from perennial grasses are unlikely to achieve what annual plants can offer because of underlying tradeoffs between perenniality and seed production. Denison argues that both genetic engineering and mimicry of natural ecosystems have the potential to improve agriculture, but only if evolutionary tradeoffs are understood and taken into account.

Broadly accessible, the book is perfect for discussion-based seminar courses and forward-thinking plant scientists. To fully appreciate the author's message, I recommend reading each chapter in sequence, taking time to pause and reflect on key concepts and examples before moving on. Denison covers many topics in crop ecology and evolutionary biology—touching on ideas of Thomas Malthus, Garrett Hardin, W. D. Hamilton, Richard Dawkins, and Wes Jackson, among others—and cites scores of peer-reviewed papers, several of which he critiques along the way. For example, he asks why a high-profile paper on genetically engineered drought tolerance in maize did not report available data from nondrought conditions, where yield tradeoffs may be lurking. He also questions the general applicability to agriculture of David Tilman's research showing that species-rich grasslands are more productive than monospecific plots (which had a lot of bare ground). Further, he exposes the confounding influence that plant spacing can have in yield trials of new cultivars. Jacob Weiner's studies of how tightly packed, evenly spaced planting patterns can reduce weed competition are praised, as are Richard Sayre's efforts to engineer safer cassava that degrades its cyanide content during processing. I found Denison's high scientific standards and probing analysis of key studies to be commendable and balanced.

Calling himself a "troublemaker" for perpetually asking a lot of questions, Denison comes across as part genius and part dreamer. He is comfortable with an astounding diversity of topics, including how long the world's supply of phosphorus will last, why crop rotation works better than polyculture, how legumes impose "sanctions" on low-performing nitrogen-fixing bacteria in their roots (and how breeders might enhance this trait), and the extent to which past natural selection has already perfected many physiological traits that are relevant to agriculture. Yet he also likes to digress; not every reader will be fascinated by forays into the defensive chemicals produced by bacteria on fungus-farming ants. Nor will all readers be receptive to terms like the recurrent "nature's wisdom" or the oft-repeated and obvious point that the structure and function of natural ecosystems have not evolved to maximize productivity (and therefore should not be imitated by agroecologists on this basis).

Less competitive. Shading from taller plants selects against the shorter wheat varieties of the Green Revolution that allocate more resources into seeds.

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Nearly everyone will find something to argue about in this rambling, thought-provoking book, and I think that is part of the author's intent. By challenging the status quo and infusing Darwinian principles more centrally into agricultural research, Denison invites readers to test his hypotheses, build on them, and think more creatively about how to feed the world. This I applaud.

References

1. G. C. Williams, R. M. Nesse, *Q. Rev. Biol.* **66**, 1 (1991).

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