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The Next Great Challenge: Breeding Seed for Organic Systems

by Micaela Colley and Matthew Dillon

It's appropriate for the organic movement to acknowledge the tremendous strides made in the past decade. We can easily see the increased acreage and greater market share that organic farming has gained. Less measurable but still tangible are a range of benefits to consumers, the environment and rural communities reaped by organic's infiltration into the agro-mainstream. Yet, amidst success there's often another formidable task around the corner. Right now, an urgent need in organic agriculture is for greater volumes of organically produced seed. But a weightier concern—at an organic *systems* level—is the essential need to encourage seed (and animal) breeding programs that are both designed in concert with organic systems, and in the public domain. As it is with many aspects of the organic movement, organic seed and breeding development will have significant scientific, economic and institutional challenges.

The present need for increased organic seed supplies is driven by USDA's implementation of the National Organic Program Rule. The Rule requires that organic growers use organic seed, except, "When an equivalent organically produced variety is not commercially available." By itself, fulfilling the requirement for organically grown seed is a very large task. For example, Miles McEvoy, Organic Program Manager for the Washington State Department Agriculture, estimates that in 2003 less than one percent of organic acreage in the state was sown with organic seed. But many in the organic movement (and others) see an even more important need—and opportunity—to steer seed breeding efforts in new directions. Changing the course of seed breeding encompasses many issues but the critical objectives are putting public participation and ownership back into the priorities and products of public seed breeding programs, and (re)establishing approaches to breeding that emphasize the agro-ecological context of plants and animals.

These very ambitious goals require settings and methods different from the dominant proprietary models at work today. They will also require a number of years to bear fruit. The following discussion focuses on some of these "new" approaches to breeding.

Seed Breeding for Organic: The State of the Industry

A mixture of institutional and market forces has led to the significant lag in organic seed and breeding efforts. Organic seed availability is low in part because few seed companies have developed resources specifically for organic production. In the private sector, seed companies with larger research and development (R&D) resources haven't invested significant funds in organic programs, in part because the organic market sector is relatively small, but also because vague NOP Rule language has provided no solid timeline for fully requiring the use of organic seeds. When larger seed companies do focus on organic, it usually consists of a simple production shift whereby the varieties offered conventionally are moved to organic fields, but with no selection or improvements for the needs of organic systems. The few pioneering seed companies that do offer organically grown seeds tend to be small and lacking in significant resources for breeding efforts.

Meanwhile, public seed breeding efforts, once predominantly in the public sector through land grant universities, have moved increasingly to consolidated private seed companies. Factors precipitating this shift include changes in university funding with greater private linkage and an increased focus on genomics. Pressure is placed on university breeders

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University researchers explore old varieties

Assessing historical wheat varieties for useful traits

At Washington State University--Pullman, a team led by Dr. Steve Jones and Kevin Murphy are growing 163 historical varieties of wheat under organic conditions. They believe that each variety potentially possesses traits that could enhance the disease resistance, weed competitiveness and productivity of modern varieties. Kevin Murphy notes, "These characteristics may be considered unimportant in high chemical input systems and therefore ignored within conventional breeding programs."

For example, if seeds used in breeding are treated with a fungicide before planting, traits such as resistance to the fungus *Pythium* or tolerance to *Tilletia* spp. (Stinking Smut) may go unnoticed. In addition, certain wheat varieties may be effective at reducing weed pressure through increased nutrient use efficiency, allelopathy, horizontal canopy coverage and/or height development rates. Jones and Murphy are also crossing these historical wheats to modern varieties and evaluating the subsequent generations. They work closely with farmer-cooperators both for variety testing and for evaluation of useful traits. Murphy says, "We place the utmost importance on breeding wheat on certified organic farms under the same conditions and systems practiced by the farmer." Steve Jones believes that their initial seed material could be adapted in other regions, but that as they continue to develop stock it will be particularly suited for the Northwest. This breeding research and subsequent seed stock will remain in the public domain.

Historical wheat varieties planted at WSU. The wheat breeding program at WSU has declared its research GMO-free and its science accessible to the public.

to develop proprietary breeds that are profitable to industrial sponsors. Breeding for the relatively small organic market has little chance of gaining a foothold in this type of university climate.

Adding to institutional issues are the poor market conditions (and subsequent lack of R&D) for organic seed caused by historical concerns among farmers about the low quality and high cost of organic seed. Price and quality concerns have made many farmers' interest in organic seed lukewarm, at best. The vast majority of organic producers continue to rely on seed that they've become accustomed to and developed markets for over the course of time--seed that is developed for productivity under high input fertilizer and pesticide conditions.

Organic producers should not be expected to embrace organic seed for the sake of a "pure" organic approach. Organic seed must perform at least as well as the conventional varieties that growers have become comfortable with. The opportunities are as vast as the need. Understanding the philosophy and learning the skills of breeding for organics is as essential as creating the funding and research infrastructure.

The Science of Breeding for Organic: Some New Approaches

What does it mean to breed for organics? Organic growing conditions present different weed pressures, fertility practices, and pest and disease complexes than conventional fields. Frank Morton, an independent plant breeder in Oregon, describes his vision of breeding for organics as, "Breeding for the whole farm ecology, developing seed that increases the positive interactions of the farm ecosystem." Varieties could be developed for better weed competition, or nutrient uptake, or beneficial soil microorganism and root interactions. For example, modern carrot breeding, while focusing on root shape, has largely overlooked selection for strong, vigorous tops, which would particularly benefit organic growers. Strong tops are more competitive with weeds, requiring less labor-intensive hand weeding. A spinach variety bred for organics could have enough mildew resistance to grow well in cool damp conditions without the use of fungicides.

Some seed companies are beginning to offer organically grown hybrid seed. There is certainly a value to hybrids and a place for their development for organic production. However, the breeding process and proprietary nature of hybrids does not lend them to farmer/breeder cooperative efforts, nor is the end product suited for subsequent on-farm selections or regional adaptation. On the other hand, when breeding open-pollinated (OP) varieties, seed may be saved from a variety by the grower or plant breeder, and the genetic elasticity inherent in OP breeding allows selection for chang-

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ing environmental conditions such as diseases, heat, cold, drought, soil type or other localized stresses.

Open-pollinated breeding also offers a way of selecting for a broad range of traits. Most modern disease resistance breeding focuses on one disease at a time by identifying and isolating a single gene that confers resistance, and then breeding that gene into subsequent varieties. This approach confers vigor through a trait that has been termed "vertical" resistance. However, another breeding model, called "horizontal" resistance, takes advantage of numerous genes during the selection process. Plant scientist Raoul Robinson has explained and described the advantages of this method at length in his book *Return to Resistance*. This method is also known as durable or polygenic (multiple gene) resistance.

Selecting for horizontal resistance works in the following way: In a genetically diverse, open-pollinated plant population, individual plants are affected by pests and disease to varying degrees. By selecting the plants that perform best under the presence of the pest or disease, the entire population begins to develop resistance, through several different traits and a range of genes. During this process, the breeder does not need to know which genes confer resistance in the healthier plants. For example, a population of lettuce may have plants with more upright leaves which evade splashing from disease spores, or a thicker cuticle which prevents spores from penetrating the surface, or an ability to grow rapidly and outgrow the period of susceptibility. Horizontal resistance takes longer to confer to a variety, but is a more enduring form of plant resistance than single gene resistance. Plants can be evaluated under a host of disease and pest pressures, and selected for a whole range of beneficial genes.

The Future of Organic Plant Breeding: A Participatory Model

The need for organic seed production and breeding will continue to grow as organic production increases. There is now growing interest in breeding for organics--what remains to emerge is the form or forms that this breeding may take.

There are three distinct forms of plant breeding: formal, farmer and participatory. Formal breeding can be either public or private, and is conducted by professional scientists with the goal of releasing new varieties for the market. While farmers may (or may not) be used in the evaluation of these varieties, they have no real decision making power. Farmer breeding is often referred to as "Seed Saving," wherein the farmer selects plants from crops in production that possess desirable qualities and then collects seed from them for future planting. The essential makeup of the variety is maintained through mass popula-

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Oregon breeder focuses on performance

Breeding lettuce to excel under organic conditions

In the Willamette Valley of Oregon, Frank and Karen Morton of Shoulder to Shoulder Farm are breeding lettuce for resistance to *Bremia lactucae* (Downy Mildew), *Sclerotinia scleritiorum*, Xanthomonis spp., and Tip Burn, all problems in organic lettuce and lettuce seed production.

Frank Morton: "We need stronger links between breeders, farmers and institutions."

Frank starts the breeding process by planting a wide range of varieties, including his favorites and those known or suggested to have some resistance, in a field with heavy disease pressure. If needed, he will inoculate the ground with the disease to ensure its presence. Many strains won't make it to bear seed; others that are too diseased will be selected out. The strongest survivors will have traits that make that strain resistant to some degree. These survivors are saved as separate lines, allowing that there will be a small amount (about 5%) of between-variety crosses. In the following generation he isolates these crosses and saves seed separately as potential new lines. The seed from the rest of the population is repeatedly grown under disease conditions for several generations to develop an increasingly resistant strain. Frank notes that, "The varieties that start with more genetic variability are the ones that make the most improvement from the selection pressures." Once a resistant strain is established he continues his program to select for other horticultural traits, like bolt resistance, heading, uniformity, or exceptional beauty.

Frank has exchanged seed and information with the USDA lettuce breeding program in Salinas, California. He says he "would like to see more support for organic plant breeding and stronger links between independent breeders, farmers saving seed, and public institutions to support this type of work."

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tion selection, although occasional selections for variation may occur. Farmers often lack the skills to select for quantitative characteristics such as disease resistance, cold emergence, etc. They also often lack the necessary resources to support selection and development of any new varietal lines that may emerge.

The participatory breeding model is a combination of formal and farmer breeding. It can take one of two modes: the participation of farmers in formal led research or the participation of science professionals in farmer led research. They often differ as to the stage at which the farmer becomes involved. Do farmers set the end goals? Are they integrated into the process of design, selecting germplasm, collecting data, evaluation, and eventual distribution? The distinct advantages to participatory breeding for organics comes in the ability to adapt varieties to whole farming systems and regional conditions, and that the farmers are involved in shaping the germplasm based on their experiences with both the crops and consumer markets.

A few companies that offer organic seeds, such as Seeds of Change and High Mowing Seed, are beginning to explore farmer-breeder participatory models of breeding for organics. Tom Stearns (owner of High Mowing Seed) and Steve Peters (Seeds of Change) point to the influence of workshops and breeding being conducted by Organic Seed Alliance's Dr. John Navazio. They are working with Navazio on plant improvement projects for each of their companies.

Developing a new model of breeding for organics and whole-farm ecology will require a re-evaluation of our current breeding system and its funding base. Only a generation ago farmers, seed companies and state cooperative extension held a closer relationship and were involved in regional evaluations and development of varieties. Participatory breeding models the greatest promise of directly serving organic growers needs, but will require developing new relationships and exploring novel avenues of collaboration. Concerted participatory efforts to breed for organics will bring quality seed to the organic movement.

Matthew Dillon *is the Director of Organic Seed Alliance, which supports the ethical development and stewardship of the genetic resources of agricultural seed. The Alliance conducts organic seed research on select crops and trains farmers to grow high quality seed while working with independent breeders and regional seed companies in participatory breeding programs.*

Micaela Colley *is an organic seed consultant and former Research Farm Manager for Seeds of Change. Seeds of Change offers all open-pollinated organic seed and conducts variety trials of open-pollinated seeds with organic market growers. They work with nearly 50 organic farmers around the country in seed production and development.*

First "Seeds and Breeds" Summit launches activist breeding network

A "Road Map" to Sustainable Public Breeding

Increased attention to breeding systems appropriate to organic farming is occurring in tandem with renewed concern for sustainability within public breeding programs.

Last fall, a **"Summit for Seeds and Breeds for 21st Century Agriculture**" was held in Washington, DC. More than seventy farmers, ranchers, land grant university researchers, breeders and non-profit representatives met to discuss the future of public breeding. The Summit was organized by a diverse planning committee that included representatives from Rural Advancement Foundation International (RAFI), The Leopold Institute, Iowa State University, University of Wisconsin, Cornell University and the Land Institute.

The Summit set as its key goal the development of "A road map for reinvigorating public domain plant and animal breeding to meet the needs of a more sustainable agriculture."

The need to restore public trust, increase farmer and rancher participation in breeding work, and provide farmers with seeds and breeds that fit integrated, sustainable and organic systems were recurring Summit themes. As the opening keynote, University of Missouri rural sociologist Mary Hendrickson described most breeding work as geared to fit a consolidated world market model, and emphasized the need to change this "top down" approach.

Stephen Jones, organic wheat breeder from Washington State University, talked about ownership of intellectual property and the impacts of the Bayh-Dole Act. The Act allows public universities to receive royalties on private products that result from their research. The Bayh-Dole Act was a key topic over the three days, and at the final session a small group of breeders read a "Public Breeder Oath" that they believe will clarify the role of university breeders and help build new trust in the profession.

Michael Sligh, working group organizer from RAFI, was impressed that the group found so much common ground and many practical steps to explore. "People recognized that there is not a single solution—like throwing more money at the land grant system. We've got to look at legal issues, funding issues, farmer involvement, the needs of sustainable systems and basic public perception."

Sligh says the next step will be to convene a working group that will begin the process of putting recommendations into practice, including discussing Farm Bill appropriations with key Senate staff as they begin the 2005 budgeting process in February, 2004.

—Matthew Dillon

For more information about the Summit and upcoming events, visit www.rafiusa.org