Welcome to the 2006 Organic Seed Grower's Conference

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This is the 4th Biennial Organic Seed Grower's Conference. Seed Quality was chosen as this year's conference theme because it is vital not only to the future of organic seed producers, but to the whole of agriculture. Our vision for the conference is to share practical, accessible information to improve our seed production and breeding practices while opening discussions that push the frontiers of seed science. The development of seed quality draws on the hands-on experience of seed growers, the theories and experimentation of university researchers, the networking, research and promotion of nonprofits like Organic Seed Alliance, and the demand for premium products supported by the seed industry. Representatives from each of these perspectives are in this room today. Through your participation in this conference you are actively contributing to the development of seed quality.

As we take in the conference sessions, open discussions, and exchange ideas, I welcome everyone to ponder their own definitions of seed quality. In part, seed quality means maintaining the genetic diversity necessary for adapting to a constantly evolving ecosystem. Seed holds the quality traits that will weather us through shifting climates and degrading environmental conditions. High quality seed provides the disease resistance important in all cropping systems, but particularly crucial for organic growers limited in pest control options. Growers also recognize that high quality seed is clean, disease-free, vigorous, and contains the optimum genetic makeup to provide the best start in production.

We have been aware of the importance of starting with quality seed since the earliest seed gatherers began saving the largest seed from the most palatable plants to sow the following year. Today, beyond holding the promise of a healthy and safe agriculture, the field of organic seed remains ripe with discovery.

Organic farming and agriculture in general are entering a new era filled with regulations and debate. At the same time the field of organic seed is maturing and holds great promise. We are just beginning to explore the full nutritional potential of our food crops, but we know that potential is held in the genepool of our seeds. We are investigating the science of antagonistic bacteria that suppress seed born diseases. New discoveries in science are challenging our entrenched ideas on the nature of heredity. At the most basic level we are still identifying the optimum soil nutrition necessary for our seed crops to bear the healthiest, most vigorous seed - quality seed needed for optimum growth and longevity in storage.

The next two days we have an opportunity to learn from each other's perspectives and experiences. It is my wish that the alliances build at this conference will be far reaching and long lasting – that together we are forming the seed of a future movement toward organic seed for organic farming.

This conference, like the improvement of organic seed, draws its strengths from the cooperative work of diverse entities. It is hosted in partnership by Organic Seed Alliance, Oregon State University, and Washington State University. In addition to Matthew Dillon and myself, Micaela Colley, from OSA, Alex Stone from OSU, and Carol Miles from WSU our conference committee includes Joel Reiten from Bejo Seeds along with seed grower and OSA board member Woody Deryx. The agenda was also set by all of you who responded to our conference survey. Your input helped develop today's session topics and steer our committee in identifying speakers. It is our vision at Organic Seed Alliance that the organic seed industry is best able to learn, grow, and succeed through the alliances we build. This conference puts the alliances we've all built into action.

We extend our thanks to all who came together to support this conference and make it an enjoyable event. We may thank Nash Huber of Dungeness Produce for providing fresh organic produce in the midst of winter for today's meals. We also thank our sponsors, Bejo Seeds, Seeds of Change, High Mowing Seeds, Territorial Seeds, West Coast Seed Manufacturing, Small Planet Foods, Growing Solutions, PCC Natural Markets, Oregon Tilth, the Organic Materials Review Institute, Western SARE, and the Risk Management Agency for helping us bring in a remarkable group of speakers, and host this conference in a beautiful setting.

We also extend a special thank you to the seed growers who support us all by forming the foundation of the organic seed movement. Farmers are the original agricultural researchers and innovators. They bring practical knowledge, experience and intuition to the scientific community and seed industry. I am encouraged that many research grants now call for farmer input and participation. It is our mission at Organic Seed Alliance to develop and support projects that utilize the farmer's perspective in the development of seed production technology, quality control, and breeding. Much of my own agricultural knowledge is drawn from my experience in the field or from speaking with farmers. I now look to the growers for guidance in my new role as Organic Seed Alliance Grower Outreach Coordinator.

Organic seed growers are the stewards of our agricultural heritage and visionaries of a sustainable agricultural future. Thank you for joining us.

Beyond Conservation: Creating Something New from Heirlooms, the Story of Painted Mountain Corn

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As a young man I asked myself, "What has our civilization overlooked, failed to do? Show me and I'll do it." There exists a tremendous resource in the world, that has never been developed for the world, nor even given to the world: the corns that have evolved in America's desert highlands for 5,000 years; the most stress-hardy corn in the world. I could foresee that farmers would some day need the genetics, and indigenous people of the world already needed it. I collected all the stress-hardy genes and create the most stress hardy corn in the world. I have been developing this seed for 31 years, turning it into a productive crop.

I am the only person who has worked with the genetics of this extra hardy corn. What is driving me is the pleasure of using my personal gifts and using my life to make food more efficient, to help indigenous people, and to reduce man's impact on the planet's resources and soil. With changing weather patterns, quick-maturing crops can escape more weather disasters. With more worn-out land and less water, we need stress hardy efficient plants. If some farmers become unable to afford fuel, corn is the only grain that can be easily cultivated without herbicides, and hand harvested. Big industry is moving in the opposite direction of all these values, disregarding consequences. They are funding the universities to do research for them. Public breeding is disappearing. There is not enough room to describe all the lines I am creating, for the US and overseas, nor to explain all the methodology I use here.

Regional Metabolism

The most important indicator of how well corn will do in a region is often how long it has evolved in that region. I believe that this factor is often overlooked. Plants are not things, they are chemical processes. We know that a cactus does not grow where an orchid grows. Well, there are corns that have evolved for millennia in opposite eco-systems. The plants may look structurally the same, but they have different invisible metabolisms, different enzymes and biological processes.

Eastern corn has evolved where everything is green and wet. The soil is deep and rich in organic substance and nitrogen, with a low pH. Nights are warm and growing seasons long. The air is humid and at sea level the corn has little damage from the sun's UV rays.

High elevation western corn has evolved under the exact opposite conditions. I have not found a single native strain of eastern corn that competes well in the west.

Regional origins have largely been overlooked in laying the genetic foundations of populations. Our civilization has only worked with one race of corn, commercial hybrid dent. All its ancestors come from the eastern region of the nation. We have been giving this to the world, as if one race of corn will fit every situation. We have "put all our eggs in one basket." We make progress in re-adapting dent corn to new environments, but it has limits, deep in its ancestry.

Creating a Montana dry land corn

Corn had been the pre-machinery food staple of our continent. There were different varieties for every imaginable micro-climate zone of this continent. But the corns that evolved in the dry land west had been thrown away. Nothing from Montana existed in the national seed banks. 99.9% of western corn had vanished from the face of the earth forever, and none were ever used nor developed. Our scientists thought we would never need them or want to use them again.

Our nation has only advanced corn with eastern ancestry. The national attitude was that "Our ancestors have had 200 years to develop east coast corn, and its progeny, commercial hybrid dent is more productive." Industry was not interested in western corns because they were "too primitive." When technology for growing wheat became more widespread and interstate shipping became easier, farmers were told to grow the crop that did best in their region. Uni-crops. We could grow wheat where corn struggled. The interest in developing native western corns dropped in the 1930's and was discarded. We did not have much forward looking vision back then.

I was told it would take more than a lifetime to make western corn useful. I experimented with all the western corns and some performed well here. I would spend my lifetime developing them, even if one person could only accomplish the first steps.

Genetic sources

Corn was not originally grown in Montana. But Indian corn was brought in from neighboring states by homesteaders in the 1860's and given to Indians on reservations here. Few sources were left to be found. I grew them. They gave me 115 years of acclimatization to Montana that I didn't have to accomplish. I consider this some of the most metabolically-exotic genetics in the world. I am the only person who rescued this locally adapted gene pool, and this rare treasure exists nowhere else but in my work.

To these I added the genes of tiny fast-maturing corn native to the Canadian Plains, and surrounding states. I located a very few rare indigenous lines from over 8,000' elevation in Colorado and New Mexico, corns that most breeders don't even know exist.

I found that by combining corns from the far north and from the highest elevations on the continent, I could create a line that could mature where I lived. I was basically collecting all the genes on the continent for cold hardiness and other western stress enduring traits, and combining them all into one strain. I used winter nurseries and greenhouses to make some initial crosses. The first ten years I had 90% crop losses. I eventually created a large gene pool containing lots of genetic variation that I called Painted Mountain Corn. My work produced many sub-strains as well.

Evolution never stops. Every year I continue to expose the corn to different deprivations and stresses, desiring to eliminate those that do not thrive. The corn gets more acclimated and more productive each year. I have created a new category of corn that grows where corn never grew before: highland northwestern corn.

Maturity: Painted Mountain grows fast even in cold climates where other corns struggle to stay alive in early spring. Pioneer International Seed tested Painted Mountain as the fastest to emerge in cold soil, the most vigorous cold-early-season grower, and the first to make grain in their 1999 trials.

Seed We Need

World organizations are advancing corn for a variety of ecosystems, especially those closer to the equator. But one ecosystem has not been addressed: Our ecosystem. The high elevation or dry land places far from the equator.

Painted Mountain can be taken higher up the mountains than other corns have evolved for. There are thousands of places in the world that match Montana's ecosystems. Many people in the world grow crops under marginal conditions, and the petro-chemical industry's seed will not perform for them. I wanted to help the farmers of Montana, Canada and farmers in matching climates around the world.

Much of the world has a climate like the west, but we never shared our corn with them. The people of the high deserts of the world are still waiting for us to give them the corns whose homelands were the high deserts of America. I have shared seed with many locations on every continent. My project is called Seed We Need. Some reported very successful production results, others not.

The biggest success was North Korea. I am one of a small number of Americans who has been inside Communist North Korea. I have been there twice and like to tell stories about it. After 5 years of trials, they concluded that Painted Mountain Corn out-produced their barley 4:1. My corn 45 bu/ac. Their barley 11 bu/ac. So, I took them 3 tons of stock seed which they planted in their coldest northern province on the China border, so they could multiply it and raise their own grain to help with starvation.

They were stripping their mountainsides trying to grow grain, which often didn't mature on time. The increased production also means that they only have to strip 1/4 as much of their hillsides to grow the same volume of food.

Even lower in their nation commercial type corn is a tragic failure for them, because it takes too much from the worn-out soil, and requires more heat units and resources than they have.

Getting inside this frightening country gave me a wonderful chance to melt hearts and show them that the free world really wants to help them.

My lines of corn are also proving themselves, or being studied, in places like Canada, Cornell University, and at North Dakota State University, where they are doing extensive breeding with my lines. I am anxious for my own state of Montana to take an interest and benefit from this corn as others are have been benefiting from.

Why Not Commercial Corn?

Modern breeding has created wonderful commercial corns. But, these are not made for the marginal regions of the world.

Nutrition

Commercial dent hybrids are largely bred for yield of calories. We tested commercial corns for protein and only got around 8%. They were also low in minerals and micronutrients. They were not created to be a significant part of the human diet.

Painted Mountain protein tested 13% in the same test, and had a little higher lysine. Trace minerals test high too. Painted Mountain has soft flour starch that is the easiest to grind for food processing, and has a significantly higher digestibility and nutrient absorption for human and animal consumption. Animals offered both Painted Mountain corn and commercial corn to eat, chose the Painted Mountain corn and ignored the commercial corn.

The nutritional quality of our corn exceeds commercial dent corn, and might find a market in food production. One nutraceutical company that tested my stress-hardy corn reported that it shows an observable extra “life force” value that other corns don't. My interpretation of that is that corn grown on stressed western land for 5,000 years, and is not supplemented or babied, has had to evolve an extra life force, or vigor, in the genetics of the seeds themselves.

Sustainability

Painted Mountain lines have about half the plant size of commercial corn and do not deplete the land so fast. One of the most damaging things about commercial corn is that it is bred to have strong woody stalks that are necessary for machine harvest. These stalks rob the soil of nutrients, putting stress on the soil and causing it to wear out really fast. Furthermore, if commercial plants are stressed, they will still make a strong woody stalk, but will run out of energy to make the cob. Commercial dent corn is not yet adapted to the cooler dry land regions of Montana.

Adaptability

I want to help people to be independent and feed themselves. Commercial corn is hybrid. The 2nd generation goes downhill, so the farmer must keep returning to purchase more seed from big companies. Painted Mountain lines are open pollinated and can be perpetuated every year by the farmer. I have been developing open pollinated gene pools containing many diverse genes. They have “horizontal resistance,” meaning many different systems of adapting to stress. When planted in a new location some individual plants will do better there. These are saved for seed. It can be tailor-selected for performance on a given farm.

They did trials in Siberia. Painted Mountain and commercial type hybrid dent corn seed from North Dakota produced about the same the first year. Both did far less than the native adapted local strain. The second generation the commercial type hybrids produced 20% less, and Painted Mountain increased 58%, passing the native line. They can start with a handful of seed from me, and never have to purchase seed stock again. Each year the crop acclimates itself to its new home, and production increases. Growing genetically diverse populations puts power in the hands of the farmer. I don't get any money, but I have helped people to feed themselves. The exciting stories have inspired many people to help us, or to do similar projects.

A friend took my corn to villages in the Himalayas. I am invited to go and teach them how to grow it. Requests keep expanding. Seed We Need has invested in training farmers to save their own seed and teaching breeding methods so they can advance their crops.

Anthocyanins Act as Antioxidants for Human Health

Anthocyanins are the chemicals that appear in colored fruits and vegetables. They are often blue, purple, or red, sometimes orange and yellow. In the last few years scientists are discovering the powerful effects of anthocyanins for human health. This is a new area of discovery.

The process of metabolism in our bodies produces unwanted byproducts called free radicals. These are not good for us. Antioxidants "mop-up" these free radicals and other pollutants, and protect our systems. Anthocyanins act as powerful antioxidants.

Landslides of research and good news about anthocyanins are pouring in, and new foods are on the shelves in even the smallest of towns. The information is getting to the consuming public. I advise all plant breeders to develop the pigmented versions of their crops whenever possible, and educate the public to their advantages.

Corn originally came with all sorts of anthocyanins in them. You can tell by the beautiful colors. History will prove that one of the stupidest things our civilization did was to remove the anthocyanins from corn and make it all yellow. Any time you add a color, gold, orange, red, blue, purple, black or all the above, the more antioxidants you are putting in the corn. With my Montana adapted Painted Mountain corn I have been able to develop all the pigments. Small grains do not have the pigment that corn can have.

Anthocyanins have antimutagenic, antimicrobial and anticarcinogenic properties. It contains cell-protecting antioxidants with the ability to inhibit carcinogen-induced tumors in rats. The list of things they helps with includes arteriosclerosis, diabetes, some have also demonstrated anti-inflammatory capabilities and the potential to help prevent obesity.

Anthocyanins are important not only for normalizing cancer cells but also with chronic fatigue and general lack of energy by taking the role of oxygen as electron acceptors. Furthermore, sufficient amounts can improve the elasticity of skin and blood vessels. With this and in combination with other bioflavonoids they are beneficial with various diseases such as allergies, inflammation, infections, parasites, cancer, liver disease, vascular diseases, thrombosis (blood clotting), chemical toxicity and coronary artery disease.

The organic market is the fastest growing sector of agriculture, and my corn is being grown organically. One of the best ways for the small Montana farmer to survive is by entering a high paying niche market. The American consumer, notably behind the European, is growing increasingly interested in what he eats and in his health.

Versatility of corn as fuel prices rise

My corn lines need to be developed more to be machine harvestable. I am starting to work on that project too. I need to breed and select plants with more standability, higher placement of cobs, and faster dry down.

However, corn was the grain of the pre-machine frontier. It is "grain on a handle." And as fuel prices escalate, and farmers fear not being able to afford fuel, or herbicides, it is comforting to know that corn is the only grain that can easily be hand weeded and harvested.

Self pollination of large numbers. Cleaning-up the whole gene pool.

I have a vision that needs to be done some day: The self-pollination of as many plants as possible, for at least three years. Why? Native corns are loaded with hidden lethal genes, or genes for defects that have never been removed. We keep tripping over the same problems. The process of self-pollination, or inbreeding, exposes plants carrying deleterious genes so they can be eliminated. At least 90% of the plants prove to carry problems. It would be good to clean the bad genes out of the population before we spread them all over Montana.

The 10% that survive inbreeding will have all the healthy genes and can be used to create a relatively trouble-free gene pool. It will have more vigor and production, and less problems to keep reoccurring. Because most plants are lost in this process, we must start out in large volumes to keep a large amount of diversity alive. I'd like to someday see 1,000 plants survive this screening and be used to build a problem free, genetically diverse population. Then native Montana corn would gain the respect of modern corn.

The Organic Seed Partnership: Breeding for and in Organically Managed Systems

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Supported by the USDA Organic Research and Education Initiative

The Organic Seed Partnership (OSP) is a project funded by the USDA OREI program with the goal of identifying, developing, and disseminating high-quality vegetable varieties for use in organic management systems. The partnership consists of farmers, public and private germplasm providers, breeders, nonprofit organizations and seed companies. A major goal of the project is to distribute vegetable breeding populations, lines and varieties collected from various sources to interested farmers/breeders/seed companies for further breeding, selection and evaluation in organically managed trial sites. These sites have been developed in a wide array of environments representing many major production regions in the US. Outreach activities aim to increase capacity within the organic community for on-farm selection and breeding of vegetable varieties and commercial organic seed production, to develop local seed production capacity, to support development and dissemination of curricula related to organic agriculture, and to engage students and the public in issues involved in the creation and maintenance of a diverse and high-quality seed supply for organic vegetable production systems.

To achieve its goal of expanding the number and availability of high-quality vegetable varieties adapted to and selected in organically managed systems, the OSP has adopted two major strategies. First, it is integrating participatory farm-based crop breeding and selection activities with work at public research sites and seed-company breeding programs to ensure the early and sustained engagement of growers, consumers and seed companies in the process of breeding and disseminating varieties for organic systems. Second, the project is developing a national network that consists of hubs representing both key production areas and regions with the potential for substantial organic vegetable production. Particular emphasis has been placed on serving regions where minorities are well represented among small farmers. At each hub, farmer-based trial networks are being developed that are similar to those already used successfully by the Public Seed Initiative (PSI), a recently completed project funded by the USDA IFAFS program.

Cooperating institutions at OSP hubs include Alcorn State University, New Mexico State University, Oregon State University, University of California at Davis, West Virginia State University, and, in the northeast, a partnership of Cornell University, the Plant Genetic Resources Unit, USDA-ARS, and the Northeast Organic Farming Association of New York (NOFA-NY). Individuals who are managing research, outreach, and cooperative arrangements at hubs include Raoul Adamchak, George Bates, Jason Cavatorta, Ravi Chintha, Elizabeth Dyck, Michael Glos, Matthew Falise, Connie Falk, Teri Ferrin, Mark Hutton, Molly Jahn, Sarah Johnston, Mary Kreitinger, Barb Liedl, Carol Miles, Jim Myers, George Moriarty, Umesh Reddy, Larry Robertson, Erin Silva and Mark Van Horn. Project management is based in the Dept. of Plant Breeding and Genetics at Cornell University in Molly Jahn's research program.

In 2005, OSP activities focused on establishing a trialing network for vegetable varieties and experimental material at the project's six hubs. Events on vegetable evaluation, selection and breeding techniques, seed-saving, and commercial seed production were also held.

In early spring of 2005 a list of nearly 200 vegetable varieties was offered for evaluation to cooperating organic growers and university-based organic farms. The list was largely comprised of established varieties from seven seed companies (Fedco, Johnny's, Rupp, Seeds by Design, Seeds of Change, Territorial, and Turtle Tree) and three public-sector breeding programs (Dept. of Plant Breeding, Cornell University; Dept. of Horticulture, Oregon State University; and the Crop Improvement and Protection Research Unit, USDA-ARS, Salinas, CA). Varieties of green bean, beet, broccoli, carrot, chard, corn, cucumber, endive, kale, lettuce, melon, okra, pea, pepper, pumpkin, spinach, summer squash, tomato, watermelon, and winter squash were included on the list. In addition to established varieties, seed of unreleased lines of cabbage, broccoli, lettuce, melon, pea, pumpkin, and summer and winter squash from the public-sector breeding programs was also offered to farmers.

With the seed they requested, participating growers received written instructions and evaluation forms. The evaluation process was informal and primarily qualitative. Farmers were asked to consider the variety's vigor, resistance to pests and diseases, tolerance of severe weather conditions, yield, taste, appearance, and customer reaction. They were also specifically asked whether they would grow the test variety again.

Farmers from California, New Mexico, New York, and Pennsylvania participated in trialing during the 2005 season. In addition, evaluation of material distributed by the OSP occurred on land in transition at the OSU Lewis-Brown Farm and on organically managed student farms at UC Davis and New Mexico State University. The bulk of on-farm activity occurred among NOFA-NY members, through a trialing network already established by the PSI. Eighty-one NOFA-NY farmers/gardeners requested and received seed of 162 vegetable varieties/lines. Farmers showed a broad range of interest in crops: there were >20 requests for varieties of green beans, beets, broccoli, carrots, cucumbers, lettuce, melons, peas, peppers, spinach, summer squash, tomatoes, and winter squash. Of the 77 farmers who requested seed for main season trialing, 51 returned evaluations, a response rate of 66%. The number of evaluations received for each requested variety ranged from 13 to 0. Forty varieties received 4 or more evaluations, 101 varieties received fewer than 4, and 21 were not reported on.

A database of the variety evaluations has been established, is being analyzed, and is being distributed to cooperating seed companies, breeding programs, and farmers. Feedback from these partners will be used to plan for varietal trialing activities in 2006 and 2007. However, it is anticipated that many of the varieties offered in 2005 will be retrialed to allow for evaluation over several seasons and on multiple farms in multiple regions. Farmers' level of participation and comments suggest that there is strong interest in continuing the work of establishing a list of varieties that are especially adapted for use in organic systems in one or more growing regions across the country.

In addition to trialing of established and unreleased varieties, farmers were offered the opportunity to participate in increase and selection projects on a variety of crops, including melons, cucumbers, lettuce, peppers, and summer squash. The most popular breeding projects with farmers proved to be selecting for an improved zucchini from crosses of the heirloom Costata Romanesca with several disease-resistant modern cultivars, using mass selection for development of a superior OP broccoli, and selecting for early maturing, cucumber mosaic tolerant, sweet red and yellow bell peppers. In each project, farmers were able to contribute seed from their selections for further evaluation by breeders and other farmers. Additional participatory breeding projects based on critical breeding issues identified by farmers are being planned for 2006.

Outreach and education events were also held in 2005 to further develop organic growers' capacity to both breed their own vegetable varieties and produce commercial lots of organically grown seed. The OSP sponsored 11 outreach and education events, including public "taste-testing" of crop varieties and workshops held on farms and at research stations that demonstrated breeding "basics," pollination techniques, and seed production and cleaning methods to interested farmers, gardeners, and members of the public. Presentations at two annual organic growers' meetings in New England, at the second annual Seed and Breeds Conference, and at the annual meeting of the Crop Science Society of America have helped to further inform the public about OSP goals and activities.

We acknowledge support from the USDA Organic Research and Education Initiative Award No. 2004-51300-02229.

A Comparison of the Nutrient and Phytochemical Content of Organic and Conventional Tomatoes and Peppers

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Consumer awareness of the relationship between foods and health, together with environmental concerns, has led to an increased demand for organically produced foods. In general the public perceives organic foods as being healthier and safer than those produced through conventional agricultural practices [1]. However, controversy remains whether or not organic foods have nutritional, quality and/or sensory advantages when compared to their conventionally produced counterparts [2]. There are important differences in organic and conventional production practices, but limited information is available detailing how these practices influence nutrient composition and quality, especially in terms of secondary plant metabolites (i.e. antioxidants) in food crops. Both conventional and organic agricultural practices include combinations of farming practices that can vary greatly depending upon region, climate, soil quality, occurrence and prevalence of pests and diseases, and farm management practices. The dynamic nature of agriculture makes adequately controlled comparisons of agronomic systems free from confounding influences experimentally challenging. However, fundamental differences between organic and conventional production systems, particularly in soil management, have the potential to impact the nutritive composition of plants and in particular secondary plant metabolites [2-6].

An important difference between conventional and organic farming systems is likely to result from differences in soil fertility management. Organic systems rely on cover crops, rotation with forage legumes, and on composts, manures and other organic amendments for fertility. All these require the activity of a diverse soil ecosystem to make nitrogen available to plants. Conventional farms use water soluble fertilizers which are directly available. The ready availability of fertilizer nitrogen in particular has the potential to influence the synthesis of secondary plant metabolites as well as proteins and soluble solids. This is important since many of the bioactive compounds in fruits and vegetables linked to decreased risks of cardiovascular disease and cancer (e.g. flavonoids) are products of secondary plant metabolism [7, 8]. There are various overlapping hypotheses that attempt to explain this relationship including the carbon/nutrient balance [9] hypothesis, growth-differentiation balance [10] hypothesis, and the protein competition model [11]. In general, these theories state that high nutrient availability leads to an increase in plant growth and development rates, biomass, and a decreased allocation of resources towards the production of carbon containing secondary metabolites such as vitamins and phenolic antioxidants, and can affect protein quality.

The objectives of the following studies were to explore the influence of organic and conventional production practices on several nutritive and quality measurements in tomatoes and peppers in two model systems. In the first study, total phenolics, % soluble solids, ascorbic acid and the flavonoid aglycones of quercetin, kaempferol and luteolin were monitored over the three-year period (2003-2005) in tomatoes (Lycopersicon esculentum sp. Burbank and Ropreco) and peppers (Capsicum annuum sp. California Wonder sp Excaliber) grown under defined organic and conventional conditions. These studies were conducted at the University of California Davis student farm using two nearby fields, one certified organic (2002) and one conventional. The fields are 107 meters apart from each other and have similar irrigation systems and Reiff very fine sandy loam soil. Within a species, the varieties were assigned using a completely randomized design with 3 replications. Soil samples were collected at the time of initial field work, at around planting and at around harvest. Soils were sampled by taking one 7" deep core per plot and pooling all of the cores together for each treatment (i.e., one pooled sample for organic, one pooled sample for conventional). Soil measurements included: soil pH, cation exchange capacity, base saturation, minerals (Ca, P, K, Mg, B, Zn, Fe, Mn, Cu), total Kejldal nitrogen, ammonia, and nitrate. Additionally, soils were monitored for total bacterial diversity and density and fungal biomass.

The organic crop production methods included the use of compost and manure, cover cropping, and manual weed control. The conventional crop production methods included: (1) fertilization (16-48-12 N-P-K) as a liquid fertilizer and ammonium sulfate; (2) weed control herbicides; and (3) insect pest management with insecticides [pyrellin and permithrin (aphids) and diazinon (whitefly in peppers)]. Fruit was hand harvest, washed, sorted, sliced and frozen within 3 hours of harvesting. Data were analyzed using Multivariate Analysis of Variance (MANOVA) models.

Significant differences between cultivar, cultivation practice and year of harvest were found. Data demonstrate an overall trend of higher levels of soluble solids, total phenolics, vitamin C and quercetin in organic tomatoes as compared to their conventional counterparts. However, year-to-year variation was significant. Cultivation practices had less of an effect on the levels of soluble solids, total phenolics, vitamin C or flavonoid aglycones in bell peppers as compared to tomatoes.

In a second study, tomato samples that had been archived from the Long Term Research on Agricultural experiment at UC Davis (LTRAS) were analyzed for two key flavonoids; quercetin and kaempferol. This archive of samples is unique in California and perhaps the world. Data derived from this archive are striking and demonstrate statistically higher levels of key flavonoids in organic tomatoes over the12 year period (Figure 1; 1994-2004). Interestingly, the levels of flavonoids increased over time in samples from organic treatments, whereas, the levels of flavonoids did not vary significantly over time in conventional treatments. This is a very interesting result that may indicate an increasing response to changes in soil quality [12] or other properties in the organic cropping system over time. There is no well quantified parallel to this result.

Data collected from these 2 model systems at UC Davis, especially those of the LTRAS archive strongly suggest that tomato fruit grown organically has higher levels of health promoting flavonoids than conventionally produced tomatoes. Our data warrants further studies of relationships between fruit quality and agronomic practices in the larger agronomic landscape.

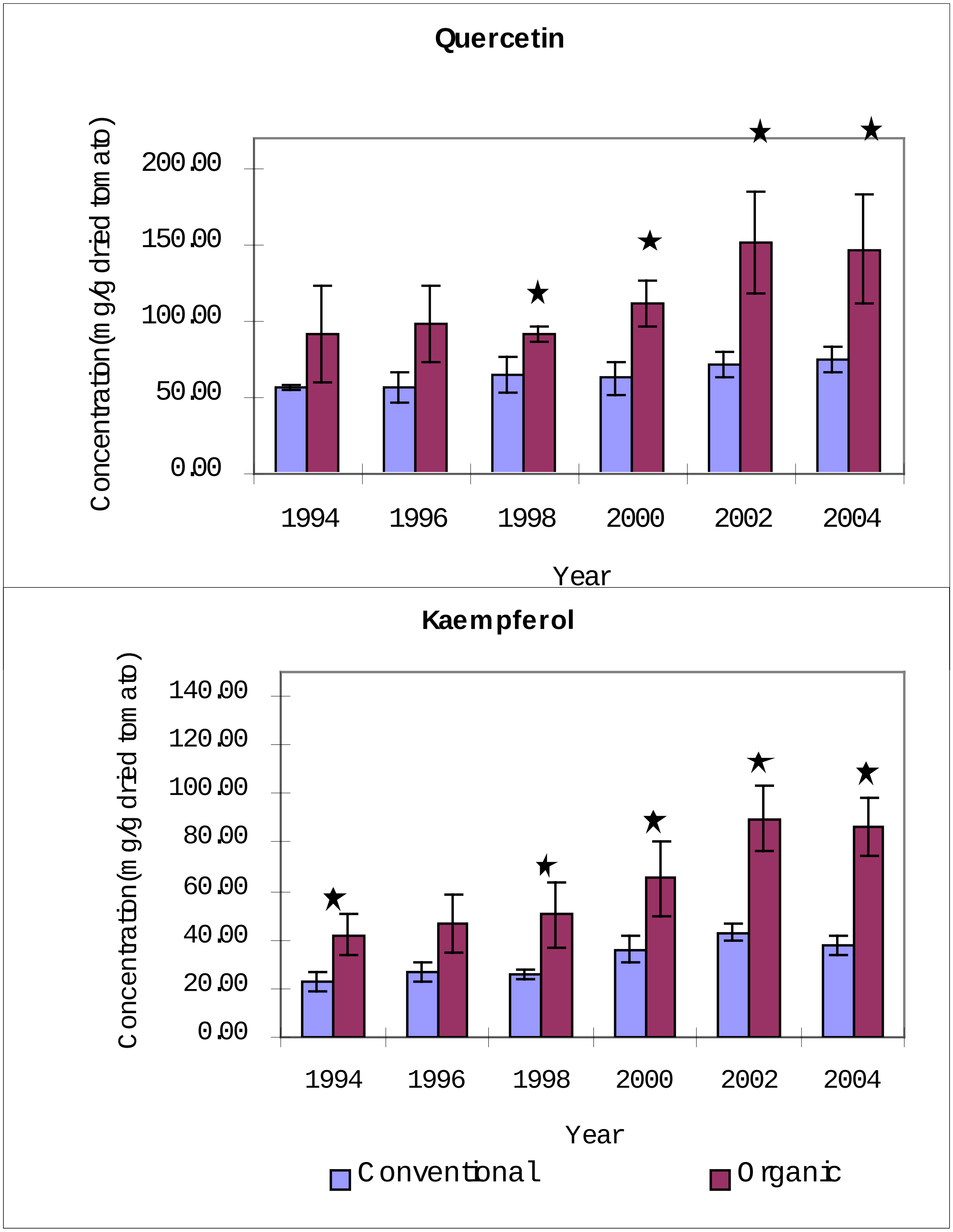

Figure 1. Changes in tomato fruit quality over time in conventional and organic cropping systems at LTRAS 1004-2004). Mitchell et al., (Mitchell et al., *in preparation*)

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Breeding Carrots for Improved Nutritional Value

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Summary

Color is often a major cue that plant breeders, growers and consumers use to evaluate crops and food. This has been true for carrots where color was an important attribute for distinguishing among production classes during its domestication as a root crop. Orange carrots, where carotene pigments account for their orange color, became popular in the 1600's. Modern carrot researchers continue to include color as a major breeding attribute. In fact, the carotene content of U.S. carrots is 70% higher today than 30 years ago. In recent years carrot breeding stocks have been developed with not only orange, but also distinctive dark orange, red, yellow and purple color. Parallel fundamental research studies to better understand the genetic basis and potential nutritional impact of these carrots are underway. Using crosses between wild white, cultivated orange, and cultivated purple carrots, we have placed 2 major orange color genes, 2 purple color genes, 25 carotenoid biosynthetic enzymes and 2 enzymes in the anthocyanin pathway on the carrot genetic map and cloned the genes for the carotenoid enzymes. These molecular tools allow us to predictably combine complementary genes for darker orange and purple color.

In addition to the colors they confer to plants, the pigments in horticultural crops are an important source of several vitamins and other "phytonutrients." Carrot pigments play a particularly important role in the U.S. diet as the most abundant source of provitamin A carotenes, providing 30% of our total vitamin A. With the development of an array of colors in carrot breeding stocks we have cooperated with nutritionists to evaluate their nutritional impact. Bioavailability studies of alpha- and beta-carotene in typical orange and dark orange carrots, lycopene in red carrots, lutein in yellow carrots, and anthocyanins in purple carrots have found all of these pigments to be bioavailable. Selected breeding stocks have been extensively tested in the field with emphasis on developing germplasm with good flavor and nutritional value. As we develop "nutritionally enhanced" carrots and expand our basic knowledge of pigments, the prospects are good for future improvements in carrot color and nutritional value useful for the vegetable industry and the consuming public. As genomic technologies are developed, new phytonutrients are described and communications between horticulturists and nutritional/medical researchers are expanded, a wider range of efforts to improve the nutrititive value of carrots can be expected.

Effect of High- and Low-Input Organic and Conventional Production Systems on Dry Bean Nutrients

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Summary

Three medium-seeded dry bean (*Phaseolus vulgaris* L.) landraces and 13 cultivars of great northern, pinto, and red market classes released between 1932 and 1998 were evaluated in four on-farm, namely high and low input organic and conventional and three Research and Extension Center (REC), namely high input conventional, drought stressed, and >50 years of continual bean production systems in 2003 and 2004. Effects of production systems on plant and seed uptake of N, P, K, Cu, Mn and Zn were determined.

There were a wide range of cultivar responses to production systems. This included whole plant growth, seed yields and harvest index. In addition, for N, P, K, Zn, Mn and Cu whole plant and seed uptake and concentration, the cultivar and production system were both highly significant, as well as the production system x cultivar interaction. This suggests that there should be a high degree of potential success to use selected cultivars in a plant breeding program to develop adapted cultivars for each of the respective production systems. For Zn nutrition within production systems, the cultivars Buster and Othello appeared more efficient in the higher input production systems (OFC, OGH), while Matterhorn and Common Red Mexican appeared more efficient in the lower input production systems (OGL, OLF). Common Red Mexican and UI 259 were also relatively high in both organic production systems (OGL, OGH). Across production systems and years, Othello, UI 239 and UI 259 were the only cultivars that had superior ratings in four selected seed yield and Zn attributes. Other cultivars were either more efficient at Zn or dry matter translocation to the seed, but not both.

Introduction

Dry bean is grown worldwide in a range of environments, production systems, soil types, and input levels and suffers from numerous abiotic and biotic constraints (Singh, 1992). The commercial seed and edible dry bean production in the western U.S. followed the arrival of canal irrigation system in the early part of the twentieth century. Soils in the western U.S. are highly calcareous with pH often >7.5, deficiency of Zn, Fe, P, and other elements, and toxicity of some. Five to eight gravity or sprinkler irrigation are applied, and yet crop may suffer from drought stress. Diseases such as *Beet curly top virus* (BCTV, a leaf-hopper vectored geminivirus), *Bean common mosaic virus* (BCMV, an aphid transmitted potyvirus), white mold [caused by *Sclerotinia sclerotiorum* (Lib) de Bary], and root rots [caused by *Fusarium solani* f sp. *phaseoli* (Burkh.) Snyder & Hansen and other fungi] are endemic problems. Furthermore, organic and continual bean production for two or more years is not uncommon. Thus, production costs are high and, despite the exceptionally high quality of seed dry bean producers face increasing challenge from producers elsewhere because most of the seed and edible bean are exported to other states and countries where production costs are relatively lower (e.g., North Dakota, Manitoba).

Crop productivity, among other things, depends on available nutrients in soil solution and air, and plant and seed nutrient uptake and utilization. Different nutrients are involved structurally or functionally in the life cycle of plants and are essential for their growth and reproduction. For example, carbon is part of all organic compounds and accounts for approximately 45% of the plant dry matter (Raven et al., 2004; Taiz and Zeiger, 2002). Nitrogen is a constituent of aminoacids, amides, proteins, nucleic acids, nucleotides, coenzymes, hexoamines, cofactors, and alkaloids. Phosphorus is a component of sugar phosphates, nucleic acids, nucleotides, coenzymes, phospholipids, and phytic acid. Phosphorus has essential role in reactions that involve ATP regulation. Iron is a component of cytochromes and nonheme iron proteins involved in photosynthesis, N_2 fixation, redox reactions, and respiration. Zinc is a component of zinc finger proteins, Cu/Zn-superoxide dismutase, alcohol dehydrogenase, glutamic dehydrogenase, and carbonic anhydrase. Copper acts in respiration and photosynthesis as a component of the redox elements and enzymes of the electron transport chains, in protein and carbohydrate metabolism, chlorophyll biosynthesis, and lignification of cell walls influencing water balance in plants (Sgherri et al., 2001). Also, Cu is a cofactor of Cu/Zn-superoxide dismutase, ascorbic acid oxidase, tyrosinase, monoamine oxidase, uricase, cytochrome oxidase, phenolase, laccase, and plastocyanin (Raven et al., 2004; Taiz and Zeiger, 2002).

Drought reduced the uptake of P, K, Mn, Fe, and Cu in *Vicia faba* (Omar et al., 1986). Nitrogen, P, K, Ca, Mg and S in leaves and seeds were reduced by water deficit in soybean [*Glycine max* (L.) Merr.] (Khan et al., 2004). Harosoy, a soybean cultivar, had increased seed concentration of P, Ca, Mo, Mn, Cu, and Zn (Samarah et al., 2004). In dry bean, there is limited knowledge regarding nutrient uptake and utilization in stressed and non-stressed organic and conventional production systems and their effects on seed nutrient concentration and nutritive value. For example, drought stress reduced N concentration, partitioning, and fixation in dry bean (Castellanos et al., 1996; Foster et al., 1995; Ramos et al., 1999; Serraj and Sinclair, 1998). Drought also reduced P uptake (Guida dos Santos, 2004). Large differences for soil Zn deficiency resistance were found (Westermann and Singh, 2000) and a single dominant gene conferred resistance to soil Zn deficiency (Singh and Westermann, 2002). Also, a single dominant gene controlled higher accumulation of Zn in seeds of navy bean (Cichy et al., 2005).

On-farm dry bean research with producers' participation in southern Idaho was initiated in 1999. Our objectives are to briefly discuss the effects of seven organic and conventional production systems on plant and seed uptake of N, P, K, Cu, Fe, and Zn and their concentration in seed. The following discussion will focus on Zn. A rigorous analysis of Fe uptake and concentration is not possible since the whole plant samples had some soil contamination.

Materials and Methods

Three landraces grown by the Native Americans or selection thereof and 13 cultivars of great northern, pinto, and red, the three major market classes of dry bean grown in the western U.S., were evaluated in four "on-farm production systems", namely low- input organic (OGL), high-input organic (OGH), low- input conventional (OLF), and high-input conventional (OFC) with farmers' participation in southern Idaho in 2003 and 2004 (Table 1). They were also evaluated at the Kimberly Research and Extension Center (REC) under high-input conventional (RFC), >50 years of continual bean cropping (RCB), and drought-stressed (RDT) production systems. A randomized complete block design with four replicates was used. Each plot consisted of four or eight rows 25 or 50 ft long spaced 22 inches apart. The OGL, OLF, and RCB plots did not receive any fertilizer. The RDT plots received high (0.62 drought intensity index, DSI) in 2003 and moderate (0.27 DSI) drought stress in 2004 (Muñoz, 2005).

Table 1. Symbol used for six dry bean production systems	
Symbol	Description
OFC	On-Farm Conventional
OLF	On-Farm Low Soil Fertility
OGH	On-Farm High-Input Organic
OGL	On-Farm Low-Input Organic
REC	Research Conventional
RDT	Research Drought Stressed
RCB	Research Continual Bean Production

At maturity, 10 plants from each plot in each production system were cut above ground for assessing plant uptake and utilization of nutrients, and dried at 60^{o}C.). The harvest index is the seed yield divided by the whole plant yield on an equivalent area basis. One hundred seeds taken randomly from each plot in two replications in 2003 and four replications in 2004 were used for assessing seed nutrient uptake. A dry ash procedure was used prior to determining K, Fe, Cu, P, Mn, and Zn. Dynamic flash combustion technique was used for N determination. In both procedures, plant and seed samples were dried, weighed, and ground through a cyclone mill. In the dry ash procedure, 0.5 g of each plant or seed sample in 100 ml low form beakers were placed in a furnace at 500^{o}C for 4 to 6 hours. The ash samples were cooled down, then 10 ml of 1N HNO_3 were added and heated on hot plate until steam formed on beaker sides. Additional water was added to make up to 50 ml. The solutions were stirred using a Teflon policeman and filtered through #50 Wahtman filter paper. The solutions were analyzed with an ICP-OES (Inductively coupled plasma optical emission spectrometry), Perkin Elmer 4300 DV. Multi-elements mixed from standard solutions were used to calibrate each element. The concentration of each element was determined comparing the sample intensity with calibration plots. Nitrogen was analyzed using the CE Elantech Flash EA1112 CNS-O analyzer that operates according to the dynamic flash combustion technique. Twenty-five mg of each plant or seed ground sample were placed in a tin capsule and dropped into a quartz tube at 1020^{o}C with constant helium flow. Nitrogen was detected by a thermal conductivity detector.

A mixed model (McIntosh, 1983) was used for data analyses whereby year and replications were random effects and production systems and dry bean genotypes fixed effects. Data for each year were analyzed separately and the homogeneity of error variances was tested according to Bartlett (1947) before performing combined analyses. All data were analyzed using the SAS (v 9.1) PROC GLM statistical package (SAS, 1985). Mean separations were evaluated with Duncan's multiple range test.

Results and Discussion

Yield

Statistical analysis showed that whole plant and seed yields were highly significant for year, production system and cultivar (Table 2). It would not be unexpected to have differences between production systems since different cultural practices (e.g., drought, available soil nutrients, and/or weed competition) were used that would affect plant growth and seed yield. Available soil nutrients in each production system were generally considered sufficient for dry bean except for the OLF production system, which was intentionally selected for marginal soil P and Zn availability (data not shown). The cultivar x production system interaction was also significant. This suggests that relative cultivar plant growth and seed yield responses are dependent upon production system. However, it is beyond the intent of this report to explore this interaction for yield and other traits.

Table 2. Statistical analysis of whole plant and seed yield and harvest index.

		Whole plant	Seed yield	Harvest index[1]
Source	df	*Pr < F*	*Pr < F*	*Pr < F*
Year	1	<0.0001	<0.0001	<0.0001
Production system	7	<0.0001	<0.0001	0.0039
Yr *Prodc. Syst.	7	<0.0001	<0.0001	0.0274
Cultivar	15	<0.0001	<0.0001	<0.0001
Cult * Yr	15	0.0007	0.0002	<0.0001
Cult * Prodc. Syst.	90	0.2573	<0.0001	0.0157
Cult * Prodc. Syst. * Yr	75	0.0272	0.0741	0.1282

[1] Harvest index= Seed yield/whole plant yield

Average whole plant yield varied from a low of 3211 kg ha^{-1} for Topaz to a high of 4389 kg ha^{-1} for Matterhorn (Table 3), while seed yield varied from 1481 kg ha^{-1}to 2165 kg ha^{-1}. Average plant yield ranged from a low of 2200 kg ha^{-1} for RCB and OGL to a high of nearly 5700 kg ha^{-1} for OGH production system. Seed yield was also the lowest for RCB and OGL but was the highest for the OFC and REC systems. The cultivar x production system interaction was not significant for whole plant yield but was for seed yield and the harvest index (Table 2). The lowest average harvest index was for Common Red Mexican while the highest was for UI 259.

Whole Plant Nutrient Uptake

Averaged whole plant nutrient uptake for different cultivars are shown in Table 4. Across production systems and individual plots, N uptake ranged from 37 to 172 kg ha^{-1}, P uptake from 4 to 24 kg ha^{-1}, K uptake from 23 to 151 kg ha^{-1} , Zn uptake from 0.03 to 0.16 kg ha^{-1}, Mn uptake from 0.07 to 0.25 kg ha^{-1}, and Cu from 0.01 to 0.04 kg ha^{-1}. The major lower nutrient uptake occurred in the low-input production systems, e.g., OGL and OLF, or where growth was limited by other stresses, e.g., RCB or RDT. As expected higher nutrient uptake occurred in high-input systems (OGH) or conventional systems (REC and OFC). In general, the higher whole plant yield also had higher nutrient uptake, regardless of production system. No visible field nutrient deficiencies existed in any production system. Soil Zn concentrations were especially low in the

OLF production system (data not shown) and an incipient early plant growth Zn deficiency could have existed in some cultivars.

Table 3. Average whole plant and seed yield (kg/ha) for 2003 and 2004. Means followed by different letters are different at $P \geq 0.05$.

Cultivar	Whole plant	Seed	Harvest Index
C. Pinto	3274ef	1481f	0.56fg
Othello	3683cd	2021ab	0.70ab
UI 320	3279ef	1778cd	0.63cde
Bill Z.	3628cd	2063a	0.69ab
Buster	4333a	1892bc	0.51g
Topaz	3211f	1561ef	0.58ef
Mesa	3877bc	2165a	0.68abc
C. Red Mex.	3817bcd	1616ef	0.49g
UI 259	3624cd	1916bc	0.72a
NW 63	3704cd	2162a	0.71ab
UI 239	4075ab	2109a	0.67abcd
LeBaron	3557cde	1814c	0.65bcde
Matterhorn	4389a	1832c	0.51g
UI 465	4144ab	1911bc	0.59ef
UI 59	3550cdef	1652de	0.58ef
UI 1140	3510def	1821c	0.61def
Pr>F	<0.0001	<0.0001	<0.0001

Table 4. Whole plant nutrient uptake (kg/ha) by dry bean cultivar averaged across year and production system.

Cultivar	N	P	K	Zn	Cu	Mn
C. Pinto	86.2	9.6	57.8	0.072	0.023	0.113
Othello	89.9	11.9	62.1	0.084	0.025	0.118
UI 320	84.8	10.2	52.7	0.074	0.022	0.109
Bill Z.	89.2	10.8	61.1	0.078	0.024	0.111
Buster	104.4	12.9	74.6	0.101	0.030	0.142
Topaz	85.8	11.4	53.3	0.076	0.023	0.097
Mesa	98.9	11.7	67.0	0.086	0.026	0.134
C. Red Mex.	101.1	11.5	71.3	0.082	0.027	0.154
UI 259	92.4	10.5	71.6	0.072	0.024	0.145
NW 63	95.8	11.2	76.4	0.079	0.024	0.145
UI 239	104.4	11.5	83.1	0.082	0.027	0.170
LeBaron	90.3	10.6	63.2	0.079	0.024	0.126
Matterhorn	115.5	13.8	79.0	0.103	0.033	0.137
UI 465	103.8	12.7	72.3	0.092	0.028	0.153
UI 59	94.4	11.4	62.9	0.079	0.027	0.112
UI 1140	89.2	11.3	62.6	0.082	0.025	0.119
Pr>F	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

The cultivar * production system interaction for whole plant and seed nutrient concentrations, and uptake were all significant for N, P, K, Zn, Cu and Mn (Table 5). The interaction for the uptake ratio (seed uptake/whole plant uptake) was also significant for the same nutrients. Most main effects (cultivar and production system) were also significant (data not shown). Again, differences among production systems were expected since production practices and soil nutrient availabilities were not uniform.

Table 5. Significance of cultivar x production system interaction (*Pr* < *F*)

Nutrient	Whole plant concentration	Whole plant uptake	Seed uptake	Seed concentration	Nutrient use efficiency ratio
N	0.1040	0.2186	<0.0001	<0.0001	<0.0001
P	0.0111	0.5240	<0.0001	<0.0001	<0.0001
K	<0.0001	0.0021	<0.0001	<0.0001	<0.0001
Zn	<0.0001	0.3069	<0.0001	<0.0001	<0.0001
Cu	<0.0001	0.3702	<0.0001	0.3261	<0.0001
Mn	0.0133	0.1256	<0.0001	<0.0001	0.0354

Seed Nutrient Concentration and Use Efficiency

Average seed nutrient concentrations for cultivars are shown in Table 6. In general, the concentrations across production systems and years did not appreciably exceed the ranges shown in Table 6 for the respective nutrients. The lowest concentration was slightly lower (10-20%), while the highest was slightly higher (10-20%).

Table 6. Average seed nutrient concentration for 16 dry bean cultivars averaged across year and production system. Means followed by different letters are different at $P \geq 0.05$.

Cultivar	N %	P %	K %	Zn mg/kg	Cu mg/kg	Mn mg/kg
C. Pinto	3.69f	0.42f	1.46bc	27.3ghi	7.8cde	12.9e
Othello	3.45g	0.44de	1.45cd	27.2hi	7.4fg	13.8c
UI 320	3.52g	0.43e	1.50b	28.1efg	7.5efg	13.5d
Bill Z.	3.52g	0.42f	1.42de	31.0c	7.6efg	13.0e
Buster	3.81d	0.45cd	1.47bc	31.8bc	8.7b	12.1fg
Topaz	4.18a	0.52a	1.54a	32.8a	8.0cd	13.6cd
Mesa	3.72ef	0.43e	1.40e	29.0cd	7.8def	12.8e
C. Red Mex.	3.73ef	0.43e	1.50b	27.9fgh	7.9cde	12.2fg
UI 259	3.91c	0.43e	1.48b	27.9fgh	7.8def	13.6cd
NW 63	3.72ef	0.42f	1.54a	26.1j	7.4fg	11.9g
UI 239	3.79de	0.42f	1.49b	27.3ghi	7.3fg	12.3f
LeBaron	3.77de	0.44de	1.47bc	28.3def	7.7ef	13.5d
Matterhorn	4.04b	0.48b	1.50b	32.2ab	9.9a	13.8c
UI 465	3.66f	0.46c	1.40e	28.6def	7.7ef	15.0b
UI 59	3.97bc	0.48b	1.46bc	29.4c	8.8b	15.4b
UI 1140	3.64f	0.46c	1.46bc	28.8cde	8.2c	16.5a
Pr>F	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

The average plant nutrient use efficiency index for each cultivar across production systems and years is shown in Table 7. As defined in this paper, this index is the seed nutrient content divided by the whole plant nutrient content on an area basis. The index may exceed unity because of sampling or analytical errors within some production systems, however this should not negate a relative comparison between cultivars for each nutrient. This problem with the data probably does nullify a through evaluation of the production system x cultivar interaction for each nutrient use efficiency index (Table 5).

Table 7. Average nutrient uptake use efficiency index (seed uptake/whole plant uptake) for 16 dry bean cultivars averaged across years and production system. Means followed by different letters are different at $P \geq 0.05$.

Cultivar	N	P	K	Zn	Cu	Mn
C. Pinto	0.87gh	0.96ef	0.52gh	0.70gh	0.71ef	0.18h
Othello	1.17b	1.32ab	0.72a	0.99b	0.95ab	0.40a
UI 320	0.90gh	0.99def	0.63bcd	0.78efg	0.75e	0.31bcd
Bill Z.	1.04cdef	1.18c	0.66ab	0.90bcd	0.86bcd	0.32bc
Buster	0.92fg	0.99def	0.55efgh	0.75fgh	0.76de	0.23efg
Topaz	0.94defg	1.01def	0.60bcde	0.80efg	0.71ef	0.31bcd
Mesa	1.10bc	1.22bc	0.65abc	0.92bcd	0.88bc	0.28dcef
C. Red Mex.	0.80h	0.89f	0.49h	0.65h	0.63f	0.17h
UI 259	1.32a	1.44a	0.71a	1.13a	0.99a	0.32bc
NW 63	1.16bc	1.24cb	0.62bcd	0.94bc	0.91ab	0.25def
UI 239	1.04cdef	1.12cd	0.57defg	0.89cde	0.80cde	0.24efg
LeBaron	1.06bcd	1.11cd	0.60bcde	0.83def	0.79cde	0.30bcde
Matterhorn	0.89gh	0.94ef	0.50h	0.73fgh	0.78cde	0.26def
UI 465	0.88gh	1.03de	0.52gh	0.77fg	0.74e	0.28dcef
UI 59	0.93efg	1.00def	0.58cdefg	0.78efg	0.74e	0.31bcd
UI 1140	0.91gh	0.95ef	.053fgh	0.73fgh	0.72ef	0.34b
Pr>F	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

The nutrient use efficiency index is also dependent upon the nutrient being evaluated. Of the six nutrients discussed, N, P, K, Zn and Cu are highly mobile within the xylem and phloem conductive tissues of the plant and will be readily translocated to the developing seed. Since Mn is not as mobile in the phloem, its index will be lower than the other nutrients, as illustrated in Table 7.

In general, the nutrient use efficiency index when high for one nutrient and cultivar was also high for the other nutrients. As an example the N index for UI 259 was the highest of all cultivars and the indexes for the other nutrients (P, K, Zn and Cu) was the highest or among the highest (Table 7). UI 259 seed yield was also relatively high (Table 3) as well as its harvest index. Neither its whole plant uptake (Table 4) nor its seed nutrient concentration (Table 6) was higher than for the other cultivars. This comparison does illustrate the problem of comparing either nutrient uptake or concentration among cultivars when there are growth differences involved. This problem is further illustrated in Figure 1. It compares the harvest index with the Zn nutrient use efficiency index. This comparison shows that as the harvest index increases the

Zn index also increases. This is analogous to saying that the plant translocates a similar portion of its dry matter and Zn content into seed production over a range of seed yields, provided the seed Zn concentration does not appreciably change.

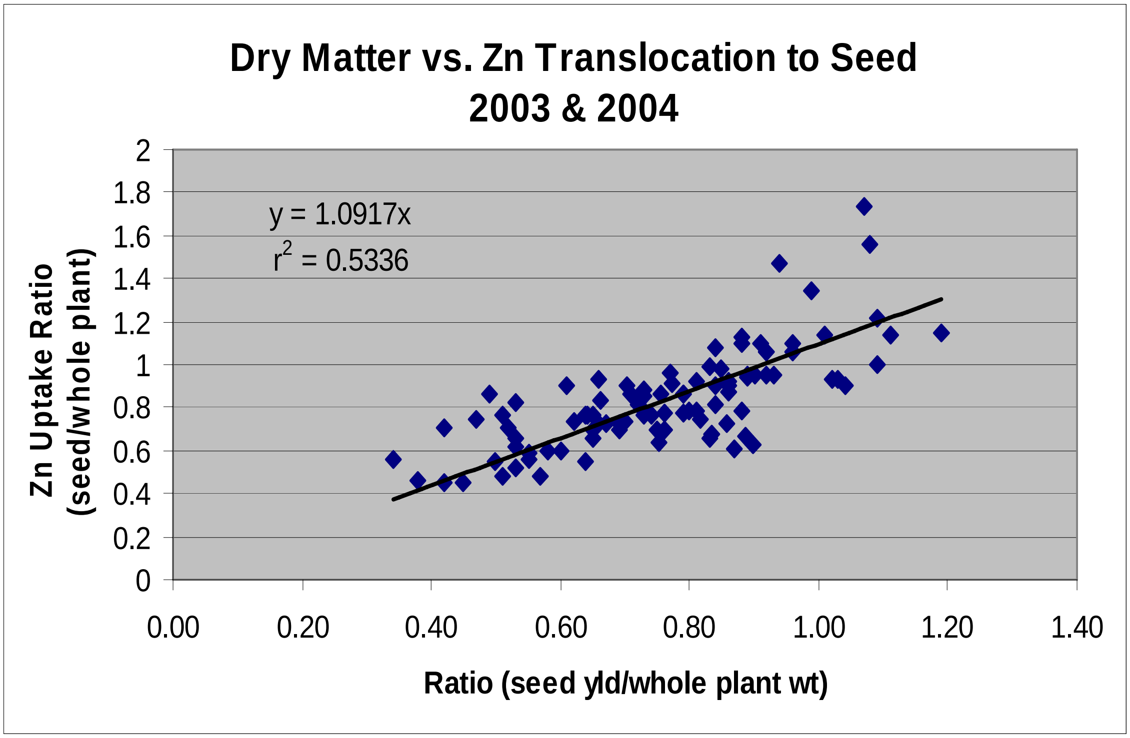

Figure 1. Relationship between harvest index (seed yield/whole plant yield) and nutrient use efficiency for Zn (seed uptake/whole plant uptake) across years and production systems.

We further explored these relationships by normalizing the relationship between harvest index and nutrient use efficiency index by calculating a nutrient translocation ratio defined by the following equation:

Nutrient translocation ratio = (nutrient use efficiency ratio)/(harvest index) (1)

This ratio increases as the proportion of nutrient in the whole plant translocated into the seed increases, effectively removing the seed yield increase from the evaluation. The ratio was highly significant for all six nutrients for cultivar and production system but was only highly significant for K and Zn for the cultivar x production system interaction (Table 8).

Table 8. Statistical significance of nutrient translocation ratio ($Pr < F$).

Nutrient	Cultivar	Production system	Cult * Prodc. Syst.
N	<0.0001	0.0012	<0.0001
P	<0.0001	<0.0001	<0.0001
K	<0.0001	0.0016	<0.0001
Zn	<0.0001	0.0005	<0.0001
Cu	0.0002	<0.0001	<0.0001
Mn	<0.0001	<0.0001	<0.0001

We further evaluated the cultivar x cropping system interaction by assignment of a relative rating to each cultivar between 1 and 16 according to the translocation ratio value within each production system (Table 9). This was an attempt to identify the best responding cultivars within each production system for Zn nutrient use efficiency/translocation ratio. For this comparison, the conventional production systems (OFC an REC) were combined. The cultivars Buster, Matterhorn and UI 259 appear within the top five rating levels four times, while Common Red Mexican appears three times and Othello appears two times. Buster and Othello appear in the higher input production systems (OFC, OGH), while Matterhorn and Common Red Mexican appear in the lower input production systems (OGL, OLF). Common Red Mexican and UI 259 also appear relatively high in both organic production systems (OGL, OGH).

Table 9. Relative dry bean cultivar Zn translocation ratio for six production system

Rating	OFC	OGL	RDT	OGH	RCB	OLF	Overall*
1	Buster	Matterhorn	UI 465	Buster	Matterhorn	C Red Mex	Buster(4)
2	Othello	C Red Mex	UI 59	C Red Mex	UI 59	Matterhorn	Matterhorn(4)
3	Topaz	UI 259	Buster	UI 259	UI 259	NW 63	UI 259(4)
4	C Pinto	Bill Z	Matterhorn	Othello	Mesa	Buster	C Red Mex(3)
5	UI 259	Mesa	UI 1140	Mesa	LeBaron	C Pinto	Othello(2)
6	Mesa	NW 63	Mesa	Matterhorn	UI 239	UI 259	Mesa(3)
7	UI 320	Othello	LeBaron	Bill Z	Topaz	Othello	NW 63(1)
8	Bill Z	LeBaron	Topaz	UI 320	UI 465	UI 59	Topaz(1)
9	NW 63	Buster	UI 259	UI 59	C Red Mex	UI 239	C Pinto(2)
10	UI 239	Topaz	UI 239	UI 1140	NW 63	Topaz	UI 59(2)
11	Matterhorn	UI 465	Othello	UI 239	UI 320	UI 465	Bill Z(1)
12	C Red Mex	UI 320	Bill Z	C Pinto	Othello	LeBaron	UI 239
13	LeBaron	UI 239	NW 63	Topaz	Bill Z	UI 1140	UI 320
14	UI 59	UI 59	UI 320	NW 63	Buster	Mesa	LeBaron(1)
15	UI 465	C Pinto	C Red Mex	UI 465	UI 1140	UI 320	UI 465(1)
16	UI 1140	UI 1140	C Pinto	LeBaron	C Pinto	Bill Z	UI 1140(1)

*Number within parenthesis is number of times a cultivar appears in first five levels for across production systems.

Across production systems and years, the relative performance of the different cultivars for the top six ratings are shown in Table 10 for selected seed yield and Zn attributes. Similar tables could be developed for each production system and nutrient. In Table 10, Mesa appears in all five attributes within the top six ratings. Othello, UI 259 and UI 239 appear four times each. Matterhorn, Buster and Topaz are in the top six for seed Zn concentration and Buster appears to be relatively efficient translocating Zn to the seed. Matterhorn and Buster also had the higher whole plant yields (Table 3). Othello also has a relatively high dry matter and Zn translocation efficiency to the seed.

Table 10. Relative rating of top six cultivars across years and production systems for selected seed yield and Zn attributes. Letters in parenthesis refer to significant difference at $P \geq 0.05$. *

Relative rating	Seed yield	Harvest index	Seed Zn concentration	NUEI-Zn	NTR-Zn
1	Mesa(a)	UI 259(a)	Topaz(a)	UI 259(a)	Buster(a)
2	NW 63(a)	NW 63(ab)	Matterhorn(ab)	Othello(b)	UI 259(a)
3	UI 239(a)	Othello(ab)	Buster(bc)	NW 63(bc)	Othello(ab)
4	Bill Z. (a)	Bill Z. (ab)	Bill Z.(c)	Mesa(bcd)	Matterhorn(bc)
5	Othello(ab)	Mesa(abc)	UI 59(c)	Bill Z.(bcd)	Mesa(bc)
6	UI 259(bc)	UI 239(abcd)	Mesa(cd)	UI 239(cde)	UI 239(bc)

* NUEI, NTR = Plant nutrient use efficiency index and Nutrient translocation ratio, respectively, for Zn.

Acknowledgments

Funds received from the USDA-Western Regional Sustainable Agricultural Research and Education program, Logan, UT since 2002 for this project (WS02-038) are highly appreciated. We are also grateful to M. Kay, H. Terán, C. Muñoz, M. Lema, R. Hayes, M. Dennis, R. Allen, J. Wright, J. Smith, D. Fullmer, R. Parrott, and K. Mulberry for their participation in plot management, data recording and/or analyses.

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The Value of Seed Crops Beyond Contracts

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List of Plants Grown for Seed

Cauliflower Nash's over winter variety	Parsnips
Cabbage January King Savoy	Jerusalem Artichokes
Cabbage Red Drum Head	Radish Black Spanish
Cilantro	Brussels Sprouts Hybrid
Arugula	Leek
Kale Red Russian	Boc Choy
Kale Nash's Red	Tat Soy
Carrot Nash's Nantes	Rye Grain
Carrot Rumba Nantes	Australian Field Peas
Spinach Outer Space	Common Vetch
Chard Red	Barley Grain
Beets Detroit Red	Tritcale Grain

These seeds represent the list of interest we have on our farm for varieties that have been important to our farming. These vegetables and grains are of value for many reasons. At times we do it for a cash crop, a contract with seed companies. For some we can produce the seed for our own use more economically than purchased seed, e.g. spinach, grain seed, cilantro. On others we have developed our own variety that we produce seed from, providing us with a unique marketing slot, e.g. our two carrots, red cabbage, Jerusalem Artichokes, Nash's Cauliflower.

Our fresh carrot market is a good example of why and how we approach seed selection and why we chose to grow a particular seed. Our success in selling carrots into the wholesale fresh market is owing to a couple of important reasons. Freshness and flavor we have found are the elements in produce, which a large percentage of the organic customers value above price. I grew carrots for the wholesale market for several years and was always competing against the inexpensive, flavorless, orange sticks out of California. We could compete on price, but there wasn't much to be gained there, initially I was growing similar varieties that were being used in the California growing area. Variety trialing is important to a farm, and we were trialing some different varieties on a regular basis. We were finding the O. P. Nantes were good for flavor, and so settled on a couple of varieties that worked well in our system. Over a span of about 6 years during the 90's both of those varieties became unavailable from their commercial sources. So it was in our best interest to grow these Nantes varieties for their seed in order to maintain our commercial marketing position within the fresh carrot market.

The red kale we are developing for the Red Boar winter kale market is an example of a market window for a winter hardy, good tasting purple kale that illustrates a couple of farm values. The current hybrid Red Boar is a beautiful but lousy tasting kale, also its resistance to mildew is poor. There is a need for a pleasant tasting winter hardy purple kale, preferable an open pollinated one, with good mildew resistance, and good shelf life. We have worked on this project for over 14 years. It's an interesting project in that it originated as a conjunction with my disaffection with the available kale varieties and a discovery of some sports in a field of vates kale. I isolated the purplish Vates sports and crossed them with a Brussels sprout. The initial results of this crossing were then vigorously selected for stature, color, winter hardiness, leaf curl, taste and shelf life. Because I didn't have any technical knowledge of genetics or plant breeding the work has probably taken longer than it should. Presently we are continuing our selection with help from Organic Seed Alliance, but also beginning to use this Kale for some commercial shipping, although it still has some considerable variability in color and leaf appearance. It does have much better taste, and mildew resistance, than Red Boar Kale. It has a great purple color, although maybe not as bright as Red Boar.

Some of these projects have their beginnings in Nash's early work with Forest Schomer of Abundant Life Seed Foundation (ALSF) and some are of recent projects. Some of my initial work with ALSF was in harvesting dandelion seed and in producing winter Bloomsdale spinach seed. The dandelion seed was harvested from fallow pastures in late spring, using a large vacuum mounted over a platform on the 3-point hitch on a small 30 hp tractor. The Winter Bloomsdale spinach I was using for an early March-April spinach market window into the Seattle market back in the 80's. It was then a relative easy transition to also grow some spinach seed for ALSF. We are no longer using Bloomsdale as a production variety.

Several years ago we begin to use the variety Space as our main fresh market spinach variety. I am always looking for ways to cut production cost and open pollinated spinach seed is fairly easy to produce. Space was a hybrid. Our experience in taking a planting of that hybrid to seed was that it would give us a pretty good OP seed for our fresh market spinach production. We have then have produced successive generations of seed from the OP lines. There are some minor problems under some growing and marketing situations with the OP lines but generally we have saved considerable on seed cost in our spinach production system. Presently we are working with the Organic Seed Alliance and Seeds of Change on a fairly broad development program to improve the OP Outer Space system of seed that we are using.

We have been producing annual rye grain for use as a cover crop seed for several years. All of our farm gets a winter cover crop of rye with Common vetch and Australian field peas, that is the fields on which we do not have a winter production crop. So we always take a few acres on to maturity for that year's seed crop. We find that the vetch and field peas mature and harvest easily with the grain crop. We do not clean out the vetch and peas, but leave them in the mix. During the summer we do find it necessary to have a crew walk the crop as the wild mustard is blooming to pull out these weeds.

For several years we have been raising chickens for egg production, and also raising some feeder pigs. Barley grows well in our maritime climate and so we produce about 30 to 50 tons of barley for use as feed in these programs. I have found grain crops do contribute considerably to the organic matter build up in our fields. Rye in particular will get 6 feet plus in height and produces a tremendous amount of straw. We give this a couple of disking with a heavy cover crop disc, and leave the straw on top of the ground through the winter. There will be a good volunteer rye and vetch crop, which covers the field, and by April of the following spring a good crop to work in for fertility. Barley is treated similarly after we harvest the grain crop.

These seeds give us quality assurance, security, and a sense of connection to our crops. If we stay on selection we know that we will get the genetics we need. We also don't have to scramble to replace varieties when seed companies drop them from their list, sell out or have crop failures. It puts the resource squarely in our hands. It gives us an edge on our fresh market crops. It connects us to a heritage of farmers as seed stewards.

These are a few examples of value we derive from seed beyond the financial benefits of seed contracts.

The Value of Organic Seed Production on a Diverse Organic Farm

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So why grow organic seed, especially if you already have your hands full with more organic row and grain crops than you can realistically handle? Of course there are economic incentives—if your plate is presently full, you would not want to take on more unless there were some presumed financial incentive. But, beyond economics, there are some compelling reasons to add organic seed production to your present cropping system.

First of all, growing your own seed is a great way to comply with the National Organic Program rule requiring organic seed, as well as providing a reliable seed source of locally adapted varieties for both cash and cover crops. Incorporating seed contracts for different crops will add diversity to your crop rotation. Because seed crops require a full growing season to flower and ripen, they provide food and habitat for beneficial organisms, while adding diversity to the agroecosystem in time as well as space. Perhaps the most compelling reason to take on the challenges of organic seed production is to complete the full cycle of that miraculous process of growing food for ourselves and our fellow eaters. This aspect of seed really helps me fulfill my quest to farm more sustainably. Harvesting seed crops from seed that I have grown myself is extremely rewarding, especially if I get the chance to select and make some improvements in that particular variety.

My Wife and I, and two employees farm 300 irrigated acres on the northern edge of the Snake River Plain, just west of Shoshone, Idaho. Our farm is surrounded by sagebrush desert, and bisected by the Little Wood River. The cropping system is a mix of row crops such as dry beans and potatoes, small grains, and pasture and hay, with some seed crops thrown in to make life even more interesting. Because we are isolated from other farms, and have a relatively intact natural ecosystem with minimal pest pressure, (compared to most agricultural areas), seed production on a moderate scale makes sense for us, at least agronomically. The dry climate allows us to grow bean and pea seed with very little worry about diseases. Our isolation reduces concerns about genetic pollution and cross-pollination. Additionally, our approach to fertility, i.e. feeding the soil through a long grass/legume rotation followed by row and grain crops, provides opportunities to grow seed crops without too much weed pressure. However, despite these apparent advantages, there are still many challenges to organic seed production on our farm.

Growing seed crops definitely requires more management and attention by farmers than the food and forage crops most of us are accustomed to. The overarching challenge is that of time (not enough), and timing. Of course these are concerns for all farmers, particularly those who farm organically, but I find that adding seed crops makes them even more problematic. For example, while the timing of planting is critical for most crops, with seed crops it is even more so. Because successful seed production usually requires a full season, late planting often results in immature or frost damaged seed, which is unsellable. For some varieties, planting too late means that flowering occurs during very hot weather, resulting in light seed yields and/or poor germination. Occasionally full-on conflicts arise due to weather constraints, such as happened to me this past spring, when because of an extended rainy spell twenty acres of potatoes and a quarter-acre seed project ended up needing to be planted at the same time. Due to the relative values of each, the seed crop took second seat to the potatoes in this case. Moreover, the time crunch continues throughout the season with cultivation, rouging and harvest, all of which must happen in a timely manner—often at the same time as other important jobs on the farm.

In addition to time challenges, unless a project is very small and can be hand-harvested, successful seed production also requires the right machinery for harvest, such as swathers and combines. If you do not have the necessary harvest equipment, finding custom operators who will even consider harvesting seed plots is problematic at best, and compounded even more so by the need for timeliness. When seed is ready, it should be harvested, in order to prevent loss from shattering or damage from rain, so having one's own equipment is advantageous. Another important consideration, especially if growing multiple varieties of the same crop such as we do with bean seed, is to have access to a powerful enough air compressor to be able to thoroughly clean the combine between each variety. Again, this can present timing challenges if you have to hire someone else to do it. If you do plan on using custom harvest help, because of the extra time involved, plan on paying more than you would for regular commodity harvest.

Another time-related conflict we have is seed cleaning after harvest. We do not have our own milling equipment, so we rely on several local companies to clean our seed. However, because our scale is so small and these companies clean their own seed first, it is hard to get seed cleaned and to the buyers when they would like to have it, particularly in time for January seed rack sales. For some time now, several of us have talked around the idea of buying equipment and starting a seed cleaning cooperative. However, we realize that we would run into the same time constraint ourselves—that of not having time to clean seed until all our other harvest and fall farm work is completed in December.

Because of the isolation and natural wildness on our farm we do not have to worry too much about many of the usual crop pests found in production agricultural areas such as aphids, lygus or carrot rust fly, but we do have our own unique problems instead. For example our irrigated oasis attracts a wide variety of wildlife, and the deer and raccoons can do considerable damage to crops like sweet corn, melons and cucumbers. We have figured out how to fence out the deer (although it is a lot of work) but raccoons remain a challenge. Consequently we have to hide these tempting crops as far from the river as possible. By contrast, some bean varieties are susceptible to curly top virus, which is transmitted by leafhoppers that move in from the desert as it dries up in late spring or early summer, just in time to infect emerging bean plants. In order to avoid curly top problems, I try to plant susceptible beans close to the river and surround them with resistant varieties to act as decoys or trap crops.

An important aspect of successful seed production is varietal purity. Due to the variability of the seed lots we grow from, in order to end up with a pure seed crop, hand removal of off-type plants, known as rouging, is sometimes necessary. Of course this only works with the self-pollinating crops such as beans. It is important to plan for the time necessary for this task because there is only a narrow window when effective rouging is possible. With cross-pollinating crops, less than pure seed lots are a problem which seed buyers need to be

responsible for, whether or not they supply the stock seed. This is an issue that needs further attention from both seed growers and seed companies.
Seed-born diseases can also be a problem in seed crops grown from an unknown stock seed lot. This hit close to home this past summer when an organic farmer friend ended up having to destroy a whole bean crop due to one infected seed lot. The State of Idaho has strict phytosanitary regulations for bean seed production, which include serology testing for seed-born disease before beans that have not been grown previously in the state can be planted. Apparently one of the half-dozen varieties this grower had planted carried bacterial blight, a very infectious bean disease, which was not detected by the pre-plant test. When it showed up in the field in mid-summer, it quickly spread to several other varieties, and all the beans on the farm were ultimately condemned and had to be plowed under (which was insult to injury to someone who never uses a moldboard plow). Not only was the income from this year's crop lost, but more importantly, the field is quarantined for all bean production for at least three more years, resulting in a much more serious potential loss of revenue if an equivalent income-producing crop is not found. This is potentially a very serious issue for all seed growers; even though farming is inherently risky (and seed crops that much more so), this is one risk too many, because it is not worth jeopardizing future production due to contaminated seed.

Given the numerous challenges of adding organic seed crops to your rotation, are the economic returns worth the extra effort? Overall the answer is yes. However, for various reasons, not every seed project will be successful, so you do not want to bet the farm on a single crop. Each year we grow several different seed crops, ranging from ten acres of bean seed down to a tenth of an acre of carrot seed. These fit in nicely with our overall crop rotation, but in the scheme of things are a very small part of our income picture. They definitely take a disproportionate amount of our time and energy on a per acre basis, and yields sometimes fall short of projections. Ultimately we do need to realize a significant monetary return for that additional time and attention that producing high quality organic seed requires. Every growing season on our farm, we devote approximately half our acreage to soil building forage crops that do not return a high value per acre. Consequently, in order to operate the farm in the black, the acres that are planted to row crops have to yield considerably more income than their cost of production. With the additional amount of management and time that the seed crops necessitate, they need to net even more than the food crops. The seed companies that we work with understand this, but as the organic seed requirement begins to be more widely enforced, there will be downward pressure on seed prices, which growers need to resist. Seed price, quality and terms of delivery should be spelled out in a contract, which ideally will be equitable for both the grower and the buyer, including who will stand the loss if there is a crop failure.

Despite the potential pitfalls, growing organic seed is definitely a worthwhile endeavor, and deserves consideration by serious farmers.

Seed Economics

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Seed production can be a profitable part of a grower's diversification of his farming operation. It can also be one of the most expensive and needs proper planning and consideration. To be successful a grower should be comfortable with all of the requirements that they will need to meet in order to produce the yield and quality that the buyer has requested.

These are some of the questions that a growers need to have answered in order to ensure that he/she has evaluated all of the potential risks of a seed growing venture.

1. What are actual costs of production and how does growing a seed crop work into my overall picture?

Seed crops need to be in the ground longer than most crops, sometimes over the winter. This will mean that the crops will be exposed to weeds, insects and diseases for a long period of time and the grower may not be experienced with dealing with these problems on a year wide basis. Methods of dealing with these problems may be more expensive that the grower is used to. Is labor available during the winter months to weed and apply chemicals?

2. Do I have a good contract and is the company that I am contracting with have the ability to pay?

Do you understand all of the stipulations of the contract? Are the methods and terms of payment clearly laid out? Is there any question that the company that you have a contract with is able to pay? If you work with a banker for ag financing, ask him to do some checking. A reputable company can provide you or your banker with credit references. Ask your neighbors; find out if they have any experiences with the company that you want to work with.

3. Can I do the job?

Be honest with yourself and don't jump off the deep end! If you don't have any experience you will more than likely not be prepared to take on a large contract? Work with the contracting company and ask for a flowering trial or a small production to get a feel for what will be expected of you. This will save you a lot of headaches and heartaches!

I will present a one page worksheet that will guide the grower through making this decision to grow a seed crop and to evaluate the risks involved.

Seed Economics

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Making money growing seeds is not as easy as many think at first. There are many different aspects of seed production and marketing that affect your profitability and success. The growers that I know who are doing it best have figured out a niche for themselves and gotten expert at producing certain crops. They have found the right markets for their seed and the right scale. In this talk I will discuss some of the ideas and strategies that I have found helpful in my own seed production as well as from working with these seed growers from across the country.

Production

Growing seeds is more complex than growing vegetables. The time from planting to harvest is longer, you have disease concerns of a whole other order and in the end the germination rate may not be satisfactory. There are a number of techniques and questions that can help make your seed production as successful as it can be from an economic standpoint.

1. Region: It is very important to know what seed crops can grow successfully in your geographic region and which do not, but don't let it prevent you from experimenting or attempting production of other seed crops on a small scale.
2. Stock Seed: Some stock seed is better than others, some has been selected for high yielding seed crops or other characteristics specific to the seed stage of plant growth. This can make the difference between a crop failure or a boom.
3. Equipment: Having the right equipment for your scale of production is very important. Tractors and irrigation is easy to find but specialized seed harvesting, processing and cleaning equipment is more difficult to locate. Much of the available equipment is not applicable to smaller growers.
4. Disease: Knowing the soil diseases that you might have already and choosing your stock seed and crops for your region wisely will eliminate many of the largest of the disease concerns. Learn about which diseases to be concerned about and which ones are not a problem. Develop a relationship with a state lab, or the seed company that you are growing for so that they can assist you in your goal of producing disease-free seed.

There are many other aspects of production that can help your seed growing efforts be financially rewarding but the above listed issues are among the most important.

Marketing

The Seed Economics Triangle

1. Scale: How much seed are you going to grow of a given variety and how much land and time will it take.

2. Variety: Which variety of a certain crop are you going to grow? An heirloom, o.p., hybrid or something of your own breeding? A popular variety or a rare or specialty one?

3. Customer: Who is your customer for the seed that you will grow. A large or small company? A company that sells to home gardeners or a company that sells to commercial growers or both?

Answering these three questions will help you to determine what makes sense for you to grow. For example, growing a small amount of a common popular variety will not generally be that profitable. But a rare or specialty variety would be more likely to be a higher price per pound. In addition, if you are only growing a small amount of seed then selling it to a smaller company or one that only resells to home gardeners may bring you a higher price. Selling seed directly to other gardeners and farmers is certainly another option but requires a great deal of additional resources, expertise and complexity and may or may not be worth it financially.

These three questions and the process of answering them may seem overly simple but many seed growers rarely go through this process formally and I have seen it be quite helpful.

Seed Borne Diseases: An Overview

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Seedborne Diseases: An Overview

2006 Organic Seed Conference, Portland, OR

Lindsey du Toit
Washington State University Mount Vernon NWREC

Classes of seedborne microorganisms

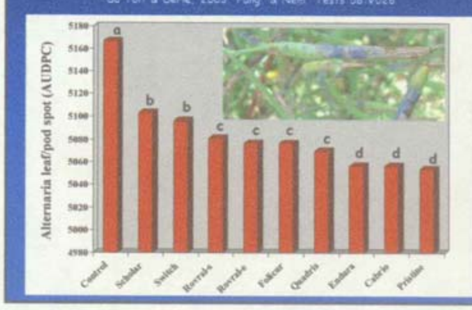
1. Infected seed = primary inoculum source. If seed infection is controlled, the disease is controlled
2. Important crop pathogen, but infected seed = minor source of inoculum
3. Seedborne microorganisms never demonstrated to cause disease
4. Pathogens that infect seed in fields or in storage, and reduce seed quality

Impacts of seedborne pathogens

- reduction in seed germination & vigor
- seed transmission
- yield loss (quality &/or quantity)
- infection of harvested produce
- dissemination of pathogens, including new races/strains

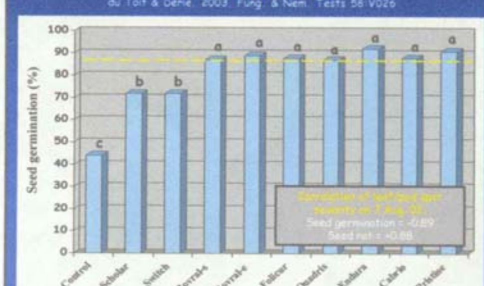
2001-02 Cabbage seed crop trial
Severity of Alternaria leaf/pod spot

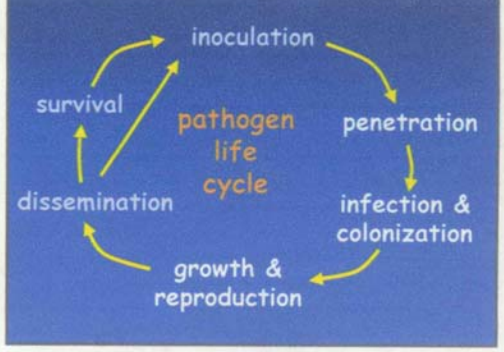
du Toit & Derie. 2003. Fung. & Nem. Tests 58:V026

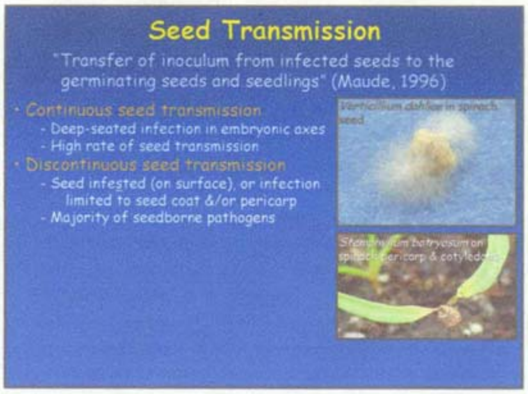


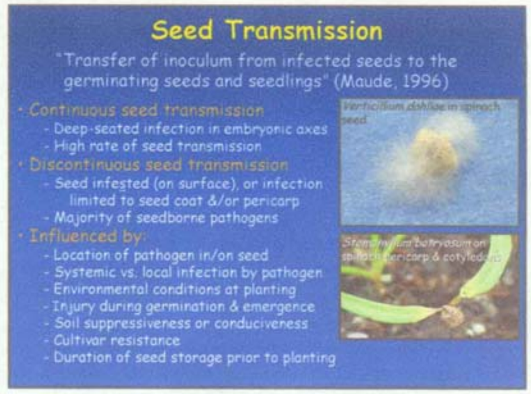
2001-02 Cabbage seed crop trial
Seed germination

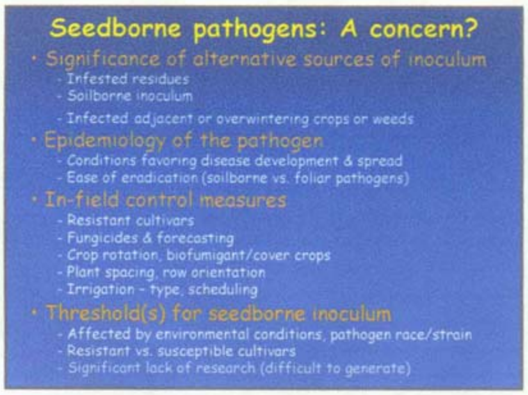
du Toit & Derie. 2003. Fung. & Nem. Tests 58:V026

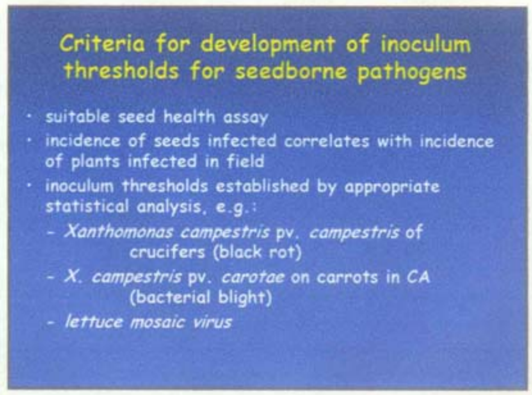




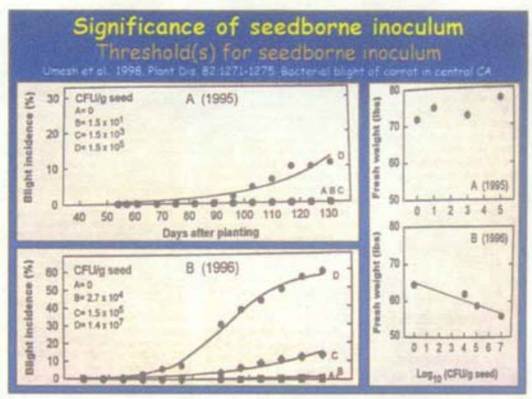

Seed Transmission
"Transfer of inoculum from infected seeds to the germinating seeds and seedlings" (Maude, 1996)
· Continuous seed transmission
- Deep-seated infection in embryonic axes
- High rate of seed transmission
· Discontinuous seed transmission
- Seed infested (on surface), or infection limited to seed coat &/or pericarp
- Majority of seedborne pathogens
Verticillium dahliae in spinach seed

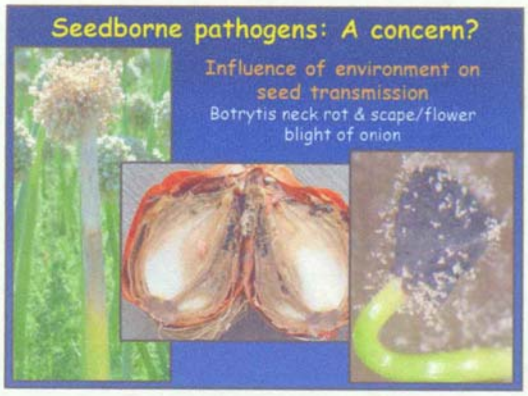

Seed Transmission
"Transfer of inoculum from infected seeds to the germinating seeds and seedlings" (Maude, 1996)
· Continuous seed transmission
- Deep-seated infection in embryonic axes
- High rate of seed transmission
· Discontinuous seed transmission
- Seed infested (on surface), or infection limited to seed coat &/or pericarp
- Majority of seedborne pathogens
· Influenced by:
- Location of pathogen in/on seed
- Systemic vs. local infection by pathogen
- Environmental conditions at planting
- Injury during germination & emergence
- Soil suppressiveness or conduciveness
- Cultivar resistance
- Duration of seed storage prior to planting
Verticillium dahliae in spinach seed

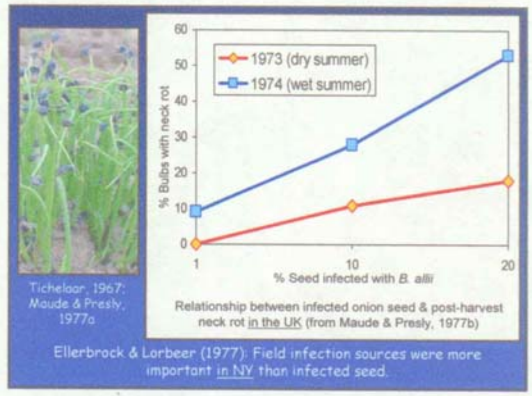

Seedborne pathogens: A concern?
· Significance of alternative sources of inoculum
- Infested residues
- Soilborne inoculum
- Infected adjacent or overwintering crops or weeds
· Epidemiology of the pathogen
- Conditions favoring disease development & spread
- Ease of eradication (soilborne vs. foliar pathogens)
· In-field control measures
- Resistant cultivars
- Fungicides & forecasting
- Crop rotation, biofumigant/cover crops
- Plant spacing, row orientation
- Irrigation - type, scheduling
· Threshold(s) for seedborne inoculum
- Affected by environmental conditions, pathogen race/strain
- Resistant vs. susceptible cultivars
- Significant lack of research (difficult to generate)

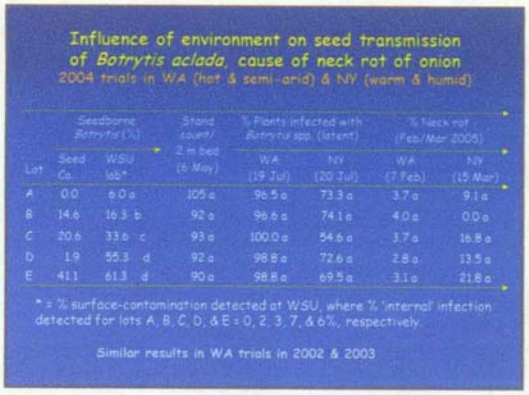

Criteria for development of inoculum thresholds for seedborne pathogens
· suitable seed health assay
· incidence of seeds infected correlates with incidence of plants infected in field
· inoculum thresholds established by appropriate statistical analysis, e.g.:
- Xanthomonas campestris pv. campestris of crucifers (black rot)
- X. campestris pv. carotae on carrots in CA (bacterial blight)
- lettuce mosaic virus

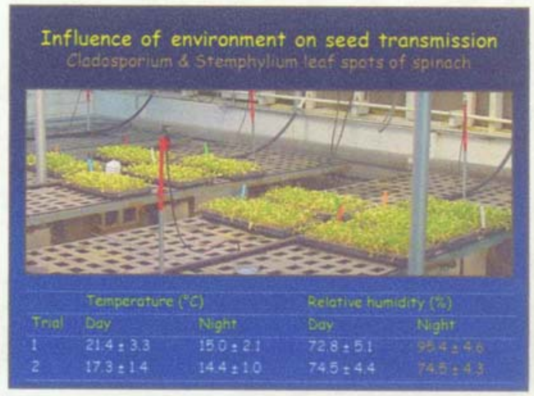

Significance of seedborne inoculum
Bacterial blight of carrot (Xanthomonas campestris pv. carotae)

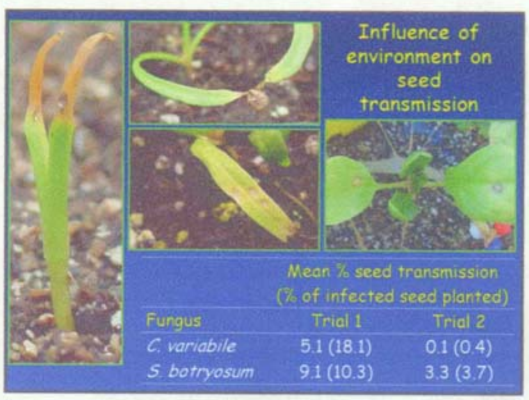

Significance of seedborne inoculum
Threshold(s) for seedborne inoculum
Umesh et al. 1998. Plant Dis. 82:1271-1275. Bacterial blight of carrot in central CA
CFU/g seed
A (1995)
A= 0
B= 1.5 x 10^1
C= 1.5 x 10^3
D= 1.5 x 10^5
Blight incidence (%)
Days after planting
Fresh weight (lbs)
B (1996)
A= 0
B= 2.7 x 10^4
C= 1.5 x 10^5
D= 1.4 x 10^7
Log10 (CFU/g seed)

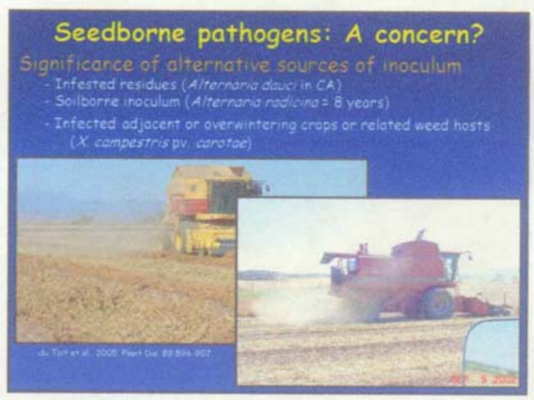

Seedborne pathogens: A concern?
Influence of environment on seed transmission
Botrytis neck rot & scape/flower blight of onion

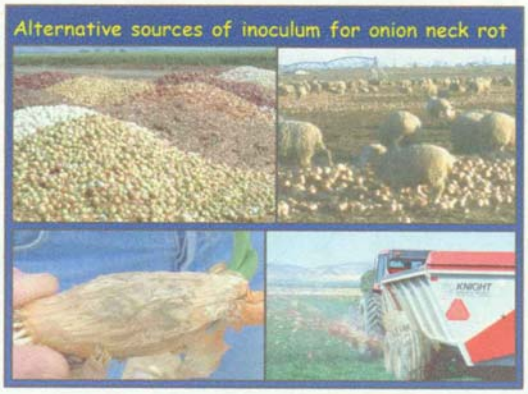

Tichelaar, 1967; Maude & Presly, 1977a
1973 (dry summer)
1974 (wet summer)
% Bulbs with neck rot
0
10
20
30
40
50
60
1
10
20
% Seed infected with B. allii
Relationship between infected onion seed & post-harvest neck rot in the UK (from Maude & Presly, 1977b)
Ellerbrock & Lorbeer (1977): Field infection sources were more important in NY than infected seed.


Influence of environment on seed transmission of Botrytis aclada, cause of neck rot of onion
2004 trials in WA (hot & semi-arid) & NY (warm & humid)
Lot | Seedborne Botrytis (%): Seed Co. | WSU lab* | Stand count/2 m bed (6 May) | % Plants infected with Botrytis spp. (latent): WA (19 Jul) | NY (20 Jul) | % Neck rot (Feb/Mar 2005): WA (7 Feb) | NY (15 Mar)
A | 0.0 | 6.0 a | 105 a | 96.5 a | 73.3 a | 3.7 a | 9.1 a
B | 14.6 | 16.3 b | 92 a | 96.6 a | 74.1 a | 4.0 a | 0.0 a
C | 20.6 | 33.6 c | 93 a | 100.0 a | 54.6 a | 3.7 a | 16.8 a
D | 1.9 | 55.3 d | 92 a | 98.8 a | 72.6 a | 2.8 a | 13.5 a
E | 41.1 | 61.3 d | 90 a | 98.8 a | 69.5 a | 3.1 a | 21.8 a
* = % surface-contamination detected at WSU, where % 'internal' infection detected for lots A, B, C, D, & E = 0, 2, 3, 7, & 6%, respectively.
Similar results in WA trials in 2002 & 2003

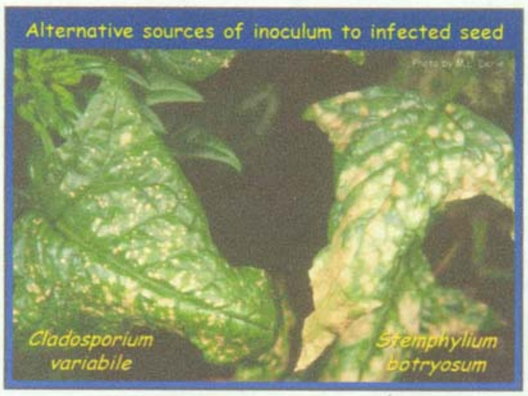

Influence of environment on seed transmission
Cladosporium & Stemphylium leaf spots of spinach
Trial | Temperature (°C): Day | Night | Relative humidity (%): Day | Night
1 | 21.4 ± 3.3 | 15.0 ± 2.1 | 72.8 ± 5.1 | 95.4 ± 4.6
2 | 17.3 ± 1.4 | 14.4 ± 1.0 | 74.5 ± 4.4 | 74.5 ± 4.3


Influence of environment on seed transmission
Mean % seed transmission (% of infected seed planted)
Fungus | Trial 1 | Trial 2
C. variabile | 5.1 (18.1) | 0.1 (0.4)
S. botryosum | 9.1 (10.3) | 3.3 (3.7)

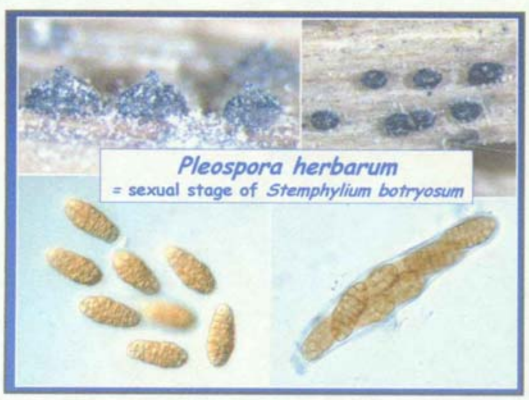

Seedborne pathogens: A concern?
Significance of alternative sources of inoculum
- Infested residues (Alternaria dauci in CA)
- Soilborne inoculum (Alternaria radicina = 8 years)
- Infected adjacent or overwintering crops or related weed hosts (X. campestris pv. carotae)
du Toit et al., 2005. Plant Dis. 89:896-907.

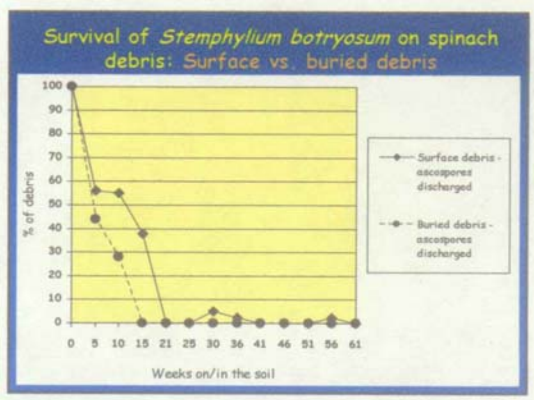

Alternative sources of inoculum for onion neck rot
KNIGHT


Seedborne pathogens: A concern?
Impact of introducing a pathogen:
soilborne
Alternaria radicina


Alternative sources of inoculum to infected seed
Cladosporium variabile
Stemphylium botryosum


Alternative sources of inoculum to infected seed
Overwintering of spinach leaf spot fungi in WA
Cladosporium variabile on volunteer spinach
Stemphylium botryosum on spinach seed crop debris


Pleospora herbarum
= sexual stage of *Stemphylium botryosum*

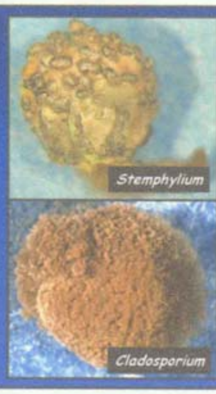

Survival of *Stemphylium botryosum* on spinach debris: Surface vs. buried debris
% of debris
100
90
80
70
60
50
40
30
20
10
0
0 5 10 15 21 25 30 36 41 46 51 56 61
Weeks on/in the soil
Surface debris - ascospores discharged
Buried debris - ascospores discharged

Significance of seedborne pathogens

Prevalence in seed lots

Prevalence of leaf spot fungi in commercial spinach seed lots

(Hernandez-Perez & du Toit. 2006. Plant Disease 90:*in press*)



Survey of spinach seed lots produced in 2003

Cladosporium variabile or *C. macrocarpum*

Country	Seed lots infected/assayed	Mean ± standard deviation (%)
Denmark	3/27	0.08 ± 0.06
Holland	1/6	0.04 ± 0.08
New Zealand	0/1	0.00
USA	22/32	0.7 ± 0.6
Total	26/66	0.4 ± 0.3

Stemphylium botryosum

Country	Seed lots infected/assayed	Mean ± standard deviation (%)
Denmark	27/27	58.4 ± 3.5
Holland	6/6	18.2 ± 3.0
New Zealand	1/1	58.5 ± 7.5
USA	32/32	6.1 ± 2.0
Total	66/66	29.4 ± 2.8

Detection of seedborne pathogens

Seed health assays

- Direct visual examination of seed
- Traditional: agar media, blotters (incubation)
- Grow-out: greenhouse, field
- Molecular: serological (ELISA), DNA or RNA

- Time, $
- Specificity
- Viable inoculum
- Variability of results among assays/labs
- Standardization/certification of assays

Reasons for seed health testing

- determine if infection is below threshold
- quarantine or phytosanitary certification
- to determine plant stand/health

Grow-out seed assays

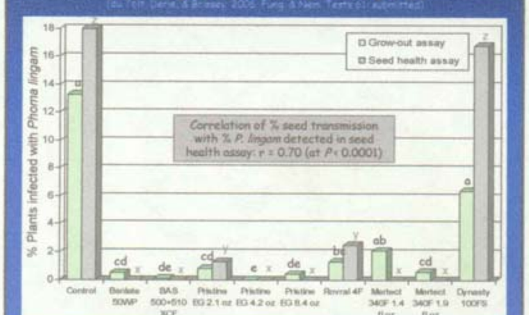
Black leg of brassicas (*Phoma lingam*)

(du Toit, Derie, & Morrison, 2005. Fung. & Nem. Tests 60:ST011)

Freeze-blotter seed health assay vs. grow-out assay

Black leg of brassicas (*Phoma lingam*)

(du Toit, Derie, & Brissey, 2006. Fung. & Nem. Tests 61: submitted)



Accurate diagnosis of seedborne pathogens

- Lookalike diseases:
  - e.g., black leg vs. ring spot of crucifers
- Saprophytes resembling pathogens:
  - e.g., *Alternaria alternata* vs. *Alternaria brassicicola*
- Strains of a pathogen:
  - e.g., seedborne nature of CMV subgroup II vs. I

Management of seedborne pathogens

Seed treatments

- Physical
  - kill pathogens, not seed
- Chemical
  - protect seed/seedling against pathogens
- Biological
  - protect seed/seedling against pathogens
  - induce systemic resistance
  - improve plant growth

Management of seedborne diseases

Seed treatments

- Hot water
- Chlorine
- Aerated steam
- Hot, dry air
- Fungicides
  - conventional, organic, biological (e.g., *Bacillus subtilis* = Kodiak)

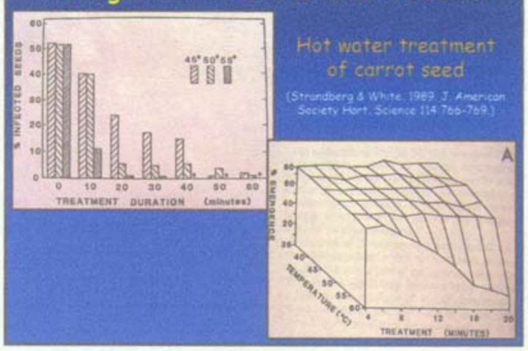
Efficacy & potential phytotoxicity:

- infected vs. infested seed
- volume of seed treated
- precise parameters
  - specific pathogens of concern
  - cultivars
  - initial seed quality
- drying seed
- shelf-life

Management of seedborne inoculum

Hot water treatment of carrot seed

(Strandberg & White, 1989, J. American Society Hort. Science 114:766-769.)



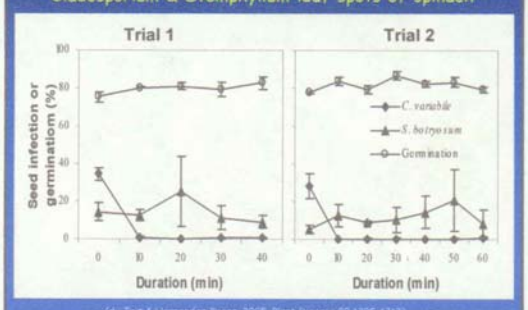
Management of seedborne inoculum

Hot water & chlorine seed treatments for leaf spot fungi of spinach:

- Chlorine (1.2% NaOCl)
  - 0, 10, 20, 30, 40, 50, & 60 minutes
- Hot water
  - 40, 45, 50, 55, & 60°C
  - 10, 20, 30, & 40 minutes

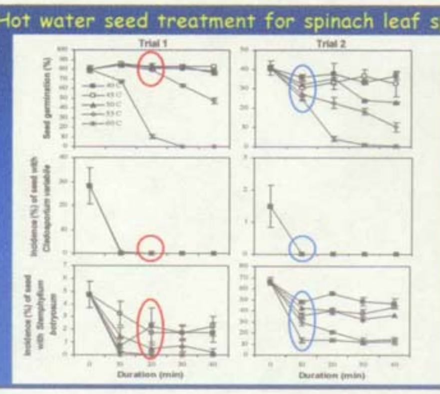
(du Toit & Hernandez-Perez, 2005, Plant Disease 89:1305-1312)

Chlorine (1.2% NaOCl) seed treatments for Cladosporium & Stemphylium leaf spots of spinach



(du Toit & Hernandez-Perez, 2005, Plant Disease 89:1305-1312)

Hot water seed treatment for spinach leaf spot



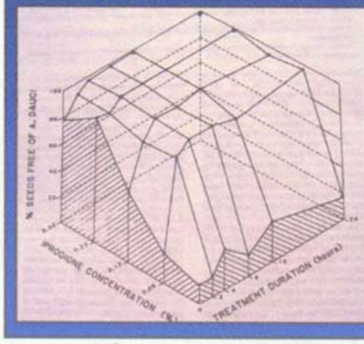
Efficacy of seed treatments
Affected by location of pathogens in/on seed

Seed lot	% *Stemphylium botryosum* Pericarp	% *Stemphylium botryosum* Embryo	% *Cladosporium variabile* Pericarp	% *Cladosporium variabile* Embryo
V	54	29	-	-
W	45	36	-	-
X	91	76	0	0
Y	45	36	2	0
Z	13	5	19	1

Cross section of the pericarp of a spinach seed (transmission electron microscopy)

(Hernandez-Perez & du Toit, 2006, Plant Disease 90: in press)

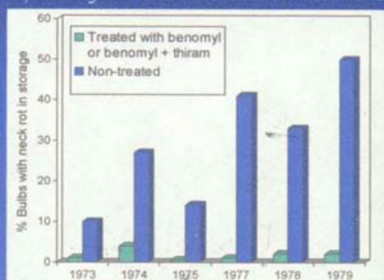
Management of seedborne inoculum



Fungicide treatment of carrot seed

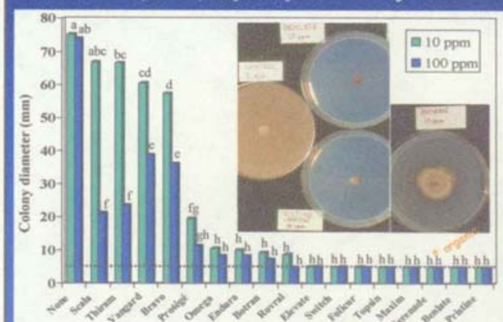
(Strandberg, 1984, Plant Disease 68:39-42.)

Management of seedborne inoculum
Efficacy of fungicide seed treatment for neck rot of onion



Control of neck rot in stored bulbs in the UK using seed treatments (from Maude, 1983, Seed Sci. & Technol. 11:829-834)

In vitro efficacy of fungicides against *B. aclada*
6 days after plating on fungicide-amended agar



Evaluation of fungicide seed treatments for management of seedborne *Botrytis aclada*:
2004 trials in WA & NY

Fungicide	% Seed germination (blotter assay)	% Seed infected + treatment (agar assay) *Botrytis*	% Seed infected + treatment (agar assay) *Asperg.*	Stand count/ 2 m (6 May)	% Plants with *Botrytis* (July 2004) WA	% Plants with *Botrytis* (July 2004) NY	% Neck rot (Feb-Mar 2005) WA	% Neck rot (Feb-Mar 2005) NY
Non-treated	94 a	11.0 a	6.5 a	42 a	100.0 a	6.5 a	11.2 bc	2.9 a
Thiram 42-S	89 bc	0.0 d	2.5 cd	45 a	97.5 a	3.0 a	15.4 ab	3.6 a
Topsin 70WP	92 ab	6.5 bc	6.3 ab	40 a	100.0 a	2.5 a	10.1 bc	5.2 a
Benlate 50WP	90 ab	0.3 d	1.0 d	44 a	97.5 a	0.0 a	6.8 c	4.6 a
Serenade AS	79 de	7.5 b	7.0 a	36 a	98.8 a	3.0 a	9.7 c	6.2 a
Maxim 4FS	91 ab	0.8 d	5.5 ab	45 a	100.0 a	3.0 a	19.9 a	4.3 a
Pristine WG	81 d	0.0 d	0.3 d	45 a	100.0 a	5.0 a	11.1 bc	7.1 a
Rovral 4F	74 e	0.0 d	5.8 ab	44 a	100.0 a	2.5 a	11.0 bc	1.0 a
Botran 75-W	89 b	4.8 c	4.0 bc	42 a	93.8 a	0.0 a	12.2 bc	4.2 a
Protégé 100FS	84 cd	1.5 d	6.3 ab	43 a	97.5 a	2.0 a	11.5 bc	8.9 a

Similar results in 2003 trial in WA

Management of seedborne pathogens

- Duration of survival on seed is affected by nature of the pathogen, location in/on seed, & storage conditions
- Pathogens usually survive as long as commercial or biological viability of the seed
- Long-term storage = limited use for disease control

Duration of survival of *Stemphylium*/*Cladosporium* leaf spot fungi in spinach seed

Age of seed lot (years)	# lots	Range in incidence (%) detected *Stemphylium botryosum*	Range in incidence (%) detected *Cladosporium variabile*
11	2	7.0 - 7.5	0
10	3	0.8 - 8.5	0
8	2	17.3 - 27.8	0 - 0.5
7	1	54.8	0
6	2	20.3 - 36.5	0
3	2	11.5 - 54.0	0 - 0.5

Management of seedborne pathogens after planting: Cultural practices

- Crop rotation
- Elimination of alternative hosts
- Destruction of inoculum in the field
- Control of insect vectors
- Irrigation - type, timing, frequency
- Planting practices
- Ventilation of seed crops
- Fertilizer programs
- Transplanting
- Harvesting
- Location

Management of seedborne pathogens after planting: Cultural practices

Crop rotation

- non-host, resistant, or 'antagonistic' crops
- minimum duration depends on:
  - host range
  - foliar vs. soilborne pathogens
  - longevity of inoculum survival
  - cultivar resistance
  - cultural practices, etc.
- be aware of asymptomatic hosts

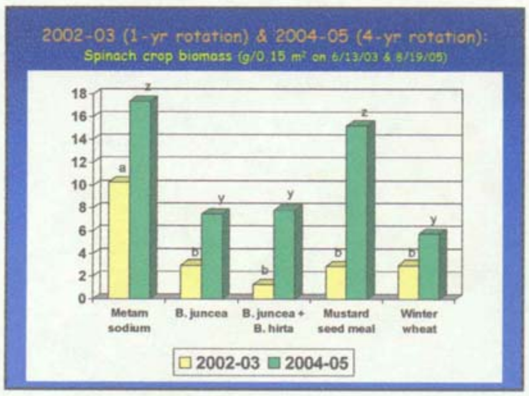
Elimination of alternative hosts

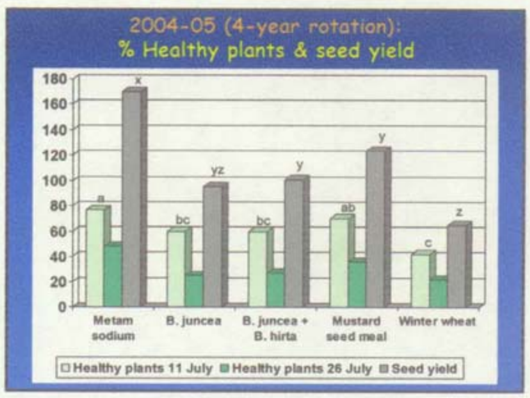
- weeds, volunteers, adjacent crops

Management of seedborne pathogens after planting: Cultural practices

Destruction of inoculum in the field

- remove or reduce amount of infected crop debris
- reduce inoculum of soilborne pathogens
- burn stubble/debris
- vacuum fields
- fumigation (synthetic, biofumigation)
- soil solarization
- incorporate infested debris into the soil





Management of seedborne pathogens after planting: Cultural practices

Irrigation practices

- reduce duration of leaf wetness, splash dispersal, relative humidity
- drip vs. furrow vs. overhead irrigation
- timing & frequency of irrigation
- economics, practicality?

Management of seedborne pathogens after planting: Cultural practices

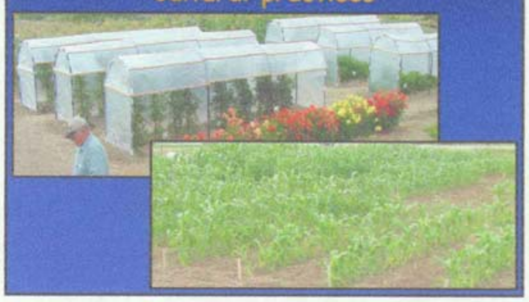
Planting practices

- planting date selected to escape inoculum
  - insect vectored pathogens
  - pathogens that don't overwinter in the region
- planting date selected for unfavorable conditions for pathogens &/or favorable for crop
- row spacing, plant spacing
- row orientation

Ventilation practices

- thinning
- canopy management for maximum air circulation

Management of seedborne pathogens after planting: Cultural practices



Brassica seed crop ventilation through row orientation, row spacing, & staking/tying

Alternaria leaf/pod spot of crucifers: *Alternaria brassicicola & A. brassicae*

Management of seedborne pathogens after planting: Cultural practices

Transplanting & hygiene

- avoid mechanical injury during transplanting
- avoid dipping transplants in water
- mechanical transmission of pathogens by workers:
  - *Septoria apiicola* in celery
  - *Xanthomonas campestris* pv. *campestris* in cabbage
  - *Tobacco mosaic virus* (TMV) on hands of smokers

Management of seedborne pathogens after planting: Cultural practices

Geographic location

- regional: environments unfavorable for disease
  - beans in dry areas to avoid bacterial blight & anthracnose
  - peas in dry areas to avoid *Pseudomonas pisi* & Ascochyta blight
  - crucifer seed in WA to avoid black leg & black rot
- local: avoid frost pockets, areas prone to fog or dew

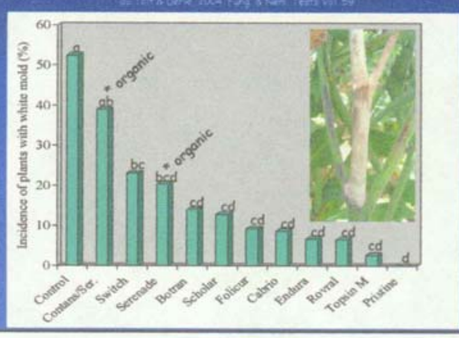
Management of seedborne pathogens after planting: Chemical applications

- **organic & biological materials**
  - e.g., sulfurs, coppers, Serenade, Contans, ...
  - 2002 Plant Health Progress article by McSpadden Gardener and Fravel
  - consistency, niche environments?
  - potential phytotoxicity
- **natural plant products**
  - oils, plant extracts, compost teas, ...
  - reliability, consistency?
- **bicarbonate fungicides**
  - powdery mildews

2002-03 Cabbage fungicide trial

White mold (*Sclerotinia sclerotiorum*)

du Toit & Derie, 2004, Fung. & Nem. Tests Vol. 59



Disease management during harvest, storage & conditioning of seed

- seed crops:
  adjust & manipulate equipment to remove pathogen structures from seed lots (sclerotia, teliospores, etc.)
- controlled storage:
  avoid development of storage molds

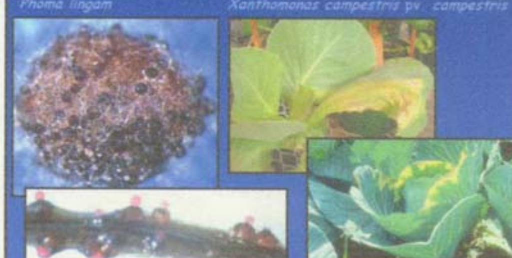
Crucifer Quarantine for Western Washington: WAC 16-301

Crucifer Quarantine for Western Washington: What are the Issues?

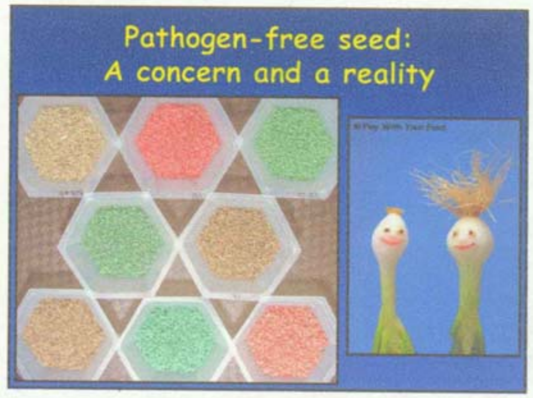
1. **Seedborne pathogens of significant economic concern**

Black leg — *Phoma lingam*

Black rot — *Xanthomonas campestris* pv. *campestris*




Crucifer Quarantine for Western Washington:
What are the Issues?
2. Dormant crucifer seed = volunteers = unwanted cross pollination


Pathogen-free seed:
A concern and a reality

Management of Black Rot of Crucifers from Seed to Seed

Ken Johnson, Oregon State University, Dept of Botany and Plant Pathology
Robin Ludy, Oregon Dept. of Agriculture
Jodi Lew-Smith, High Mowing Seeds, and
Alex Stone, Oregon State University, Dept. of Horticulture

The Disease

Black rot (causal agent *Xanthemonas campestris* pv *campestris; Xcc*) is the most important bacterial disease of cruciferous vegetable and seed crops worldwide. Many cruciferous weeds such as yellow rocket, shepherd's purse, and wild mustard are also hosts for this pathogen.

The bacteria over-winter in weeds, plant debris, and in and on seeds from diseased plants. The bacteria can survive in decaying plant residue for up to two years and free in soil for approximately 60 days. The bacteria can spread through and between fields from splashing or moving water, wind, people, and machinery. Insects can also carry the bacteria between plants. The most important source of inoculum is from planting contaminated seed.

Bacteria enter the plant through wounds and natural openings (stomates, hydathodes). Free moisture (leaf wetness) is required for infection. Bacteria then move through plant tissue into the conductive tissue (xylem) and subsequently move systemically through the plant. Symptoms of the disease appear about 7-14 days after infection when air temperatures are about 77-86° F.

Symptoms

Symptoms appear first as yellow V-shaped lesions along leaf margins, with the tip of the lesion pointed towards a leaf vein. As the disease progresses, these lesions expand, become black (necrotic) and move into the stems. When stems are cut, black vascular tissue with a yellow bacterial slime can be observed. Symptoms vary amongst cruciferous species; in cauliflower, black rot may occur as black specks on the leaf, scorched margins on the leaf, and discolored curds. Some cruciferous weeds are symptomless disease carriers (free of symptoms when infected).

Management Overview

Black rot can be managed in the field by:
1. planting disease-free seeds and transplants
2. adopting a rotation of 2 or 3 years out of cruciferous crops
3. eradicating cruciferous volunteers and weeds
4. adopting a plant spacing that permits good air movement and leaf drying
5. avoiding sprinkler irrigation
6. avoiding working in the field when plants are wet
7. avoiding moving people, machinery, and equipment from infested to non-infested fields
8. destruction/rapid decomposition of infested plant residues
9. application of fixed copper pesticides to reduce disease spread

Managing the Pathogen on Seed

All cruciferous seed should be tested for contamination by *Xcc*. *Xcc* can reside on or within seed. If seed cannot be tested or is tested positive for *Xcc*, seed should be hot water treated to eliminate contamination. Hot water treatment can reduce seed germination and vigor, so it is better to produce/purchase disease-free seed than to hot water treat seed to eliminate the pathogen.

Private Laboratories that Test Seed for *Xcc*

(This list does not include all labs that test seed for *Xcc* and inclusion in this list does not imply a recommendation):

California Seed & Plant Lab, Inc.
7877 Pleasant Grove Rd., Elverta, CA 05626
Tel: 916.655.1581 Fax: 916.655.1582
http://www.calspl.com/

STA Labs, California Branch
5653 Monterey Frontage Road, Gilroy, CA 95020
Tel: 408.846.9964 Fax: 408.846.9954 Customer Service: 888.782.5220
http://www.stalabs.com/

Hot Water Seed Treatment

It is recommended that a very small sample of a seed lot be hot water treated before an entire lot is treated to determine the effect of the treatment on seed germination, as different species and lots may react differently to hot water treatment. Treat only young, high quality, raw seed.

It is very important to follow hot water treatment specifications exactly, as exposing seed to higher temperatures or for longer periods can damage or kill the embryo, and lower temperatures or shorter exposures may not eradicate the pathogen.

Wrap seed in a woven cotton or nylon bag. Pre-warm in 100° F water for 10 minutes. Place pre-warmed seed in a 122°F water bath. Brussels sprouts and cabbage should be treated for 25 minutes; broccoli, cauliflower, collard, kale, kohlrabi, rutabaga, and turnip should be treated for 20 minutes; and mustard, cress and radish should be treated for 15 minutes. After treatment, place seed bags in cold water for 5 minutes to bring them quickly to room temperature. Immediately after cooling, spread seed out in a single layer to dry.

*For more information on the pathology and management of black rot, refer to the Oho State University Extension Fact Sheet HYG-3125-96, "Black rot of crucifers", by Sally Miller, Fikrettin Sahin, and Randall Rowe (*http://ohioline.osu.edu/hyg-fact/3000/pdf/3125.pdf). *For more information on hot water treatment, refer to the Ohio State University Extension Fact Sheet HYG-3085-05 "Hot water and chlorine treatment of vegetable seeds to eradicate bacterial plant pathogens" by Sally Miller and Melanie Lewis Ivey, (*http://ohioline.osu.edu/hyg-fact/3000/pdf/3085.pdf). *These fact sheets were the primary source of the information described above.*

Whole Systems Seed Growing: Diversified Approach to Successful Seed Growing

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Introduction

A promising niche market exists within the field of growing organic vegetable seed, which can benefit small producers looking to diversify an existing fresh market or CSA operation. Seven Seeds Farm is in its 10th season of growing seed commercially, fresh fruits and vegetables for direct marketing and a cooperative CSA. Livestock and grass pasture are also an important part of our system and rotation. Diversification has improved our overall farm efficiency and contributed to the productivity, profitability and overall quality of life.

Objectives

The historical notion of a farmer saving some of their crop for seed for the next season is inextricably woven into the fabric of agriculture itself. Unfortunately the fabric of traditional agriculture has unwoven to the point wherein most farmers grown little to none of their own seed. Not only can on-farm seed production save money by minimizing seed procurement costs, but it can also develop superior regionally adapted varieties and a niche market of a value added specialty crop. Models are needed of how farmers can reestablish the tradition of on-farm seed production. I hope to demonstrate a viable model through looking into the details of our efforts at diversified mixed farming.

Seven Seeds Farm grows seed for on-farm use and on a contract basis with 5 seed companies (Seeds of Change, Turtle Tree Seed, Fedco, Renee's Garden & Abundant Life). We also produce fruits and vegetables for local farmer's markets and a cooperatively run Community Supported Agriculture Program (CSA). Chickens, ducks, geese and sheep graze throughout the farm in a management intensive rotational grazing fashion. The productive land of the farm consists of 8 acres total, 2 ½ acres in vegetables, 2 acres in tree fruits and raspberries, 3 acres of pastures and ½ acre of ponds, which are stocked with edible species of fish.

Seed growing was a natural development for our farm in that we live in a sparsely populated area with limited markets for fresh produce and a number of existing farms capturing much of this market. Also our land is surrounded by forest on all sides, 3 of which are BLM public forestlands, affording us genetic isolation from other vegetable pollen sources and any potential GMO contaminants. Furthermore, we enjoy the lifestyle of not needing to spend time in town marketing our produce, rather we simply work on the growing and processing aspects and then mail seeds to the companies we contract with or deliver CSA vegetables and fruits to a local pack-out point.

A key aspect to increasing our farm's productivity has been planning for overlapping yields, or multiple yields from the same crop. Because we are working with limited acreage (30 of our 40 acres is forested) we have had to creatively design systems, which can provide diverse, multiple yields from a given area. Our CSA program is a cooperative of farms, which grew food for 85 members this past year. We were responsible for a portion of this production. This enabled us to focus on producing surplus from our contracted seed crops or harvesting the rogues and culls from selective breeding work. For instance, this year we grew and did breeding selection on radish, lettuce and onions. We grew more than we would need for the eventual seed production in order to have plenty of leeway to select heavily for a number of traits. The vegetables we rouged in these crops were distributed to our CSA shareholders and sold at a local farmers market. Another example is that we grew Calendula for medicine for a number of years on a contract basis (from 50 – 300 pounds of dried blossoms). We would try to arrange a seed crop for this too, harvesting the largest first blooms for medicine and then letting it mature to seed and getting a seed crop from the same ground. These examples are also coupled with the fact that we often graze down our cover crops, which preceded these crops with our flock of sheep using portable electric netting. So, using the Calendula example the yields from this crop included:

- Medicinal dried flowers
- Flower seeds
- Wool, manure, mowing services, and meat from the sheep
- Pollinator/beneficial insect habitat
- Educational resource/model
- Beauty and inspiration

In the future, we hope to utilize our growers cooperative to develop value added businesses, which make use of plant material by-products of vegetable seed processing. Seed crops such as tomatoes, peppers, winter squash and melons could yield both seed and ingredients for salsa, sauce, juices, baby food and more. The key is attaining an efficient scale of production and access to a certified processing kitchen. We have already performed a preliminary business plan to assess the viability of such a plan, but it is beyond the scope of what our farm alone can do. However, with many organic growers in a cooperative the above system could be feasible, particularly if local demand could be generated for these products.

The concept of overlapping yields underscores the importance of thorough planning in a whole system approach. We carefully assess how a given variety fits into our system. How many yields and benefits does it bring? Will our animals eat any of the waste products? (Chickens and ducks love the waste from tomato and pepper processing and I believe that the waste from chili processing has an anti-parasite action on our poultry, thereby eliminating our losses due to parasites.) How much effort and labor does it require? What is the economic yield for a given area? We use bed footage as a unit of measure for assessing the economic viability of the crops we chose to grow. Because our cropland is limited we simply can't grow corn, beans or grains on any scale and remain profitable in our farming. So we set a financial threshold for our row cropped land which acts as a primary screen or filter to help determine which crops we will grow. This threshold is affected by variables such as ease of seed crop processing/harvest, do we like eating it (melons score points here), varietal yield differences (e.g. Brandywines tomatoes are lousy seed producers, while cherry tomatoes yield very high) and will it assist our crop rotation in a positive way.

Because our operation is labor intensive we must organize our crop diversity such that we don't have too many crops all ready for harvest at the same time, which would overwhelm our small labor crew. We manage our operation with a 3-person crew and chose not to have to arrange for spot labor too often. We have found that over wintering and biennial crops help us in our planning and evening out our seasonal workload. For one, biennials represent guaranteed income for the next year, which we can budget on. Also, fall planted crops such as garlic, kale, collards, root crops and other biennials mature and ripen earlier than spring planted crops, so they are harvested when our workload is lighter in July and August. We have settled on a cropping plan which has about 1/3 of our ground planted in garlic, over-wintering onions, and biennials each year. This is also advantageous because these crops are out of the field early in the summer and planted to cover crops such as buckwheat or cowpeas, thereby reducing our summer weeding chores. Our crop rotation has developed this nice syncopated rhythm to it that we have more general categories to work with and more dynamic processes occurring on the farm at any one point. For instance, garlic that is planted to buckwheat post harvest for the summer encourages beneficial insect habitat and nectar flow for honeybees in addition to biomass for soil organic matter replenishment.

Animals continue to benefit our farm in a multitude of ways and stimulate our creativity to utilize them in new situations. We have 26 ducks, 35 chickens, half dozen geese and 13 sheep, 8 of who are pregnant, likely with twins. Our ducks and geese free range through our perennial plantings (orchards and cane fruit) and are highly effective for slug and insect control. Low fences that are about 3 feet high keep them out of gardens and row crops, which they would love to sample. The ducks and geese also help control aquatic weeds in our pond aquacultures. They are happy to perform this service voluntarily and reward us and our neighborhood with delicious and nutritious eggs and an occasional roast duck. We cannot keep up with the demand for our eggs at $4/dozen, all sold from our home in a self serve produce stand. We view our geese as God’s answer to the weed whacker, they mow the grass in the tight spots, which the mower can’t get, or is inconvenient to temporarily fence the sheep into. They provide our family with delicious meat and tremendous entertainment and fertility. We are looking into increasing our flock to meet local demand for organic goose. Natural vegetarians, they relish culled tomatoes, apples, peppers and seed crop residue. Our chickens free range in a one-acre orchard/pasture and make the most of our seed cleaning room wastes and fruit and vegetable compost, scratching up a storm to get the small and light seed.

We graze our small flock of sheep all over our farm using portable solar electric netting with which I can set up a quarter acre area in about 15 minutes. This netting enables us to graze them in the margins between our crops, which are already being irrigated by hand line sprinklers. Prior to having sheep I used fuel and time to mow these areas. Now they are producing fertility, wool, meat and replacement stock with no fossil fuel inputs. We also can graze our cover crops down with our flock within the netting, helping them to contribute their gifts to our future soil fertility. Also by managing more of our farm in pasture it diversifies our crop rotation further and provides land on which to grow clover/grass hay for mulch in late spring when our forage exceeds their consumption. We basically use part of our first cutting of hay to mulch our row crops with guaranteed weed free organic nutritive mulch. So far our animal systems have basically produced enough to cover their own feed and management costs, however, they produce food for our family and employees and fertility and other services, which are hard to account financially for. We are developing local direct sale markets for our wool and lamb as we grow our flock size.

I wanted to also give some consideration to the concept of production scale in relation to energy descent, economics and quality of life. As a small farm we are successful on account of an array of niche markets – specialty organic seeds, CSA, eggs, tree fruits, hand spinning wool, permaculture education and others. As the organic seed industry grows to meet the needs of organic vegetable producers there is a strong push to mechanize, grow in size and produce seed at a lower price. This is the capitalist model. There are many sound arguments for mechanization of seed harvesting and processing. Our farmer cooperative is pursuing acquiring some small-scale equipment for harvesting and cleaning seed, including an Allis Chalmers All Crop, a vine harvester and clipper cleaner. I am sure that this will cut our labor costs and possibly even increase our quality. However, the seduction of increasing the scale of our operation overlooks the concept that the small farms which thrive on niche markets can never compete with the larger models if they are expected to produce at prices closer to that paid for conventionally grown seed. Economies of scale could eliminate the profitability of small producers. We have done a feasibility study with our agricultural cooperative and have noted the viability of having shared equipment for a number of small seed farmers. Nonetheless, I am skeptical of the continued viability of growing an acre or two of seed in a future of considerably lower prices paid for organic seeds.

The clarity of the future of small-scale organic seed growing is clouded by the geological certainty of the peak in global oil production, known as Peak Oil in popular circles. The ensuing energy descent and economic contraction, which will occur over the coming decades, should encourage us within the organic seed industry to recognize the value in small producers who can produce high quality seed for their region. I believe that we don't simply need the existing seed growers and companies to grow larger to meet growing demand; rather we need many more of them. The increased costs for transporting seeds and materials for farming should preclude following the seed industry model of highly specialized seed growing regions. Many of us growing organically have always been mavericks in the field of agriculture; perhaps we can develop new models of what is a successful organic seed marketing approach. I envision a return to the model of regional seeds men and seeds women custom growing seed for their bioregion and growers who work with them directly. I believe that this model will weather the coming challenges to our economy from climate change and oil depletion far better than the modern centralized model.

I would like to put forward the concept that agriculture should operate on a wider definition of economics than the commodities mindset. Without redefining agricultural economics we risk losing our diverse, small family farms, which have been a global repository of locally adapted, heirloom varieties and unique, sustainable cultural practices for millennia. My definition of economics spans from money to ecology to community and family. Rudolf Steiner called money, "the most spiritualized form of matter on the planet." He was referring to the fact that money we receive for a product or a job quite literally represents our personal life force. This is particularly relevant for farmers and seed growers in particular. I feel that everyone who eats has a moral responsibility to participate in supporting small scale agriculture for it has what has fed, healed and clothed humanity for millennia. Abandonment of the ideals of our agrarian roots in a world which is increasingly overshadowed by climate change, oil depletion and unfavorable economic conditions may very well preclude the economic existence of farms such as ours. Ironically, it may very well turn out that small scale, diverse micro farms may very well be what feeds Americans much more so than large scale corporate agribusiness in the face of Peak Oil. Fortunately humanity has proven itself long on creativity in the face of challenges and clearly many models will arise to reflect regional needs and customs. Now represents a period of opportunity to take advantage of the abundant resources available to us to develop successful models of sustainable seed growing.

Environmental Challenges of Raising Organic Vegetable Seed West of the Cascades

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There are a number of vegetable seed crops commonly referred to as "cool season, dry seeded vegetable crops" (CSDSVC) that are well adapted to the climatic conditions of the Pacific Nothwest (PNW). As a region for CSDSVC production this area extends from S.W. British Columbia, through Washington and Oregon west of the Cascade Mountains, and into the northernmost coastal valleys of California. The vegetable and herb seed crops that have proved to be the most economically reliable in this region are primarily from four crop families that include the *Alliaceae* (chives, leeks, onions), *Apiaceae* (cilantro, parsnip, parsley), *Asteraceae* (chicory, endive, escarole, radicchio, lettuce), *Brassicaceae* (arugula, most Asian greens, cabbage, cauliflower, kale, mustard, radish and many others), and *Chenopodiaceae* (beet, spinach, and Swiss chard). These crops are uniquely suited to the long cool wet spring, dry summer, and relatively dry late summer/early autumn weather of the PNW. However, there are a number of challenges that prevent these crops from being grown in some areas within this vast geographic region. Fitting a specific crop to its appropriate climate is an important aspect in trying to insure success for seed growers. Knowledge of regional climatic differences, specific crop (species, crop type, and cultivar) climatic production parameters and adaptive limitations, agronomic considerations such as water availability and soil type, and equipment needs that include threshing and preliminary seed cleaning must all be considered when placing crops.

There are a number of developmental stages during the reproductive phase of the CSDSVC that are environmentally dependent and are essential for a grower to consider when choosing a crop. These stages are as follows:

1. The Plant "Frame:" Establishing a plant with adequate photosynthetic area and a vigorous root system that can support the plant throughout the reproductive phase of its life cycle and attain its full reproductive capacity is essential. This production of a vegetative plant is done through the cool long spring with annuals (cool season annual crops can grow vigorously during this period) or in a combination of fall and spring with a number of biennials adapted to the PNW. The resultant plant with a significant rosette of leaves is commonly referred to as the "frame" of the plant and it is important that the grower choose a growing area for the specific crop that allows an early enough planting time and a long enough spring to insure proper plant frame establishment.

2. Flower Initiation due to Day-length: There is much evidence that many Angiosperms (flowering plants) require a certain duration of day-length to initiate flowering. There is at least one of the PNW crops, spinach, that is very specific in its day-length requirements. Most commercial spinach varieties grown in North America require upwards of 16 hours of day-length to flower, insuring bolt-resistance before the long days of June in most commercial locations. If spinach is grown for seed in PNW regions south of the Puget Sound (day-length is dependent on latitude) there may be problems initiating flowering in a timely fashion for late summer harvest of fully mature seed. To insure adequate bolt-resistance,

spinach should always be planted under long days with continual selection against early bolters in each production cycle.

3. Appropriate Temperatures at Crucial Reproductive Phases: Each crop species has an optimum temperature range for proper physiological development during a) flower initiation, b) anthesis, and c) seed development. Extremes in temperature, either too hot or cold, can prevent proper development in any or all of these reproductive steps. This is especially true during anthesis for CSDSVC when temperatures at or above a range of 25° – 28°C (77° – 82°F) may disrupt a number of steps in the pollination process resulting in low fertilization rates and subsequent poor seed set. Hot temperatures in this same range can also cause poor endosperm development, resulting in smaller average seed sizes and lower germination rates in resultant seed crops. Several of the aforementioned crops (notably spinach and cauliflower) have rather narrow geographic production windows due to hot temperature limitations that effect anthesis and endosperm/seed development.

4. Seasonal Dry Period for Seed Maturation and Harvest: A seasonal dry period in many PNW locations, lasting from summer through to mid-fall, has been instrumental to the success of CSDSVC. As all dry seeded crops are largely exposed to the environment it is important to have maturation of these crops before fall rains (and storms producing winds) to insure the following; a) ease of harvest, b) minimal spoilage, c) minimal disease on seed, d) cleaner, unblemished seed, and e) less use of seed driers. Due to relative maturity dates with different crops there are definite regions where some CSDSVC cannot be grown as the fall rains come too early.

In all seed crops growers must be mindful of diseases that attack their seed crops. Plant pathogens under environmental conditions favorable to disease development can cause losses in crop yield, seed size, and germination rates if the mother plants are weakened. However, of particular importance to seed growers is the incidence of seed-borne diseases. In order to produce high quality commercial seed there must either be no detectable pathogenic material capable of reproducing or very low amounts that are below established thresholds for possible infection in subsequent crops. Seed growers must first familiarize themselves with the diseases of the crops they are producing and distinguish these with the so-called seed-borne diseases that when present on seed are capable of infecting subsequent crops under favorable environmental conditions. There are a number of seed-borne diseases of CSDSVC that are particularly problematic such as *Cercospora* leaf spot (*Cercospora beticola*) and Canker (*Phoma betae*) in beets and *Fusarium* wilt (*Fusarium oxysporum*) and Cucumber Mosaic Virus (CMV type II) in spinach. While *Cercospora* leaf spot has a known geographical range and doesn't thrive in certain regions of the PNW the other three diseases can be problematic across the entire area. Therefore conscientious growers must have; a) thorough knowledge of the regions in which these diseases occur and the environmental conditions conducive to these seed-borne pathogens, b) skills in the monitoring and identification of the diseases known to infect the seed crops they produce, c) familiarity with the crop species, crop type, or specific crop cultivars that are particularly susceptible to specific seed-borne diseases in their region (this is especially important to organic growers as they do not have the chemical control options of their conventional counterparts), and d) knowledge of organic disease control strategies that have proven efficacy in the field.

There are a number of Participatory Plant Breeding (PPB) strategies for working on improving the crops grown in the PNW, especially as regards disease resistance. Work is underway with "farmer-breeders" working with crops that have not been found to have qualitative genetic resistance that confers absolute or complete resistance. Working with regionally adapted crop germplasm that has sound levels of quantitative or partial resistance these farmer-breeders have learned to distinguish between levels of resistance under their environmental conditions. Pilot projects have demonstrated success in increasing levels of disease resistance in several crops. Regional breeding under organic cropping systems for disease resistance and other necessary improvements in regionally adapted varieties of these minor crops will be an important step in meeting the challenges of developing a regional seed system in the PNW for the future.

Mitigating Weather-Related Risk to Specialty Seed Crops

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Introduction

The Willamette Valley of Oregon is recognized as one of the world's premium locations for growing high value seed crops for specialty vegetables and flowers. Aside from its soils and favorable latitude (45° N), the predictable dry period from July through mid-September is an essential feature of the region's seed production attributes. In years when this dry period is interrupted by punctuated or persistent rain, the dry seed grower is in a position to lose all or a large percentage of the year's crop, especially if wet and windy weather occurs just before peak ripeness or in the midst of the harvest process. Seed crops of some botanical families are especially vulnerable if they lack a pod, shell, or fruit to protect the seed from repeated wetting and infection by wind-born pathogens. The Parsley-Carrot Family (*Apiaceae*), Spinach-Beet Family (*Chenopodiaceae*), and the Lettuce-Sunflower Family (*Asteraceae*) are all vulnerable in this way, and farmers of these seed crops need to have a plan in place for reducing loss or damage from unwelcome rain at the worst of times.

Response Options

- *Do nothing.* If predictions are for light rain of short duration, the best option may be to let it pass, especially if the crop is on the immature side of the maturity curve. The more mature the seed-crop, the more loss a short duration rain will induce through shattering, pathogen infection, and lodging. The more mature the crop, the more important it becomes to do something in anticipation of rain.

- *Harvest whole plants (early, if necessary), cure the crop in windrows on tarps, paper, or fabric under cover at a moderate temperature.* This is only possible where there is enough covered area to protect the crop, while allowing air circulation for drying. Though the most expensive option (in consideration of labor and the cost of covered area), this is the best practice for insuring the safety and quality of a valuable seed-crop in the face of a serious wet period.

- *Harvest seed heads (slightly early, if necessary), and treat as above.* This greatly reduces area needs for the curing process, but will reduce the amount of post harvest seed ripening that can be expected. This is also an option when a crop has been caught in the rain, dry weather is not forthcoming, and threshing isn't possible due to water in the seed-head. Rain-soaked seed heads should be dried by cool blowing air and repeated turning and stirring. It is best to minimize seed shattering until heads are dry, since a lot of fallen seed will tend to cake, delaying the drying process.

- *When crop size precludes the possibility of bringing in the harvest, and rain is expected to last several days to a week (or more), the best option may be to windrow and cover the crop in the field.* This process presents several challenges of its own, especially since strong wind gusts frequently accompany late summer rains, and heavy rains may be interspersed by intense sunny periods. In such circumstances, plastic sheeting tends to blow away, or to "solar cook" the crop between showers. Moisture will also condense beneath plastic sheeting with each heating and cooling cycle, wetting the crop as surely as rain. Our experiments in the last two years suggest that a breathable "geotextile" landscaping fabric may provide a suitable material for protecting windrowed seed crops in these unfavorable conditions.

Geotextile Fabric for Windrow Protection

Geotextile fabric is a spun polyester product used as a weed barrier in landscaping applications. Lightweight versions are familiar to farmers as row covers, while heavier versions are used as an underlay for gravel in new road construction. The "landscaping weight" comes in rolls 3 or 6 feet wide, and 300 feet long, and is durable enough to be reused for many seasons. Its virtues for this application include breath-ability and permeability to pooling water, while shedding about 80% of hard rainfall from seed heads in a properly prepared windrow.

A Database to Smooth the Use of Organic Seed by Organic Growers: What Do You Think It Should Be Like?

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Summary

OMRI has agreed to take on the task of providing a comprehensive organic seed database for USDA certified growers. We are working with seed producers and distributors, certifiers, and farmers to structure the information needed for all to have access to complete information on organic seed. A Web based database will be freely available to all providing relatively current information on the availability of organic seed. Growers will be able to search for variety specific seeds and print out a date stamped listing of availability. Certifiers will be able to check current availability prior to deciding upon exemptions to the organic seed requirement. Seed suppliers will be able to update their listing through a password protected system. Old listings will be so noted. OMRI will spot check certifications. What are your suggestions for required and optional information, systems of presentation, or other approaches?

Introduction

With the implementation of the regulations for organic food production in October of 2002, organic farmers found themselves required to use organically produced seed except – "7CFR205.204(a) (1) Nonorganically produced, untreated seeds and planting stock may be used to produce an organic crop when an equivalent organically produced variety is not commercially available,"--- . This aspect of the regulation has been inconsistently handled by seed suppliers, growers, and certifiers. Many organic seed suppliers stepped up their production of organic seed because there had not been a requirement for organic seed prior to implementation. Some of that seed was not up to the quality which growers had come to expect. Organic growers often could not find varieties which they had come to depend upon, and not always were the varieties truly the same in their production system. Certifiers allowed exemptions on an inconsistent basis. Ultimately seed suppliers found that too often they were unable to sell their inventory and much "conventional" seed continued to be used by organic growers. The USDA National Organic Program has neither the authority nor the resources to affectively address this issue.

Comprehensive information available to suppliers, certifiers, and growers seems to be the only available answer. The Internet provides the only cost effective means of making this service readily available. Our proposal is below. Suggestions please.

Organic Seed Database – OMRI's Concept
November 8, 2005

Goal

To provide comprehensive current information to organic growers and certifiers on the availability of organically produced seed that would be "equivalent" to the variety that growers desire. Information will need to be web based to provide as timely information as possible.

Gathering the data to a web enabled database and informing growers and certifiers of its existence will be crucial.

- In order to identify organic seed possessing agronomic characteristics that are potentially "equivalent" to those for the conventional seed that growers would be using, the website will need to collect fairly detailed information both from suppliers and from growers and certifiers using the website.

- At the same time that the website would be disseminating relevant data on available organic seed, it would also be a tool for collecting certain data directly from the growers and certifiers using the website. For example, as growers and certifiers would use the website, they would record the varieties of organic seed they were seeking. This information would tell the organic seed trade which seed varieties are in the greatest demand among organic growers, so that seed suppliers can meet this demand.

Proposal
OMRI will build and maintain a database with Internet access for seed suppliers to post their availability. Growers and certifiers would be able to search and print out data as needed.

1. Suppliers

    1.1. Register company on website, gain access through a password protected interface, pay fees with a credit card

    1.2. Company information

        1.2.1. Name
        1.2.2. Address
        1.2.3. Telephone
        1.2.4. Fax
        1.2.5. Website
        1.2.6. Email contact
        1.2.7. Logo
        1.2.8. Contact person (if so desired)
        1.2.9. Name of Company's Accredited Certifying Agent under USDA National Organic Program

    1.3. Load seed information

        1.3.1. Website will have a spreadsheet template that suppliers can download and use to put seed information on the site.
        1.3.2. Incentives and Reminders to Suppliers to Keep Information Up to Date
            1.3.2.1. Information appearing on database will automatically show date and time it was updated.

1.3.2.2. When information appearing on database lists more than one potential supplier, suppliers who update regularly will get preferred placement at top of list.

1.3.2.3. OMRI will remind suppliers in monthly Emails to remember to update.

1.4. Format of information on organic seed to be entered by suppliers for horticultural crop seeds.

1.4.1. Species (Kind) and Type - suppliers would need to enter these manually
1.4.2. Variety - suppliers would need to enter this manually
1.4.3. Quantities available (specify either "Commercial" or "Market Gardener" quantities)
1.4.4. Germination rate (with date last tested)
1.4.5. Purity (with date last tested)
1.4.6. Seed treatments if any
1.4.7. Diseases seed resists. (At first, suppliers would enter the diseases manually. In time, database could collect and display the diseases on a menu for suppliers to choose.
1.4.8. Pests seed resists (Same process as for diseases)
1.4.9. Names of the conventional variety, or varieties, that are comparable to the organic variety.

1.5. Format of information on organic seed to be entered by suppliers for agronomic crop seeds.

1.5.1. Species (Kind) and Type - suppliers would need to enter these manually
1.5.2. Variety - suppliers would need to enter this manually
1.5.3. Quantities available (specify either "Commercial" or "Market Gardener" quantities.
1.5.4. Germination rate (with date last tested)
1.5.5. Purity (with date last tested)
1.5.6. Seed treatments if any
1.5.7. Diseases seed resists. (At first, suppliers would enter the diseases manually. In time, database could collect and display the diseases on a menu for suppliers to choose.
1.5.8. Pests seed resists (Same process as for diseases)
1.5.9. Average maturity, including variations according to zones where seeds would be planted. These could be choices on a menu.
1.5.10. Protein composition, if applicable (examples: corn, soybeans)..
1.5.11. Oil composition, if applicable (example: corn).
1.5.12. Names of the conventional variety, or varieties, that are comparable to the organic variety

1.6. Certification info per line

1.6.1. OMRI will spot check certification info
1.6.2. Upon written complaint OMRI will check all certification info. OMRI would charge a nominal fee to the party making the request.

2. For growers and certifiers

2.1. Access would be free

2.2. Interface should be as simple as possible for those with dial-up connections

2.3. To encourage growers and other members of the public to use the website freely, the website would not require them to enter their names or have a password.

2.4. However, in the case of certifiers, OMRI would strongly request that certifiers take passwords to log into the website, which means OMRI could track their use of the website. This would enable OMRI to work with the certifiers as they actually use the website and solicit their input on how they view the website. It should be a standard practice for certifiers to log in. We would request that USDA make this a requirement for certifiers.

2.5. Growers and certifiers searching the website would first enter information about the organic seed they would be seeking, corresponding to the information items listed above in 1.4 (horticultural crop seeds) or 1.5 (agronomic crop seeds).

2.6. Information to be entered in search for organic horticultural crop seeds.

2.6.1. Species (Kind) and Type - searchers would need to enter these manually.
2.6.2. Variety – searchers would need to enter this manually.
2.6.3. Quantity sought ("Commercial" or "Market Gardener")
2.6.4. Seed treatments, if any
2.6.5. Diseases seed must resist. Until the diseases are available on a menu for searchers to choose, searchers would have to enter the diseases manually.
2.6.6. Pests seed must resist (same process as for diseases.)

2.7. Information to be entered in search for organic agronomic crop seeds.

2.7.1. Species (Kind) and Type - searchers would need to enter these manually.
2.7.2. Variety – searchers would need to enter this manually.
2.7.3. Quantity sought ("Commercial" or "Market Gardener")
2.7.4. Seed treatments, if any
2.7.5. Diseases seed must resist. Until the diseases are available on a menu for searchers to choose, searchers would have to enter the diseases manually.
2.7.6. Pests seed must resist (same process as for diseases.)

2.7.7. Average maturity, including variations according to zones where seeds would be planted. These could be choices on a menu.
2.7.8. Protein composition, if applicable (examples: corn, soybeans)..
2.7.9. Oil composition, if applicable (example: corn).

2.8. Searches available in a multiplicity of manners

2.8.1. Go directly to a company and see its available varieties
2.8.2. Search for a variety
2.8.3. Search for a variety in a region

2.9. Format of searches

2.9.1. Default to a sort by most recent "update" date/time
2.9.2. Most fields will be able to be "sorted" on.
2.9.3. All searches would have Web server date/time stamped at the bottom of each page
2.9.4. All printing would be done in black and white.

3. Costs

3.1. To build system, about $10,000 – 2 months work @$5000/month. Donations have been solicited and some already pledged.

3.1.1. OMRI expects seed suppliers to advise OMRI on whether website will give adequate information to growers.
3.1.2. OMRI expects input from certifiers that the website will meet their needs.

3.2. Fees charged per line, discount for large numbers of lines, annually renewable. In consultation with suppliers, OMRI will establish fees for suppliers based on revenue needed to maintain the website and anticipated usage by suppliers and the public.

3.3. Once functioning OMRI will maintain system, website, and certification checking system targeting a breakeven to slight profit.

4. Questions

4.1. How do we get and maintain this database adequately "populated"?

4.1.1. Currently many poorly done versions of this kind of database
4.1.2. Need strong effort by seed industry to focus their efforts toward this service
4.1.3. Must be inclusive, big and small suppliers
4.1.4. OMRI can work with some of the current sources to get people directed at this site

4.1.5. OMRI does not know seed suppliers well enough to gather a comprehensive portion to the service – Must have seed suppliers draw others to the service

4.1.6. How do we keep the information up to date with minimal cost?

4.2. Why will people use this one?

4.2.1. USDA National Organic Program (NOP) staff claims it does not have formal regulatory authority to require growers and certifiers to use any privately operated database. However, NOP staff has been concerned that organic seed requirement is not clearer and more enforceable. The NOP staff has indicated that if OMRI establishes a database, it would use informal means at its disposal to induce certifiers to use our database.

4.2.2. If website is sufficiently comprehensive, then certifiers will push growers at service

4.2.3. OMRI plans to get grant funds

4.2.3.1. To travel to organic farm meetings to promote service

4.2.3.2. To promote service to extension agents

Looking Ahead – Concerns, Collaborations, and Momentum

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As conference organizers we were faced with the unenviable task of deciding which subjects would be included, and as such, what we would not cover. Sticking to a theme of seed quality provided us with cardinal points, but even with a compass we have undoubtedly neglected information of importance. So let me first start out by saying – please tell us. Fill out your evaluations, tell us what you want from future educational events – workshops, field days, manuals and conferences. There may be research you would like to see, perhaps more on organic seed coatings, or relationships between soil fertility and seed yield and quality. Feed us these ideas so that we, as representatives of universities, the private sector, and Seed Alliance can work with you to find funding, and develop the research you need to be successful. I can't underline this enough: we need to hear your needs.

We, as an organic seed movement, are an essential component to the success of organic cropping systems. The input of quality seed is perhaps even more essential in organics than in other forms of agriculture. As Frank Morton says, "We can't spray on our resistance," and we certainly can't afford to have our seed working against us – with poor germination, disease contamination, lack of vigor. A few years ago I gave a talk at the Organic Trade Association meeting in Chicago. The organizers titled it for me, "Urgency on the Organic Seed Frontier", but when I went to the podium I suggested that we might have called it, "Organic Seeds – Why Bother?" as at the time there was certainly no consensus among stakeholders on the need for organic seed, with many questions and concerns about quality and economy.

One seed professional from a vegetable seed catalog communicated:

> *"The growers don't want it (organic seed), and for the consumers it's just another arcane detail. The environmental benefits of farming seed production organically…are easy to like. But the environmental benefits come at high costs – I mentioned above the costs to the growers, and for most of the seed producers there are large technical barriers to entry which would be costly to overcome. Does the organic community really want to have to use OG seeds, and are they willing to pay the price? How do we know that?…before the seed industry advocates for a requirement, I want to be settled about the cost/benefit and the existence of demand."*

And I think it is still an important question to ask ourselves, so that we who are working in this sector can be advocates for organic seed development.

Section 205.204a of the NOP regulations require organic growers to use organic seed. However, certifiers may excuse growers from following this requirement if the organic seed is <u>not commercially available</u> in an <u>equivalent variety</u>. <u>Commercially available</u> is defined elsewhere in the rule as "The ability to obtain a production input in an appropriate form, quality, or quantity to fulfill an essential function in a system of organic production or handling, as determined by the certifying agent in the course of reviewing the organic plan." "Equivalent" is not defined, and is perhaps the major point of contention amongst a host of disagreements, inconsistencies and polarized opinions regarding the seed requirement.

Is equivalent definable? Should it be measured simply by species? Sub-species? Is it an issue of phenotype - comparable days to maturity, flavor, levels of resistance, yield, etc? Some argue that variety alone is the measure of equivalence. But are all varieties created equally? What of the genetic maintenance that goes along with seed production? Anyone who has conducted true professional trials knows that not all Nantes carrot varieties, for example, are maintained equally.

These questions create difficulty for producers and certifiers in interpreting the NOP Rule's seed requirement. Go to any organic farm conference and ask producers how their inspectors/certifying agencies handle the seed requirement and you'll hear a wide range of tales and a fair share of grumbles. And you'll likely hear, "Why bother with organic seed?"

The seed industry has its grumbles about equivalence as well. One seed producer has pointed out to me that when an organic farmer is required by the NOP to use an approved fertilizer they do not leave it up to the farmer to determine if the organic fertilizer is equivalent to anhydrous ammonia and allowed an exemption if the farmer determines that it is not. While this fertilizer analogy does not translate perfectly, it highlights one of the challenges of equivalence – who decides, how is that decision made and what about those people who want equivalence to mean exactness?

Farmers, in addition to suffering from a lack of clear information and defined protocol regarding the seed rule, have another level of difficulty with the rule: the fear of losing the seed exemption. Producers live with the fear that a "drop-dead deadline" will be imposed without adequate notice for them to transition, and more importantly, without adequate seed. These producers understand the need for the existing exceptions. Their concerns regarding adequate seed can be summarized as such:

- Quantity: not enough organic seed produced
- Form: producers needing pelleted, sized, graded or treated seed
- Varietal choice: producers are accustomed to planting varieties that are integrated into their systems, seasons, markets and personal preferences. Even if these varieties aren't "perfect" - they've made them work.
- Quality: low or inconsistent quality. This is both an experience and a perception. Think back to the 1980s and the scabby organic apples and pest-hole riddled lettuce that many of us purchased (or in my case sold) from natural food stores. Even as organic seed improves it will have to fight the past perception of low germ and poor genetic maintenance.

So why bother with organic seed? All these issues, vagaries, complexities, expenses and regulations - really - what's the big deal if an organic farmer uses conventional non-treated seed? It doesn't pollute the farmer's soil in any measurable way, produces a crop, is relatively easy to source and isn't as expensive as those darn organic products. One manager of a certifying agency told me that the push to use organic seed is just a ploy for the seed companies to make more money. Perhaps a few of you thought so too, but are becoming the wiser. Lots of good reasons to ask, “Why Bother?”, and yet here we are working towards the improvement of organic seed and the increased of its use. But I still often ask myself “Why Bother?”, and not just when I deposit my “nonprofit” paycheck.

Certainly the use of organic seeds would support the economies of the seed trade (producers and companies). As long as these seed professionals are supplying us with a good product at a good price, I see no argument against this benefit. In regards to price, most of us agree that organic producers/handlers deserve and need a premium on their product - and so organic seeds will be more expensive than their conventional counterparts. But there are other, better, reasons for increasing the use of organic seed beyond economic arguments.

Why are you growing or selling organic products? Is it about your farm’s health (soil, animals, workers, economics)? Your customers’ health? Improving agriculture as a whole (ecologically, nutritionally, economically)? For old mother earth? For the almighty dollar? For a few of us it may be only a business, devoid of emotional, philosophical or eco-psychological factors. For a few it may be only a belief system - the “true believers” or “organic devotees”. But I would guess that for the majority of us, a complex of factors affects our belonging to this organic community.

I believe that integrating seed into the organic system is an essential step in fulfilling the spirit of organics, both of the law and, more importantly, of the movement. It also makes economic sense, agriculture sense, and common sense. Quality organic seed can bring benefit to our ecosystems, to organic producers and to the organic movement as a whole regardless of your viewing this whole as a scientific/economic system or a spiritual/life-style movement or some mixture of the two.

At present there is no clear data on the amount or types of pesticides applied to conventional seed crops. Even in California, which requires an accounting of pesticide applications by crop type, there is no separate data for seed production (except grass seed). In vegetables, seed crops are highly susceptible to a host of diseases beyond that of their edible crop counterparts, and as they are regarded by the pesticide regulations as non-food crops, intensive applications of chemicals such as methyl-bromide are routinely used. Is the organic movement strengthened or weakened by supporting these practices that contaminate “up stream” from our fields? Does this strengthen the integrity of the system as a whole? Whose health are we interested in? Whose earth? Whose long term economy are we promoting? Buying organically produced seed certainly “cleans up” one of our essential inputs in organic agriculture, and since the emergence of the organic farming, the concept of minimizing ecological impacts has been a catalyzing force in its development.

As for the gardeners, farmers, processors, marketers and consumers, the measurable benefits will be in the form of improved genetics; crops that are bred to fit the more specific needs of organic agriculture. Breeding needs include adaptation to diverse scales of production, niche markets, customer demands for diversity, quality, nutrition as well as adaptation to organic cropping systems - weed competition, durable disease resistance, increased nutrient uptake, cold soil emergence, etc. An integrated organic seed system is not simply producing seeds in organic fields, but necessitates an understanding of the difficulties inherent in seed as an organic crop (such as disease issues) and recognition of the role of breeding for this system. The research and development of this system will be slow to evolve without support from outside of the seed industry. We cannot just wait for organic seed to catch up. It is clear that without support a nascent industry will not emerge and in fact may dwindle. Many seed companies that have in recent years increased organic production are now taking a step back, finding that farmers choose not to buy their product - even when it was the same variety offered by the same catalog. This is counter to the momentum the rest of organic production is experiencing. Without economic success, how will the organic seed movement develop?

For many of us the immediate concerns are economic: will farmers and gardeners pay the premium necessary for our farm or company investments in organic seed? Will the NOP be help or hindrance? We have discussed a seed database as one tool. Education and access to information are necessary to assist farmers in their transition to organic seed. From the perspective of OSA, we feel strongly that this should not be a regulatory tool, but an information resource to help growers, certifiers and the seed companies assess what is available and what the additional needs are. Extension and alternative education programs can be developed to teach trial techniques of organic varieties. Certifiers can survey and collect data on what producers lack in the way of seed - and along with the database this will give us a better indication of how far we are from a full and fair (to the farmers and seed suppliers) implementation of the requirement.

Beyond information and education, the development of this organic seed system must be funded - through both public and private dollars. It is clear that reform in policy and shifts within appropriations of funding need to be made on state and federal levels to benefit organic agriculture, including seed systems. Larger organic production companies – The General Mills, Del Montes, and Mission Ranchers of the movement - need to be encouraged to make the investment in organic seed as their high volume purchases can help pave the road. Their investments in breeding programs are also necessary. I am not suggesting charity, but rather an investment in organics that will be of mutual benefit as we, the organic seed movement, provide them with a higher quality product. A representative from one large organic processing company (canned/frozen) told me that they were not using organic seed because of availability and cost. I explained that when you are using hundreds of pounds of a tomato seed <u>you can make the seed available</u>. The industry will listen to that size of purchase order. There are dozens of conventional seed companies moving into organics or already existing organic seed companies that would be happy to contract to produce that volume of seed for a processor and could do it well. “But the cost?” he rebutted. Yes, it would be more expensive - probably close to double, but looking at the margins we eventually figured that it would cost the company an additional fraction of a penny per jar of tomato sauce. Why not make the investment?

Beyond the economic concerns that to a large degree arise from the NOP rule and seed exemptions, there are many of us concerned about consolidation and ownership issues – not because we are against “being big” but because we care about farmers having a diversity of choice, and being served by regional breeders and researchers. We need regional seed companies.

I understand that the funding necessary to run varietal R&D can be prohibitive for smaller firms, and so I want to suggest that we will need creative collaborations, public-private partnerships that will keep private costs reasonable – though it may also exclude longterm royalty benefits of proprietary development and release. Organic Seed Alliance will be releasing a white paper in 2006 on our vision of "Open Source Varietal Development", outlining a vision of public-private investment that can fuel innovation, particularly at the level of regional seed needs.

There are also concerns about genetic contamination, with the recognition that biotech crops will likely expand beyond the major commodities and into specialty crops. Our markets and our product identity need to be protected. The natural resource of plant genetics – seeds – need to be protected from contamination. Liability for contamination is necessary, as it is in any other endeavor. If your bees feed on the pollen of my apple trees, we both benefit and so have positive neighborhood effect. If your private elk herd gets into my orchard and eats my apples, we have negative neighborhood effect and I will be compensated, if not in a neighborly fashion with coffee, pie and a discussion, then via the courts. The precedent of common law and common sense is overwhelming. Indeed it was one of our founding economists, John Locke, who first used the terms "neighborhood effect." For these principles to not be in place in regards to plant genetics, and for this liability to not be placed firmly on the patent holder of the contaminant – is a travesty of the American economic system. But this is where we are today. We need to change this. We will be remiss in our responsibilities as seed innovators and as stewards of a natural resource if we do not.

But beyond these concerns, there is the success and I hope we all leave this conference with recognition of the positive momentum in organic seed development. As we have heard, there is great potential - for farmers, seed companies, breeders and the customers who are end-users. There are an increasing number of organic breeding programs both public and private, farmers are returning as seed innovators and hold a special place in the emergence of organic varietal development, collaboration amongst diverse stakeholders - universities, seed companies and farmer based organizations is on the increase. Organic Seed Alliance is proud to be involved in promoting and consulting on many of these projects, and applauds the work of other groups – Practical Farmers of Iowa, Northern Plains Sustainable Agricultural Society, Oregon Tilth, Carolina Farm Stewards, NOFA-Cornell partnerships such as the OSP, and the Southern Siskiyou Producers Cooperative. And I applaud the universities – WSU, OSU, Cornell, University of Idaho, UC Davis, Iowa State, North Dakota State, University of Wisconsin and many others that have begun in organic seed research and education. Collaborations between farmer based organizations and university breeders is perhaps best exemplified through the coalition, "Seeds and Breeds for 21st Century Agriculture", with whom OSA is proud to have partnered with in a summit and conference. This group is advocating for increased federal funding for public breeding for sustainable agriculture, as well as encouraging public breeders to focus their attention on low-impact agricultural production. And I applaud the seed companies – all of you here and many others – taking on financial risk, working to serve the needs of farmers and gardeners, and willing to invest in research and education that goes beyond the benefit of your own companies to the greater benefit of all of our understanding of seed development and quality. We are all innovators and leaders, and we should feel proud of this achievement.

For those of you who are not familiar with the history of this gathering, it began as a way to bring together the seed growers for Abundant Life Seed Foundation – over 60 growers who cared about heirlooms and classic open-pollinated varieties, who wanted to be sure that future gardeners, farmers and plant breeders would have access to a diversity of choice. Many of these growers recieved little or no economic gain from their work, sometimes donating the seed to ALSF just to keep the seed collection vital. These growers – the original Seed Growers Network – date back to the early 1970s. Nash Huber here amongst us is one who grew seed for ALSF in those early years. Many of the others are not here today in person, but it is their spirit as seed growers, committed to – even at times obsessed with – the desire to leave the next generation better than the present, is at the core of what we do. Not only improving plants generation to generation, but improving our farms, our communities, ourselves. I want to thank all of the seed growers who have shown us the way for so many centuries, and thank all of you for continuing to do so. Thank you.