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Non-GMO Dairy Transition Guide

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Increased consumer demand, a reduction in corn-insect populations due to Bt corn, and comparable feed-grain yields make non-GMO dairy production a viable option for many producers. However, making a transition requires considering alternative pest management strategies and establishing a system of traceability of all inputs to the system in order to verify the non-GMO status of milk products. This publication will assist producers in making a decision by discussing feed-crop and livestock management, pest control, non-GMO standards, and economics. A list of resources for further reading is included.

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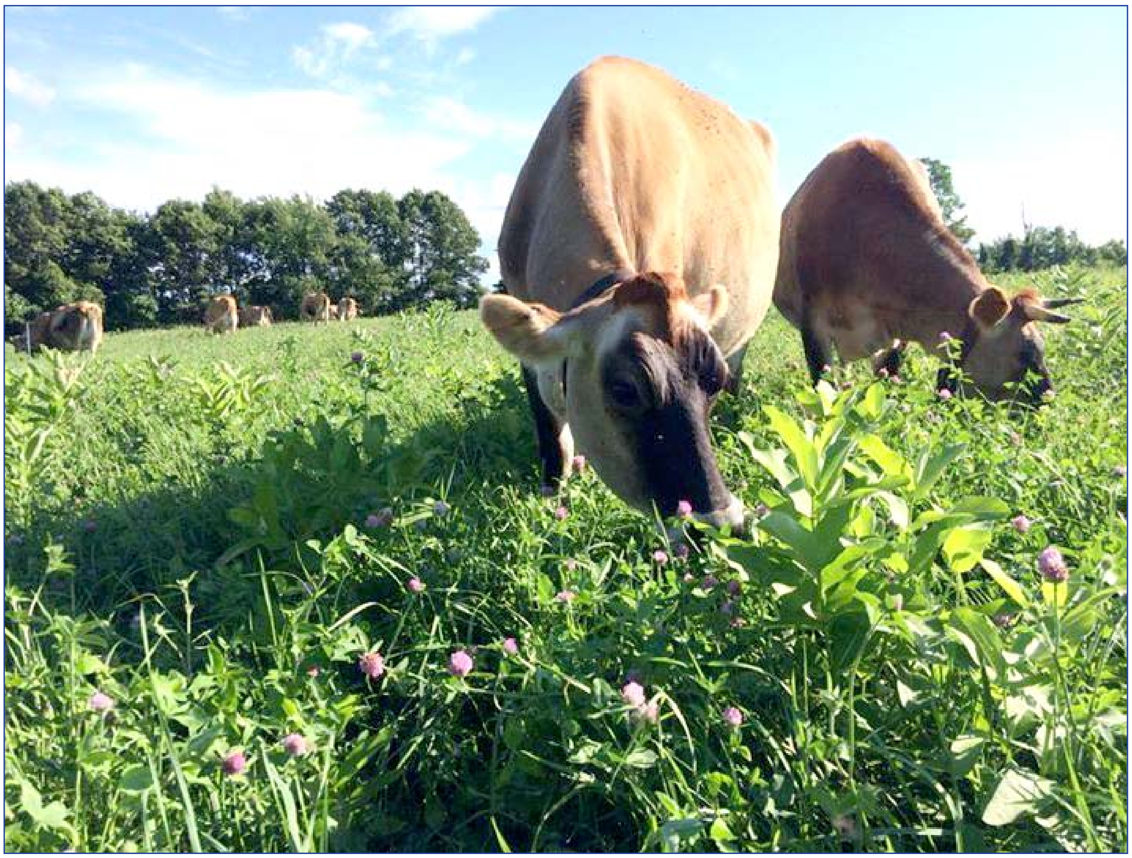

Jerseys grazing in New England. Photo: Andy Pressman, NCAT

Introduction: Transitioning to Non-GMO Dairying

Producing non-GMO milk is an enterprise opportunity that is gaining traction due to market demand for non-GMO foods. Many dairy companies—including Snowville Creamery in Pomeroy, Ohio; Maple Hill Creamery in Stuyvesant, New York; Trickling Springs Creamery in Chambersburg, Pennsylvania; and Ben & Jerry's in South Burlington, Vermont—are now sourcing non-GMO dairy, or have begun to explore a transition to non-GMO dairy.

GMOs, or genetically modified organisms, are genetically altered to possess specific traits, such as herbicide resistance or insecticidal properties, to reduce crop yield loss due to weeds or insects. One such trait is Bt, in which *Bacillus thuringiensis* genes are transferred into the DNA of corn. The corn then expresses a protein that kills insects such as the European corn borer and the corn rootworm. Another trait, glyphosate resistance, imparts herbicide resistance into crops, such

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Related ATTRA Publications
www.attra.ncat.org

Transgenic Crops

Dairy Resource List: Organic and Pasture-Based

Dairy Production on Pasture: An Introduction to Grass-Based and Seasonal Dairying

Raising Dairy Heifers on Pasture

Organic Alfalfa Production

Principles of Sustainable Weed Management for Croplands

Weed Management in Organic Small Grains

Farmer Profiles: Two Organic Grain Farm Case Studies

Intercropping Principles and Production Practices

Pursuing Conservation Tillage Systems for Organic Crop Production

Tipsheet: Crop Rotation in Organic Farming Systems

as corn or soybeans, to allow producers to use glyphosate to control weeds without harming the cash crop.

For most dairy producers, making a transition to non-GMO production means sourcing or growing non-GMO feedstuffs. Many producers are cutting the cost of such a transition by reducing the amount of grain in their dairy ration and using more pasture. To reduce the incidence of pest and weed problems, producers of non-GMO feed grains, either for the commodity market or for feeding their dairy herds, are using more diverse, longer crop rotations. Another consideration for transitioning producers is developing a quality-control system to ensure their products are not contaminated with GMOs.

This publication is designed to assist producers who would like to make the transition from GMO production to non-GMO production. Consideration is given to crop and livestock production, sourcing non-GMO inputs, maintaining the integrity of non-GMO crops and products, and managing risk.

Feed-Grain Crop Management

Sources of GMOs in Animal Nutrition

The principal feed grains for dairy production include corn for grain or silage, soybeans, barley, and sometimes canola, triticale, sorghum, oats, and forage peas. Corn and soybeans are the predominant crops grown for feed, and both have been genetically modified for herbicide tolerance (HT) and/or insect control. As of September 2013, about 7,800 releases were approved for genetically engineered corn and more than 2,200 for genetically engineered soybeans (Fernandez-Cornejo et al., 2014).

Seeds with HT trait were planted on 93% of all U.S. soybean acres in 2013, and accounted for 85% of U.S. corn acreage in 2013. *Bacillus thuringiensis* (Bt) corn, which is engineered to control the European corn borer, the corn rootworm, and the corn earworm, was planted on 76% of U.S. corn acres in 2013 (Fernandez-Cornejo et al., 2014).

Among the genetically modified feeds that include the Bt trait, are corn silage, corn grain, and cotton (Bessin, 2004). The donor organism for this GM technology is a naturally occurring soil bacterium, *Bacillus thuringiensis,* and the gene used produces a protein that kills corn borers and rootworms in corn and the bollworm and tobacco budworm in cotton. Bt corn and Bt cotton are used by producers to reduce or eliminate the application of insecticides.

Glyphosate (i.e., Roundup©) resistant crops include corn, soybeans, alfalfa, and cotton, and represent the vast majority of GM crops worldwide (Duke and Powles, 2009). Producers adopted these HT crops primarily due to perceived cost savings and easier weed management (Fernandez-Cornejo et al., 2014). However, with the rise of herbicide-resistant weeds, farmers are opting for higher herbicide applications or are switching to alternative herbicides and/or sustainable weed control methods.

Table 1: Major Crops in the United States with GE Traits

	Herbicide Tolerance	Insect Resistance
Corn	X	X
Soybeans	X	X
Alfalfa	X	
Cotton	X	X
Canola	X	
Sugar Beets	X	

Source: Johnson and O'Connor, 2015

ATTRA Publications Related to Sustainable Weed Management

- Organic IPM Field Guide
- Principles of Sustainable Weed Management for Croplands
- Sustainable Weed Management for Small and Medium-Scale Farms
- Thistle Control Alternatives
- Weed Management in Organic Small Grains

Access these publications on the ATTRA website at www.attra.ncat.org/pest.html#weed or call 800-346-9140 to request a print copy.

As some weed populations, such as marestail, begin to express resistance to glyphosate, crop scientists and producers have been turning to other herbicides to achieve effective weed control. New herbicide development is expensive, so crop science has focused on herbicide-resistant traits for other commonly used herbicides. Among these are 2,4-D and dicamba. These herbicides have been in use for many years with few known weed-resistance issues, and corn and soybean varieties have been released that express resistance to 2,4-D and dicamba (Johnson et al., 2012). 2,4-D and dicamba are far from a panacea, and many farmers and researchers are concerned that herbicide resistance in weeds can develop for these herbicides, necessitating an integrated approach to weed management.

Glufosinate-ammonium (i.e., Liberty© and Finale©) is a broad-spectrum herbicide that is often used to control glyphosate-tolerant weeds. Glufosinate resistance has been developed for corn and soybeans, and glufosinate is used post-emergence on these crops for the control of broadleaf weeds.

The adoption of Bt crops has resulted in a decrease in the use of synthetic insecticides in corn and cotton since 1995. However, the use of HT crops has not caused a similar reduction in the use of herbicides in corn, cotton, and soybeans, mainly due to herbicide resistance of problem weeds (Fernandez-Cornejo et al., 2014).

For more detailed information, including crops that have been genetically modified, economic considerations, and legal and management concerns, as well as political and regulatory aspects, see the ATTRA publication *Transgenic Crops,* available at www.attra.ncat.org or by calling ATTRA at 800-346-9140.

Most feed grains produced in the United States are GMO. But there are more pathways to the introduction of GMOs to livestock than just feeds: some pharmaceuticals are processed with GMOs. See the Livestock Management section on page 6 for more information.

Non-GMO Crop Production: Cropping systems and rotations

Growing non-GMO feed grains requires the development of a management system that, in particular, addresses pest control. GMO grains have been developed to control insects (e.g., rootworm and European corn borer in corn) and weeds (e.g., Roundup Ready soybeans), and the transition to non-GMO production will necessitate an Integrated Pest Management (IPM) system to deal with pests. Since their development, GMO traits have had both positive and negative effects on agriculture. In the case of Bt corn for insect control, the incidence of rootworm and European corn borer yield losses has declined due to the Bt trait. On the other hand, with the implementation of herbicide-tolerant crops, some weeds have become resistant to herbicides through natural selection. Regardless, to transition to non-GMO a producer must look deep in the "toolkit" and select from a variety of cultural, mechanical, and chemical methods of protecting crops. The section on Pest Management Strategies covers these issues in detail.

The ATTRA Toolkit for Ecological Pest Management

ATTRA Biorationals Ecological Pest Management Database
www.attra.ncat.org/attra-pub/biorationals

This searchable database lists biorational pesticides in the following categories:

- Microbial pesticides: formulations of viruses, bacteria, fungi, or nematodes that have low non-target impacts;
- Pesticides derived from plants that have low non-target impacts and degrade into non-toxic components; and/or
- Various new types of pesticides, such as particle film barriers, pheromones, and compounds such as Spinosad, that have low non-target impacts and degrade into non-toxic components.

See also the ATTRA publications on ecological pest management at www.attra.ncat.org/pest.html.

The development of a non-GMO cropping system for animal feeds should focus on some key management practices:

- Multi-year, diverse crop rotations
- Increased scouting and application of economic thresholds for treating insect pests
- Strategic soil-applied insecticide, pre- and/or post-emergence (i.e., corn rootworm)
- Integrated weed management, through rotations, cover crops, tillage, and the judicious use of herbicides when warranted.

For non-GMO production, feed grains grown or purchased for livestock feed must come from non-GMO seed. Management of your feed-grain crops should be focused on traceability, from seed sourcing through planting and all field operations. Pay careful attention to storage and transport to prevent commingling with any GMO crops, because a little residue can undo months of planning and can threaten your investment. Consider developing a monitoring program with periodic testing to ensure you are remaining below thresholds for GM traits. And it's always a good idea to save some of your corn seed in case testing is necessary, should contamination occur later in the production season. If you're verified through the non-GMO Project or through your feed mill or milk company, you may have to prove that non-GMO corn was planted, and this may also help identify other vectors of contamination.

GMO Testing and Labs

Strip Test – This is a rapid, on-site method of testing for GMO by analyzing DNA proteins. Although good for testing loads of seed or feed grains on-site, it should be backed up by a strong traceability program and PCR testing.

PCR Test – The worldwide industry standard for testing for GMOs at low concentrations. This test is conducted by labs.

For a list of labs that test for the presence of GMOs in seed, feed grains, and food products see the Non-GMO Project's Approved Labs and Resources List at www.nongmoproject.org/product-verification/about-gmo-testing/accredited-labs-and-resources.

Crop Rotations

Non-GMO corn production is really not all that different from GMO corn production. The same rotations and production practices are recommended, with the exception that continuous corn cropping is strongly discouraged in non-GMO production by most practitioners and researchers, given the potential for rootworm infestations. Crop rotations provide yield and cost benefits over continuous cropping, as well as weed, disease, and insect control. Rotations, especially with cover crops, improve soil physical properties such as tilth and bulk density, and allow for efficient use of plant nutrients and nutrient management. A well-thought out corn rotation can be implemented on conventional or no-till ground with some minor adaptations.

Table 2: The Non-GMO Project Action Thresholds for High-Risk Inputs and Products

Items that test over the action threshold may not be used in Non-GMO verified products.

Category	Action Threshold
Seed and other propagation materials	0.25%
Human food, ingredients, supplements, personal care products, and other products that are either ingested or used directly on skin	0.90%
Animal feed and supplements	5.00%
Packaging, cleaning products, textiles and other products that are not ingested or used directly on skin	1.50%

Source: Non-GMO Project Standard

Table 3: Corn Rotations

Crop Rotation	Corn Yield (bu/A)
[a]First-year corn yield	
[b]Second-year corn yield	
Continuous corn	139
Corn/soybeans	145
Corn/two-year alfalfa	154
Corn/corn/three-year alfalfa	153[a]
Corn/corn/three-year alfalfa	148[b]
Source: Roth, 1996	

Growing non-GMO soybeans can be much the same as GMO beans, with good management. The basic difference is seed and pesticide costs for the crop. In many cases, these costs can offset each other: prices for GMO seed are higher and pesticide costs can sometimes be higher in non-GMO plantings. However, with diverse rotations and cover crops, pesticide use can be reduced or even eliminated.

Eight General Principles of Crop Rotations

1. Follow legume crops with a high-nitrogen-demanding crop (e.g., corn)
2. Grow less-nitrogen-demanding crops in the second or third year after a legume sod
3. Grow annual crops for only one year in a particular location
4. Don't follow one crop with another closely related species
5. Use crop sequences that aid in controlling weeds
6. Maintain fields with a steep slope in perennials for longer periods of time
7. Incorporate a deep-rooted crop (e.g., tillage radish) into rotation to aerate the soil
8. Grow high residue crops, especially cover crops

Adapted from Magdoff and van Es, 2010.

Crop rotations are important in non-GMO feed-grain production to break pest cycles, increase biodiversity, and adequately utilize soil nutrients for successive cropping. Research in Pennsylvania has suggested that where corn borer pressure is low and rootworms are controlled with crop rotation or insecticides, yields of leading non-GMO corn varieties were similar to GMO varieties (Roth, 1996); see the Economics section on page 21 for cost and yield data comparing GMO and non-GMO crops. Cropping systems where corn is planted after alfalfa or soybeans perform well in terms of improved soil quality and yield, and they can prevent insect damage better than corn-on-corn systems, by breaking the insect's life cycle. When all is said and done, good rotations and soil management are probably more important for determining yields than whether the crop is GMO or non-GMO.

Crop rotations are a significant weed-, insect-, and disease-control tool that is crucial for a non-GMO producer. The type and length of your rotation depends on many factors, including your cash crops, whether a cover crop is in your mix, the key insects or diseases that can affect your crops, and the size of your land base. A crop rotation should specifically take into account the pathogen or insect life cycle and the crops that serve as hosts during the growing and dormant seasons.

Corn rootworms are a good example of an insect whose damage can be avoided through crop rotation. The adult rootworm feeds on corn silk, then lays its eggs in the soil and the base of the corn stalks. If corn is planted in the same field the following year, the larvae emerge and feed on corn roots, causing damage. Breaking the cycle of continuous corn planting easily helps reduce the problems associated with rootworm.

Common Five-Year Rotation for the Northern Midwest and the Northeast:

Year 1: Corn

Year 2: Oats (seeded mixed grass–legume hay)

Years 3 through 5: Mixed grass–legume hay

A Four-Year Rotation Using Mainly No-till Practices in Virginia:

Year 1: Corn, winter wheat no-till planted into corn stubble

Year 2: Winter wheat grazed by cattle after harvest, foxtail millet no-till planted into wheat stubble and hayed or grazed, alfalfa no-till planted in fall

Year 3: Alfalfa harvested and/or grazed

Year 4: Alfalfa harvested and/or grazed as usual until fall, then heavily stocked with animals to weaken it so that corn can be planted the next year

Source: Magdoff and van Es, 2010

Crop rotations are important in non-GMO feed-grain production to break pest cycles, increase biodiversity, and adequately utilize soil nutrients for successive cropping.

Some small dairies in the Northeast, especially farms with a small land base, utilize continuous corn but separate the crops with a fall cover crop of cereal rye. This rotation helps to build organic matter and keep the soil covered but does little to break pest life cycles. A better system would spread the corn cropping out to at least every other year, as in following example:

Year 1: Corn (followed by rye cover crop)

Year 2: Rye baleage and sorghum-sudan for grazing, followed by field peas or vetch/rye

Year 3: Corn (followed by rye cover crop)

An excellent discussion of the characteristics of rotational systems and their implications for management can be found in Chapter 11 of the SARE publication *Building Soils for Better Crops,* by Fred Magdoff and Harold van Es. See the Resources section for details on obtaining this book.

Fertility Management

Soil carbon is the substrate that provides energy for the soil microorganisms that drive the soil food web: the system of interactions between plants, roots, fungi, bacteria, and protozoa that supports all life above and below the soil surface. Nitrogen fertilizers are known to inhibit the microorganisms that form soil humus, a stable form of soil carbon. Therefore, nitrogen management is crucial for the soil life that supports crop production.

The bottom line is that fertility can be enhanced by the use of diverse cover crops and crop rotations.

Farmers are aware of the nitrogen-fixing capabilities of rhizobium bacteria, the microorganisms that, in symbiosis with legumes, fix atmospheric nitrogen. But in addition to plant-associated nitrogen fixation, healthy soil is full of bacteria that fix nitrogen without direct plant associations. Non-legume nitrogen fixation is accomplished by soil bacteria and archaea (Jones, 2014). The more growing plant cover there is on the soil surface, the more of these microbes there are, doing their work, beneath the soil.

Connecting everything together and forming the pathways that facilitate nutrient transfer are the mycorrhizal fungi. These fungi soak up carbon in the form of sugars from plant root exudates and deliver nitrogen and other nutrients to plants through a web of hyphae that extend well past the individual roots of the plants. These fungal hyphae produce the glues that bind soil together into aggregates that give healthy soil all the characteristics we look for, including water-holding capacity, soil tilth, nitrogen fixation, and carbon sequestration (Jones, 2014).

Maintaining the carbon pathway in the soil is the key to fostering soil health and plant fertility. Jones (2014) points out that there are four principles on which farmers can base their practices to enhance the carbon pathway:

1. Provide year-round living cover (i.e., perennial pasture, annual cover crops, and annual cash crops) so there are actively growing roots in the soil for as much of the year as possible
2. Enhance biological activity by reducing N and P fertilizers that disrupt the flow of carbon from microbes to plants
3. Promote plant and microbe diversity (by incorporating short-, medium-, and tall-statured plants and a variety of cool season and warm-season grasses and broadleaves)
4. Use high-stock-density animal impact for nutrient cycling as well as stimulating the activity that grazing has on plant roots and associated processes and microorganisms.

Finally, the soil food web can be significantly strengthened by reducing nitrogen fertilizer applications, which deter the nitrogen-fixing capability of soil organisms. Farmers who give more attention to promoting the soil food web can rely on the nitrogen-fixing bacteria in the soil to do the job. Feed the soil, feed the crop.

The bottom line is that fertility can be enhanced by the use of diverse cover crops and crop rotations. There are many documented cases of farmers who have been successful building fertility on their farms, as ATTRA's *No-Till Case Studies* show.

Livestock Management

Breeding and Genetics

The ideal dairy cow will not be the same for all dairies. Variations in expectations for milk production, sizes of herds, and size of farms are all criteria that factor into the type of cow that will work best. The bottom line is that the cows should be well-suited to the environment of the farm and to the management, goals, and expectations of the farmer.

If high milk production per cow is the goal, the large-framed Holsteins that have been bred for productivity work very well. These cows have high potential for productivity but come with some baggage. To maintain productivity, these cows require high intake of grains and silage for energy. They also may not breed back to their genetic potential, but this is often offset by the length of their lactation. Also, with these high-producing cows, more confinement is the norm, which poses risks for respiratory disease and mastitis. Other diseases related to high production are displaced abomasums, downer cow disease, ketosis, off-feed issues, hoof issues, and other metabolic diseases such as fatty livers. Farmers of high-producing milk cows have become adept at managing these cows and, for some farms, it works.

ATTRA Farmer Case Studies Show Crop Diversity, Rotations, and Livestock Contribute to Soil Health and Fertility

Non-GMO producers can manage fertility, pest control, and crop yield with cover crops, rotations, and livestock. Four crop farmers were interviewed by staff from the National Center for Appropriate Technology, and the results of their conversations are contained in ATTRA's series of No-Till Case Studies, available on the ATTRA website at www.attra.ncat.org/field.html

One No-Till Case Study, *Brown's Ranch: Improving Soil Health Improves the Bottom Line,* draws attention to promoting soil health through the use of no-till farming, diverse cover crops, and intensive rotational cattle grazing. These practices have allowed Brown's Ranch, a North Dakota farm and ranch, to become increasingly profitable. This publication relates details of a field tour with Gabe Brown, explaining his approach to soil management.

Bauer Farm: Cover Crop Cocktails on Former CRP Land features the Bauer family in Bismarck, North Dakota, who converted CRP land back to crop production. Their goal was to increase nutrient cycling and breakdown of old residue while maintaining the no-till benefits gained during the CRP period. To do this, they planted a low-carbon cover-crop cocktail with no cool-season grasses. This publication relates the results of their experience.

Marlyn and Patrick Richter of North Dakota discuss their farming practices in *Richter Farm: Cover Crop Cocktails in a Forage-Based System.* Their forage-based cropping system routinely removes most plant biomass from the land by baling hay or chopping silage. This results in inadequate plant residue for healthy soil biology function and soil protection. One solution is to grow a multispecies cover crop cocktail after an early forage harvest to add needed residue, organic matter, and available soil nutrients for the subsequent cash crop.

Miller Farm: Restoring Grazing Land with Cover Crops discusses Ken Miller's practice of converting marginal cropland back to grazing land by planting several years of a diverse cover crop mixture containing legumes, tap roots, and more. For Miller, a farmer in Mandan, North Dakota, a cover crop cocktail helps break up the old plow layer, increase nutrient cycling, and improve productivity.

Access these publications at www.attra.ncat.org/field.html.

For producers who want more pasture in the mix, and for whom time on pasture is important, milk production is often lower. This is a tradeoff that many grass-based dairies accept because feed costs and veterinary bills are usually less, as well. The ideal dairy cow for grazing must have the following (Heins, 2016):

- High milk fat and protein
- Excellent fertility and the ability to produce a calf regularly
- Longevity (approximately five to seven years)
- Low somatic cell count
- Smaller body size
- Efficient conversion of grass to milk

Usually the smaller-framed breeds work well for grass-based dairying. In addition, crossbreeding for important traits results in heterosis, the phenomenon where an important trait of the offspring is often higher than the average of the traits of the parents. Crossbreeding for selected traits, such as milk solids, milk production, conversion of grass to milk, and breeding back on time, can be an important tool for developing a well-functioning grazing herd.

For more information on grass-based dairying and grazing, see the ATTRA publication *Dairy Production on Pasture: An Introduction to Grass-based and Seasonal Dairying,* available at www.attra.ncat.org or by calling 800-346-9140.

Pharmaceuticals

Some veterinary products and pharmaceuticals are developed with the use of genetically modified organisms. These can include rBST, semen, and vaccines. Producers who are considering non-GMO production should check their end-user's standards to see if there are any restrictions or provisions for these products. Most cattle vaccines have not yet been developed with the use of GMOs; however, some have, like bovine salmonellosis vaccine (ICF International, 2011).

Feed Rations

Feed rations for non-GMO herds must be from non-GMO feeds. Dairy cattle must be on non-GMO feed for 30 days prior to verification to the Non-GMO Project standard, and from birth for slaughter animals. The milk processor may have some set standards for non-GMO feeds, or may be Non-GMO Project verified, whereby they will conform to the Project's standards with respect to testing. Feed for cattle that are in a Non-GMO Project verification relationship with a processor does not have to be Non-GMO Project verified itself, but it does have to undergo testing to ensure the action threshold is not surpassed (see Table 2 for details).

Nutrition Program

A non-GMO dairy nutrition program will differ from a conventional GMO program mainly with respect to cost and traceability. Certainly the first impact would be increased cost for sourcing non-GMO grains, as well as finding a dealer in your area that handles non-GMO products.

Sourcing non-GMO grains can be an issue, depending on your location. Most feed grains in this country are produced using genetically modified seed, and not many mills are available that can adequately deal with non-GMO products, due to demand, lack of infrastructure for storage and transportation, and providing traceability services for the producer.

Non-GMO dairy feed can be more expensive than conventional feed. Some dairy feed options for non-GMO production include changing to a pasture-based system, using small grains, and, if land is available, growing all your own feed.

Herb Bonnice, a dairy and beef nutritionist in Northeastern Pennsylvania, suggests that for non-GMO herds, sourcing proteins can be the most difficult part of developing a non-GMO feed ration. Corn is fairly simple and straightforward, and many producers grow their own corn, which provides most of the energy needs for a lactating herd. However, protein is a little different. For high-producing herds that need a balanced ration high in essential amino acids, soybean meal is often the protein of choice. However, it's not so easy for producers to grow their own soybeans and roast them for high-producing herds. This is because there is a limit to how much roasted soybean can be fed, due to its high fat content. Too much fat in the ration leads to lowered intake, which affects milk production. Feeding roasted, farm-grown soybeans could be useful for a 50- to 60-pound-per-day herd. But for highly productive herds, this will not be enough because of the limited amount of essential amino acids that are available in a ration consisting of roasted soybeans (Bonnice, 2016).

For producers looking for alternatives to soybean meal, there are other options, such as liquid protein supplements. Canola meal is another option. USDA scientists have found that canola meal not only compares favorably with soybean meal, but can result in higher milk production as well as higher milk protein (O'Brien, 2015). Cottonseed meal is also an option for those producers in cotton-growing regions. However, most canola and cotton grown in the United States is genetically modified, so sourcing these could be very much like sourcing soybean meal. Be sure to check with your local feed mills or view the listings in the Resource section for more information on sourcing non-GMO feeds.

Dairy producers who have a hard time accessing non-GMO protein sources should look for opportunities to reduce protein feeding. Often, protein is fed at too high a level, and this causes problems as the cow tries to turn it into energy, wasting much of the protein and increasing milk urea nitrogen. When you reduce the amount of excess protein in the diet and decrease the amount that must be passed out of the body, you reduce the cow's energy demands (Newport, 2013). Protein can be reduced by limiting silage and other low-protein forages, which will reduce the amount of supplemental protein the cows need. Utilizing pasture can also be a way to reduce protein supplementation. Forages at 16 to 20% crude protein are usually adequate for productive cows. Also, protein can be obtained more efficiently from pasture when paddock movements are as short as 12 to 24 hours (Penn State Extension, no date). On quality pasture that is not too mature, research has shown higher protein intake with quicker paddock rotations. Thus, using pasture more efficiently can reduce the amount of supplemental protein that is required.

Grazing: An option for feeding non-GMO dairy herds

One way to reduce feed costs is to reduce the amount of grain and oilseeds fed to cattle. Pasture can provide the nutrients a lactating dairy animal needs, but it is important to carefully plan a transition to less grain and more pasture feeding. This is an enterprise you should not enter without first becoming a serious grass manager and selecting the right animals for the job (See Breeding and Genetics, on page 6). High-producing cows, over 70 pounds per day, will decrease their milk production as well as their body condition if grain is reduced and pasture increased. However, well-managed pasture that provides high-quality forage will support moderate-production cows with 40 to 50 pounds of milk per day. Some of the considerations you should think about if you're going to reduce grain and feed more pasture are as follows (Flack, 2004):

- Will the decrease in total milk production still allow enough cash flow to cover farm and labor costs?
- Is the quality of the winter stored forage and summer grazing excellent and consistent? For most graziers the winter feeding ration is often the most challenging.
- Are the manager's grazing and feeding skills high enough?
- Is there a system to allow supplementation with enough minerals?
- Is there enough market demand and is the price for products high enough?

There are several marketing opportunities for milk produced with less grain. Various milk processors offer a premium for grassfed and/or organic milk.

Sourcing Non-GMO Feeds

The *Non-GMO Sourcebook* is an excellent resource that is updated annually, featuring suppliers of non-GMO and organic seeds, grains, ingredients, and animal feed. The book also contains listings for GMO testing labs and test kits, identity preservation/non-GMO certification firms, and organic certifiers. Also, the Northeast Organic Farming Association of Massachusetts offers a *Non-GMO Animal Feed Resource Guide,* available online with sources in the northeast, as well as a listing of national feed sources. See the Further Resources section for information on accessing these valuable guides. In addition, ATTRA hosts a database of Organic Livestock Feed Suppliers and a Directory of Organic Seed Suppliers where you can search for regional suppliers of organic and non-GMO feeds and seeds at www.attra.ncat.org/directories.html.

Pasture Management and Soil Health

Livestock producers are challenged with providing high-quality feedstuffs to produce high-quality livestock products. In a time when feed and fuel costs continue to rise, many producers are turning to pasture to supply more nutrients and dry matter intake for livestock. Consumers are also demanding more products from animals raised on pasture. Non-GMO dairy producers must remember to use non-GMO pasture seed and non-GMO legume inoculants when establishing pasture.

More information on pasture and grazing management is available from ATTRA at www.attra.ncat.org/attra-pub/livestock/pasture.html or by calling 800-346-9140.

Pasture and Grazing Costs

Increasing grazing on dairy farms has some cost implications. There are the costs associated with pasture development, if improvement is needed, and costs associated with inputs such as lime, fertilizer, seed, and fuel. Fencing and water facilities are also costs that producers will incur when developing pastures for more intensive grazing. Iowa State Extension (Barnhart and Duffy, 2012) has developed a set of decision spreadsheets designed to help producers estimate the costs of improving pasture, including lime, fertilizer, weed control, and renovation. The spreadsheets are available for download at www.extension.iastate.edu/agdm/crops/html/a1-15.html.

In a time when feed and fuel costs continue to rise, many producers are turning to pasture to supply more nutrients and dry matter intake for livestock.

Implementing pasture and grazing production practices that foster nutrient cycling, water quality, and plant vigor is supported by government assistance programs, particularly NRCS conservation programs. Both technical and financial assistance are available to support projects on the farm that directly benefit pasture development and grazing. These include:

- Comprehensive nutrient management plans
- Grazing management plans
- Fencing
- Water pipelines
- Forage plantings
- Prescribed grazing
- Stream crossings
- Integrated pest management
- Watering facilities

To be eligible for assistance, a producer must be engaged in agricultural production, control or own eligible land, comply with adjusted gross income requirements, be in compliance with the highly erodible land and wetland conservation requirements, and develop an NRCS EQIP plan of operations that addresses at least one natural resource concern. For more information on NRCS conservation technical and financial assistance and to learn about application deadlines, contact your local NRCS office at http://offices.sc.egov.usda.gov/locator/app.

Table 4: Best Management Practices for Pasture and Grazing

Management Category	Practices/Objectives	Benefits/Purposes
Soil Health	Animal impact	Hoof action incorporates plant litter, carbon source for soil organisms and water retention
	Animal density	Distributes manure and urine for nutrient cycling
	Soil and tissue testing	For adjustments in soil pH and micronutrients
Species Diversity	Animal impact	High grazing density encourages grass tillering and opens niches for other plant species
	Re-seeding	To incorporate species into the forage mix; frost seeding, interseeding, etc.
	Renovation	Tillage and planting to a species-rich forage mix when needed
Manure Management	Animal distribution	Distributes manure and urine for nutrient cycling
	Calculated manure applications	To prevent nutrient overload on pastures
	Composting	Reduce waste volume, concentrate nutrients, potential resale
Pest Control	Plant diversity	Encourages beneficial organisms to keep pests in check; diverse plants occupy more niches in the soil profile to discourage weeds
	Field borders, hedgerows	Habitat for beneficial organisms
	Plant diversity	Provides multiple forage species to lessen potential for pest outbreaks that occur with one crop species
Grazing Management	Rotational grazing	Provides sufficient quantity of high-quality forages and allows for pasture rest
	Fencing	To separate paddocks for uniform grazing through rotations; to delineate laneways and manage use of sensitive areas
	Water Systems	To meet animal needs and provide animal distribution and efficient pasture use
Planning, Monitoring, and Assessment	Grazing plan	Detailed plan of grazing to match forage production to animal needs while maintaining and improving pasture resource
	Monitoring Plan	Provides feedback on efficacy of pasture management practices

Benefits and Risks of Pasture and Grazing

Well-managed pasture and planned grazing provide many economic and environmental benefits. Among the economic/production benefits are:

- Decreased feed costs
- Reduced veterinary costs due to reduced respiratory, acidosis, and hoof problems
- Potentially lowered somatic cell counts
- Increased energy efficiency through less manure spreading, tilling, planting, and harvesting
- Potential increase in net profits due to increased herd health and reduction in feed costs, even if milk production decreases with reduced grain feeding

Well-managed grazing has been known to positively affect soil health by increasing soil organic matter, nutrient cycling, and biological activity. With more carbon comes more water-holding ability, thus making soils more resilient during drought. Plant diversity can also be increased with planned grazing through the interaction of plants and animals.

There is also the benefit of public perception, as consumers show a growing interest in pasture-raised beef and dairy products. Because of perceived health benefits, a concern about where and how their food is raised, a desire to support small and mid-size family farms, and a belief that pasture-based farms protect soil and water resources, consumers are more likely to respond with their purchasing power to products that are "pasture-raised" (Pirog, 2004). The perception of the consumer is becoming increasingly essential to the sale of milk. Pasture-based production will result in increased milk sales overall and limit criticism from the animal welfare constituency. In addition, it has been widely researched and communicated to consumers that pasture-raised animal products contain more vitamin E, beta carotene, conjugated linoleic acid (CLA) and omega-3 fatty acids than their conventional counterparts (Schivera, 2003), which further substantiates their claim of perceived health benefits.

Like all new enterprises, transitioning to more pasture and less grains and oilseeds has some very real risk factors. There are several risks a producer will have to manage when using more pasture:

- Less-uniform feed intake
- Less-uniform milk production
- Decrease in milk production with reduced grain feeding
- Seasonality of forage production and greater reliance on weather and climate for production
- Nonpoint source pollution of streams if managed improperly

Managing these risks is key to successful pasture-based livestock production. For more detailed information and resources on pasture and grazing for dairy cattle, see the ATTRA publication *Dairy Production on Pasture: An Introduction to Grass-based and Seasonal Dairying.* This publication is available from ATTRA at www.attra.ncat.org or by calling 800-346-9140.

Well-managed grazing has been known to positively affect soil health by increasing soil organic matter, nutrient cycling, and biological activity.

Pest-Management Strategies

Pest-management strategies entail keeping pest numbers low enough that they do not cause production yield declines or environmental damage. A resilient agro-ecosystem can be established by utilizing cultural practices such as crop rotations and resistant crop varieties, which serve as the first line of defense in an integrated pest management system. When pest numbers increase to their economic threshold—that is, they cause damage to the crop and reduce yield and profitability—chemical controls using the least-toxic pesticide may be applied to reduce the pest population.

Principles of Weed Management for Non-GMO Cropping Systems

- Diversify weed-management strategies
- Use combinations of herbicides together
- Rotate the herbicide use
- Rotate crops
- Use mechanical weed control
- Scout fields
- Control a resistant weed before it seeds

Lady Beetle Larvae. Some 97% of the insects on a farm are either beneficial or benign (Daly, 2015). Photo: Courtesy Whitney Cranshaw, Colorado State University, Bugwood.org

"Farmscaping" is a whole-farm, ecological approach to pest management. It can be defined as the use of hedgerows, insectary plants, cover crops, and water reservoirs to attract and support populations of beneficial organisms, such as insects, bats, and birds of prey.

Most often, pesticides are not effective because of pesticide resistance and/or the pesticide is applied at the wrong time—for example, when insects are too mature for the pesticide to work properly. In addition, herbicides and insecticides often target a broad spectrum of species, and many times beneficial plants and insects are killed along with the pest population. Broad-spectrum insecticides will be harmful in the long term because they decrease biological diversity and, therefore, reduce the benefits that diversity provides to the farm. In order to reduce pesticide use successfully, a system of integrated pest management must be established.

Organic farms combat pests by building a resilient agricultural ecosystem and increasing biological diversity. Some strategies that organic farmers use are as follows:

- cover crops
- complex crop rotations
- tillage
- release of beneficial insects
- farmscaping with diverse flowering plants to serve as habitat for insects
- adapted varieties, including pest-resistant crops

The practices used by organic farmers can be used by anyone who wants to reduce pesticide use. For more detailed information on organic and reduced-pesticide pest-management practices, review ATTRA's pest-management publications at www.attra.ncat.org/pest.html.

Methods of Pest Control

- Cultural controls: crop rotation, crop variety, planting space, timing of planting
- Physical controls: tillage, mulches/barriers, cover crops
- Biological controls: presence of beneficial insects that consume weed seeds or depredate on pest insects
- Chemical controls: various pesticides labeled for use in corn, soybeans, and alfalfa

Pest Control Options for Farmers Transitioning to Non-GMO

- Farmers using Bt corn (grain and/or silage): non-GMO options include crop rotation and seeking out varieties that offer some natural resistance to the pest
- Farmers using RR corn: non-GMO option of switching to a conventional variety and using other weed control methods besides glyphosate, such as pre-emergent labeled herbicides and cultural control
- Farmers using stacked Bt/RR Corn: a mixture of the above options
- Farmers using RR Soybeans: planting conventional varieties and using other weed-control methods besides glyphosate, such as pre-emergent labeled herbicides and cultural control
- Farmers using RR Alfalfa: not a problem if grown with grass mixture; option is to switch to conventional variety, use in mixture with grass, manage harvesting to improve stand, and use other approved chemical weed control methods.

Chemical Weed Control in Non-GMO Crops

Because herbicide-resistant GMOs are the most commonly used varieties, and because weed resistance to glyphosate is becoming a major concern, non-GMO farmers will need to look for other options for controlling weeds.

The two main herbicides used in GMO cropping systems are glyphosate and glufosinate. The weeds that have expressed resistance to glyphosate include several pigweed and amaranth species, tall waterhemp, giant and common ragweed, horseweed, kochia, and several grass species including annual and perennial ryegrass, annual bluegrass, johnsongrass, goosegrass, and windmillgrass (Heap, 2016). Dealing with these weeds in a non-GMO system will require using a comprehensive approach.

2,4-D and dicamba are common in those states where they are approved for use. To control herbicide-resistant weeds, farmers will need to use different herbicide programs and/or utilize cultural controls in an integrated weed-management system.

Switching to non-GMO production will likely change the way an herbicide program looks. It could mean applications of pre- and post-emergent herbicides, and possibly a return to controlling ALS-inhibitor-resistant weeds. The ALS-inhibitor herbicides function by inhibiting the action of a plant enzyme, stopping plant growth, and eventually killing the plant. They are applied either pre- or post-emergence to crops, commonly at 1/50th or less of the rate of other herbicides (Battaglin et al., 1998).

ALS-inhibitor-herbicide resistance has been identified by Penn State researchers in weeds such as pigweed, shattercane, and giant foxtail (Curran, 2012). Non-GMO farmers should check with their Extension service for recommendations on herbicides to best control weeds in non-GMO crops.

For corn, starting with a clean field is important. Utilizing a few tillage events that give time for weed seeds to sprout and get tilled under is a good practice. For herbicide use, a successful burndown application can give farmers a good start to the season. For corn crops, a soil-applied grass herbicide and a broad-spectrum post-emergence herbicide while the weeds are small is most effective. Scouting for weeds and understanding the herbicides that are available are key to a weed-control program for corn. The same goes for soybeans: a pre-emergent followed by a post-emergent application works best to catch the weeds while they are small and set the crop on a good footing (Bechman, 2011).

Table 5: Common ALS-Inhibitor Herbicides (sulfonylurea, imidazolinone, and triazolopyrimidine herbicide families)

Herbicide	Corn	Soybeans
Accent	X	
Beacon	X	
Canopy		X
Harmony	X	X
Python	X	X
Scepter		X

Non-GMO Spray Program Considerations

- Time applications correctly: read labels and get familiar with rotational restrictions and the herbicides that are new to you
- Manage for efficacy
- Use residual-grass herbicides in corn
- Use full labeled rates
- Get at the weeds when they are small; grassy weeds are harder to control in corn and broadleaf weeds are harder to control in beans.

Non-Chemical Weed Control

The main non-chemical strategies for weed control are prevention, crop rotation, crop competition, cultivation, and cover crops (Curran, 2004).

Prevention entails understanding weed biology and the life cycles of the weed species in your fields. Knowing when they are most resilient and when they are weak can help in making a decision on when to cultivate, till, or apply herbicides. Another preventative measure is controlling weeds before they go to seed.

Planting date is a key strategy for ensuring high **crop competition**. Delaying planting means that the soils are warmer and the crop seeds will germinate quicker, allowing them greater ability to compete with weeds. A dense, highly productive crop can shade out weeds and reduce the need for herbicide applications. To take full advantage of crop competition as a weed-management strategy, select high-quality, vigorous seed, use regionally adapted varieties, make sure the seeding depth and spacing are correct, and use cover crops and rotations for building a healthy, fertile soil. These

For any weed-control program, it is best to start with a clean field with low weed pressures, especially if going from a GMO to non-GMO field, and watch out for volunteer corn/beans. Consider a year or two of cover cropping with or without tillage to clean the field prior to planting to a non-GMO crop.

A good source of information on implements for weed control is the SARE publication *Steel in the Field: A Farmer's Guide to Weed Management Tools*. Here is an excerpt from the Introduction:

> In some ways, cultivating for weed control is almost a lost art. Herbicides seemed to work so well for so long that many farmers abandoned mechanical means of control. Today, farmers are employing many techniques to control weeds, including careful selection of crops in rotations, using cover crops to compete with and smother weeds and, of course, mechanical cultivation. With new implements and improved versions of the basic rotary hoes, basket weeders and flame weeders of 50 years ago, we are seeing improved efficiency.

The book is only available online. Download it free of charge at www.sare.org/Learning-Center/Books/Steel-in-the-Field.

Table 6: Average Rooting Depths of Several Cover Crops

Rooting Depth in Feet	Cover Crop
7 +	alfalfa (plants at least two years old)
5 to 7	red clover, lupine, radish, turnips
3 to 5	common vetch, mustard, black medic, rape
1 to 3	white clover, hairy vetch

techniques can foster vigorous plant populations that compete well with weeds (Curran, 2004).

Tillage is also a good weed-control technique. Pre-plant tillage can bury weed seeds and dig up perennial weeds that could cause a problem in annual crops.

Cultivation, beginning before planting and continuing until the crop is too large, is also effective at removing annual weeds. Implements such as a tine weeder and rotary hoe pull small seedlings up and let them desiccate. Many organic farmers find this successful, and by the time the last cultivation has occurred the canopy is closed and the crop is off to a good start.

Cover crops can reduce weed and insect problems while building soil fertility and resilience, which ultimately strengthens plant immunity. A cover-cropping system should maximize biomass production and, if appropriate, provide nitrogen carryover to the succeeding crop.

Cover crops should be placed into the sequence of your crop rotation. Characteristics such as germination, good seedling vigor, biomass production, nitrogen production, or nutrient uptake should be considered. It's important to choose cover crops that do not harbor diseases or pests of the cash or feed crop succeeding them.

Some typical cover crops include vetches, winter pea, bell bean, cereal grains, buckwheat, sorghum-sudan, and annual grasses like ryegrass. In addition, cereal grains make excellent nurse crops for establishing clovers or alfalfa. Some species of cover crops, such as daikon radish, are good sub-soilers as well. Their extensive root systems are highly effective in loosening and aerating the soil and can penetrate compacted soils. The SARE publication *Managing Cover Crops Profitably* is a good resource for incorporating cover crops on your farm. Download the free publication at www.sare.org/publications/covercrops/covercrops.pdf.

Small grains can produce 2,000 to 4,000 pounds per acre of biomass annually, and take up as much as 77 pounds per acre of nitrogen in eight to 10 weeks (Clark, 2007). Washington State University notes that farmers in the Columbia Basin can capture and recycle more than 100 pounds per acre of nitrogen for a following crop (McGuire, no date). Rye grows faster in the fall and spring, and overwinters while oats are usually winterkilled in northern regions. Rye will take up more N than oats (Clark, 2007).

Table 7: Biomass and N Contributions of Selected Cover Crops

Cover Crop	Biomass (lb/ac)	Nitrogen (lb/ac)
Hairy vetch	3,260	141
Winter pea	4,114	144
Rye	4,000 +	38-50
Alfalfa	6,000 +	120-140

Sources: Sarrantonio, 1994; and Killpack and Buchholz, 1993

Use Non-GMO Rhizobium

Legumes often need to be inoculated with soil bacteria the first time they are planted in a field. Known as rhizobia, these bacteria form nodules on plant roots and convert atmospheric nitrogen to plant-available forms. There are some rhizobia in the marketplace that are genetically modified. Be aware that the rhizobium used to inoculate your seed must be compliant with any identity-preserved systems for non-GMO.

Funding is available from NRCS to offset costs associated with establishing cover crops. Contact your local NRCS office for more information or deadlines at http://offices.sc.egov.usda.gov/locator/app.

See the Further Resources section for useful guidebooks on soil health and the use of cover crops.

Insect Control

Genetically modified corn has been developed with the Bt trait to protect crops from insects, particularly the corn rootworm and the European corn borer. Since the advent of this trait, European corn borer populations have been in decline, and this has benefitted conventional non-GMO farmers as well. However, careful attention should still be given to rootworm problems.

Corn Rootworm

Rootworm is typically not a problem in first-year corn. However, continuous corn cropping systems are potentially vulnerable to yield loss due to rootworm. Farmers can expect larval hatches from May to June, and for adults to be present in the fields from July through September, where they will begin laying eggs in the soil to overwinter and be present for the next year's crop.

Western corn rootworm adult. Photo: Courtesy John Obermeyer, Purdue Extension Entomology

Northern corn rootworm adult. Photo: Courtesy of Kanas State University

Both the larvae and the adults can cause damage to corn and decrease yields. The larvae feed on root hairs and tissues, reducing the plant's ability to take up water and nutrients. Adults feed on corn silk, but early planting of corn usually prevents this problem because by the time the adult is large enough to cause damage, the corn crop has already pollinated. Plantings later than June 1 are usually more vulnerable to silk damage.

Scouting fields is crucial in a rootworm control program. Fields should be scouted in August when the adults are present, and the adult count should be compared to a threshold to determine whether corrective action should be taken. The scouting procedure will let the farmer know if pollination is in jeopardy during the current year, or if a pre-emergent insecticide should be applied to the following year's crop.

Penn State Extension recommends implementing a scouting program in August, or when the adults have begun laying eggs. A system of randomly selecting 40 pairs of plants in a field, by walking a "W" path through the field, provides the most accurate count of rootworm adults. Count the number of adults from the bottom up, and record your findings. Use an economic threshold from your state Extension service to determine whether a pre-emergent insecticide is necessary the following year.

Table 8: Economic Thresholds for Rootworm

	Adults (beetles) per plant	
Species	***First-year corn***	***Continuous corn***
Northern rootworm	2	3
Western rootworm	1	1.5
Source: Calvin, 2003		

For most corn producers, crop rotation is the best defense against rootworm. A three-year rotation to a legume, broadleaf crop, small grain, or sorghum provides the best protection (Calvin, 2003).

Crop rotations should be as diverse and extensive as possible. In the Midwest, farmers have seen that even corn that is in a long corn-soybean rotation may be vulnerable to rootworm. In Illinois and Indiana, fields that have been in a corn-soybean rotation for the last 35 years have become susceptible to rootworm as adults started laying eggs in soybean fields. The resulting generations produced, through natural selection, rootworm populations that favored soybean fields and would lay eggs to feed upon the next year's corn crop (Calvin, 2003). To avoid this situation, rotating corn to a small grain, followed by a summer annual and fall cover crop or perennial grass/alfalfa stand, brings diversity of species and length of time to prevent the incidence of rootworm infestations.

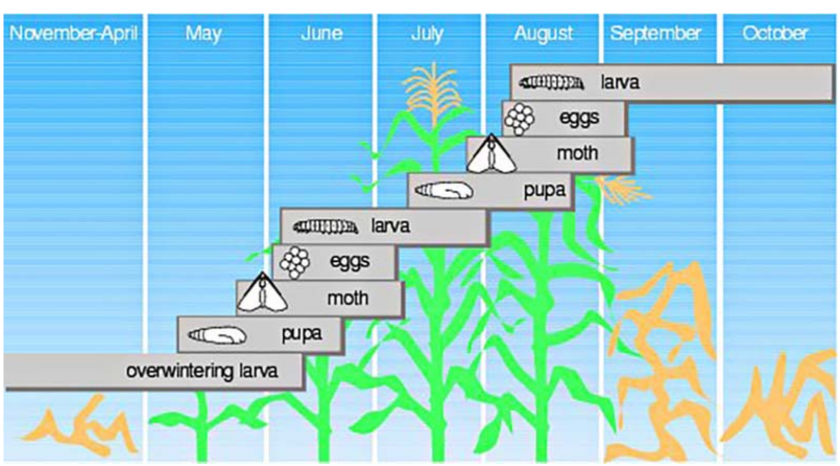
Pre-emergent rootworm control is helpful in continuous corn. A labeled insecticide can be chosen and applied based on the scouting done during the previous growing season. If the number of adult insects found during the scouting is at or above the economic threshold, an application of a pre-emergent insecticide can be beneficial in preventing rootworm damage.

European Corn Borer

The European corn borer is a one- or two-generation per year insect that feeds on a host of plants including tomatoes, potatoes, peppers, corn, sorghum, and many weed species (e.g., pigweeds, smartweed, ragweed, and foxtail). It is a predictable pest in terms of migration habits and a preference for vegetative cover, such as weeds and weedy or grassy field borders. The adult is a white or grayish moth, and the off-colored white larvae that emerge from eggs laid on the leaves are about one inch long. Late spring finds the emergence of the first-generation insect, usually from May to June depending on the latitude. After emergence, the larvae work their way to the stalk to cause their damage and then begin their pupal stage.

First-generation insects rarely do much damage, but second-generation insects hatch from July to August and can cause damage and potential yield loss by feeding on the tassels. Late-planted or late-maturing corn varieties are most susceptible to second-generation corn borers.

European corn borer adult. Photo: Clemson University-USDA Cooperative Extension Slide Series, Bugwood.org



Life cycle of the European corn borer, showing two generations. Photo: Tom Hiett, Iowa State University (Edwards, 1996)

European corn borer larvae. Photo: Mariusz Sobieski, Bugwood.org

European corn borer is usually not a problem and insecticides are rarely used, since it has declined in most parts of the country since the advent of the Bt strain. For control, choose hybrid varieties that perform well, and plant as early as possible if corn borer is endemic to your area. Control is not needed if corn is used for silage, but for grain, especially with second-generation borers, damage could occur late in the season. Monitor maturing plants and treat when 75% of plants show feeding evidence in the whorls of leaves close to the stalks (Bohnenblust and Tooker, 2010).

For soybeans, insects are mostly of minor economic importance, as soybean plants can take a lot of defoliation before yields decline. Penn State entomologists suggest soybean plants can tolerate up to 35% defoliation prior to bloom; about 20% while pods are small and soft; and about 35% when the seeds are filling. Defoliation below these levels has not adversely affected yields (Gesell and Calvin, 2000).

Identity-Preserved Crops

Specialty grains have been in production for quite some time. Consider the differences between food-grade soybeans and livestock feed, or grains and oilseeds used for high oil content or high protein content. Within these markets, there has to be a way of distinguishing one type from another, and this is accomplished through identity preservation. It's a way of segregating and preserving the important traits of one type of product from another. Some examples of identity-preserved grains follow:

- Organic vs. non-organic
- Feed grade vs. food grade
- Grain vs. seed production
- GMO vs. non-GMO

Identity-preserved grains must be segregated and protected from contamination to assure the purity of the product.

A Note on Disease Control

Diseases in feed crops are best controlled by rotations between crop families. Rotating crop families prevents the buildup of disease pathogens in the soil. The length of the rotation is important, as this helps to break the life cycle of the pathogen. The longer the rotation, the better the control, as most pathogens will die without a host plant within two to three years. In addition, tillage is a key disease-control strategy, as this has the ability to bury some pathogens deep in the soil.

Standards, Verification, and Risk Management

Standards for non-GMO production provide the basis for making a non-GMO product claim. Depending on the milk company a dairy producer works with, there may be different standards. Some processors rely on third-party standards, such as Non-GMO Project Verification or NSF True North certification, while others have their own standards to which producers must adhere.

The Non-GMO Project is a non-profit organization dedicated to preserving and developing the non-GMO food supply. Through extensive public input, the Project has developed standards for non-GMO verification, which cover the following systems:

- Testing for high-risk inputs
- Traceability of the supply chain
- Segregation to protect inputs from contamination
- Sourcing inputs in accordance with specifications
- Accurate product labeling
- Quality assurance for maintaining operational consistency and addressing issues rapidly

The Non-GMO Project Verification Process

- Complete and submit a Verification Inquiry Form to the Non-GMO Project
- Choose your third-party technical administrator (TA). Currently there are four companies that are approved to perform product evaluations:
  - — FoodChain ID
  - — NSF International
  - — SCS Global Services
  - — Where Food Comes From
- Sign a licensing agreement between you and the Non-GMO Project
- Complete the product evaluation and submit documentation to your TA. The documents required may include ingredient statements, certificates of analysis, PCR test results, and standard operating procedures at the facility.

To get started, contact the Non-GMO Project at www.nongmoproject.org.

In 2015, another third-party non-GMO certification standard was launched by NSF, known as True North. Additional information about this standard and how it applies to dairy products can be found at www.nsf.org/services/by-industry/food-safety-quality/label-claims/gmo-transparency.

Verification of non-GMO status requires strict adherence to traceability, segregation, and testing of high-risk ingredients. The verification process is usually handled by independent, third-party technical administrators (TAs) who determine if a product complies with standards.

Recordkeeping

To establish traceability, producers of non-GMO products should keep accurate records. Records document attempts to maintain the integrity of the non-GMO system and are used to verify adherence to standards. Producers should establish a list of high-risk and low-risk crops and inputs, and develop a management system of tracking each input from the time it is purchased to the time milk is shipped off the farm. Some of the types of records a non-GMO dairy producer should maintain include the following:

- Field records: to show where non-GMO seeds were planted, along with a record of lot numbers or bag numbers to identify seed
- Feed and seed purchase records and feed tags: to establish origin of inputs to verify compliance to standards
- Crop storage logs: to distinguish non-GMO from conventional seeds or feedstuffs and prevent commingling and contamination
- Animal health records, including all materials used: to verify that all pharmaceuticals used are in accordance with standards
- PCR and strip test documentation: to document the results of GMO testing of seeds and feedstuffs
- Equipment and bin clean-out records: to verify that equipment is not contaminated with GMO materials

ATTRA offers a comprehensive set of recordkeeping materials that farmers can use to document their management systems. The publication *Documentation Forms for Organic Crop and Livestock Producers,* though developed for organic farmers, is also appropriate for non-GMO farmers as it includes forms for recording the following types of information:

- Field history
- Prior land use
- Planting and harvest records
- Input records
- Seed source records
- Storage inventory
- Equipment cleaning log
- Field buffer logs
- Adjoining land use affidavits
- Livestock feeding and healthcare forms

The publication can be downloaded from the ATTRA website www.attra.ncat.org, or call 800-346-9140 to order a copy.

On-Farm Practices and Risk Management

The first line of defense in GMO risk management is to ensure that only pure non-GMO seed is being planted. Always get assurance from your seed source that the seed is pure, and consider testing the seed with a strip test before planting. Be sure to document all tests and planting data in your records.

Contamination of non-GMO feed crops can occur in many ways. In addition to seed impurity, some sources of contamination are wind-borne cross pollination, insect-borne cross pollination, improper equipment cleanout and documentation, and storage and transport contamination. Contamination from commingling of GMO and non-GMO grain can occur at planting, harvest, drying, storage, or grain transport. In addition, fields can be compromised by volunteer corn. Because of this risk it's a good idea not to plant non-GMO corn into a field that was planted with GMO corn the preceding year.

A twenty-row buffer between adjacent GMO and non-GMO fields is sufficient to keep any contamination to less than 1%. Alternatively, a buffer of 660 feet between a GMO and non-GMO field eliminates the need for a twenty-row corn buffer (Nielsen, 2000). It is important to segregate the corn harvested from buffer rows and sell it, or feed it to animals that are not a part of your non-GMO management plan.

Buffers are not the only way of segregating GMO and non-GMO crops. Fields can also have a "temporal" buffer, by choosing different crop maturities and planting crops at a different time to ensure that tasseling dates of the non-GMO crop and the GMO crop are as wide apart as possible. A three-week period between tasseling dates of crops can help to reduce the incidence of cross-pollination.

Genetic controls can also be used to prevent contamination from neighboring GMO crops. For example, the PuraMaize™ corn hybrids from Blue River Hybrids use genes from tropical corn varieties that prevent pollination by other varieties. Using traditional plant breeding, the genes expressing this trait were incorporated into corn hybrids, resulting in a corn variety that resists pollination from neighboring corn fields.

Finally, use crop testing prior to harvest to document potential trouble spots in the field in case contamination occurs. This way, if there is an issue, the whole field won't be compromised.

GMO contamination risks are inherent to farming. There is no legal standard for non-GMO, so there is no federal compensation procedure for risk management. Therefore, best management practices are warranted to minimize risk.

Preventing Contamination in Equipment and Storage

- Segregation and clean-out practices are relevant particularly for farmers who are growing their feed on-farm and/or are storing GMO and non-GMO feeds on-site
- Have custom operators clean equipment and provide documentation
- Clean and purge planters and combines before taking them into non-GMO fields.
- Maintain separate storage bins for non-GMO crops and seeds
- Ask haulers to provide you with clean transport affidavits for deliveries of bulk items, i.e., feed

Non-GMO Plus: Transitioning to certified organic dairying

There are many ways in which non-GMO production can take on the characteristics of an organic operation. Producing a non-GMO crop or product requires putting some controls in place to protect the integrity of the crop. Good records and procedures that show traceability, segregation, and the prevention of contamination, and field crop production practices like rotations and cover crops, are key for profitable non-GMO production.

Some producers are taking their practices one step further and are transitioning to organic production. In addition to recordkeeping and segregation of crops, organic dairy production includes the following practices or requirements:

- An Organic System Plan that details the production practices on the farm
- 100% organic feed for all certified livestock
- 30% dry matter intake from pasture for all cows and heifers for a grazing season of at least 120 days

ATTRA Publications Related to Organic Dairying
www.attra.ncat.org

Dairy Resource List: Organic and Pastured-Based

Tipsheet: Organic Cattle, Sheep, and Goats for Dairy

- Diverse crop rotations
- An animal health plan that does not use synthetic materials, like antibiotics
- Organic soil fertility plan that uses cover crops, manure, and/or compost, and does not use synthetic fertilizers
- A crop-protection plan that does not use synthetic pesticides

Organic production can be a viable opportunity for many dairy producers, and the price offered by organic milk processors can be as much as 30% more than the conventional milk price. For those producers interested in transitioning to organic, the first step is to contact an accredited organic certification agency. Accredited agencies are listed on the USDA's National Organic Program website at www.ams.usda.gov/nop. Also on the website are guides to organic certification and a description of the certification process.

For more information on organic certification, see ATTRA's organic resources at www.attra.ncat.org/organic.html or call 800-346-9140.

Table 9: Comparison of GMO, Non-GMO, and Organic Production Practices

	GMO	Non-GMO	Certified Organic
Use of genetically modified organisms	HT and IR traits in crops, broad-spectrum herbicides, reduced insecticide use	GMOs prohibited, process verification system, periodic testing according to thresholds	GMOs prohibited, process verification system
Seed	GMO seed	Non-GMO seed, difficult to source in some regions	Certified organic, non-treated, non-GMO seed
Livestock feed	Conventional feedstuffs and forages	Feeds grown from non-GMO seed	100% certified organic feed and forages
Soil fertility	Synthetic fertilizers applied to meet nutrient needs of the crop	Synthetic fertilizers applied to meet nutrient needs of the crop	Ecological soil management focused on soil health through use of cover crops, crop rotations, manure, and approved organic fertilizers
Crop rotations	An option for conventional production	Recommended for non-GMO production, especially for pest control	Complex crop rotations required in organic production
Cover crops	An option for conventional production	An option for non-GMO production	Strongly recommended in organic production, for building soil health
Pest control	Mechanical, cultural, and chemical controls; use of herbicides specific to herbicide-resistant varieties	Mechanical, cultural, and chemical controls; alternative chemicals to GMO production	Ecological management for soil health and system resilience. Mechanical and cultural controls, use of approved non-synthetic chemicals only – synthetic pesticides prohibited
Grazing	An option for conventional production	An option for non-GMO production, can help reduce feed costs	Required for organic production, 30% dry matter intake from pasture during grazing season
Recordkeeping	An good option for conventional production to track productivity and costs	Required for non-GMO production for traceability	Required for organic production to verify organic integrity
Segregation and contamination control	As needed depending on management system (i.e. seed treatments, medicated feeds, etc.)	Required to prevent commingling and devaluation of crop	Required to prevent commingling and loss of organic status
Third-party certification and inspections	None	Annual inspection	Annual inspection, comprehensive Organic System Plan
Price premiums	Based on quality or IP system, if any (food grade, oils, etc.)	Based on market, approx. \$0.50 to \$1/bu for corn	Based on market, approx. \$2 to \$10 for corn, approx. 30% milk premium over conventional

Land and Cattle Requirements for Organic Certification

Land must be free from the use of synthetic materials (prohibited substances), such as pesticides, seed treatments, and fertilizers, for a period of 36 months. Crops can be sold as organic 36 months after the last application of a prohibited substance on the field. Feed grown from the farm's fields in the last twelve months of transition can be fed to transitioning cows.

Dairy cattle must be managed organically, with 100% organic feed, for 12 months prior to marketing milk as organic. This is a one-time transition. After that, all new acquisitions of cattle must be from certified organic herds.

Slaughter cattle must be managed organically from the last third of gestation, meaning the cow and her calf have to be managed organically from the beginning of her last trimester to the slaughter of the calf for meat.

Contracts and Agreements

Feed and grain companies and food processors can make contract commitments that give the producer stability through a dedicated market and assist with verification to ensure non-GMO status. A producer of non-GMO products needs the right contract and relationships in order to maintain an adequate supply as well as quality of product. This allows farmers to continue uninterrupted in non-GMO production.

Some of the items a non-GMO contract will detail might include:

- Feed grain moisture, quality, grade, damage, and color
- GMO threshold
- Pay premiums for product delivered, according to quality and threshold
- A system of documentation for traceability, including clean-out and handling

Economics: Feed Grain Costs and Yield Considerations

The cost of purchased feed grains will likely be one of the biggest expenses for a non-GMO dairy producer. Non-GMO feed grains can be as much as 10% higher in price than their conventional GMO counterpart.

Table 10: Price Comparison, Conventional and Non-GMO Feed Corn

	Conventional	Non-GMO
US #2 Yellow Corn	$3.37 - $3.53	$3.40 - $3.92

Sources: Daily National Grain Market Summary, USDA-MO Dept Ag Market News, Feb 29, 2016; and National Weekly Non-GE/GMO Grain Report, USDA-CO Dept of Ag Market News, Feb 24, 2016

The cost of production for GMO and non-GMO crops is roughly similar in most respects except for seed cost and the cost of applying pesticides. Generally, a dairy farmer can expect non-GMO seed for feed crops to be roughly 70% the cost of GMO seeds. However, pesticide applications on non-GMO crops could almost offset this cost if the crop is not protected through rotations, scouting, and other cultural pest controls.

Table 11: 2016 Partial Budget for GMO and Non-GMO Corn Silage

Input	GMO cost/acre	Non-GMO cost/acre
Seed	$100	$68
N,P,K	$117	$117
Lime	$14	$14
Pre-emerge	$16	$22
Post-emerge	$22	$16
Fungicide	$15	$15
Insecticide	$5	$18
Fuel	$17	$17
Labor	$35	$35
Total Variable Cost/Acre	$341	$322

Source: Reinbott, 2016

Variable costs are one thing to consider, but yield potential is also a factor in determining the profitability of transitioning to non-GMO production. Some farmers are concerned that seed companies are no longer introducing non-GMO versions of certain hybrids, or they are releasing non-GMO versions long after the original hybrid has been introduced (Thomison et al., 2016). With the new hybrids being GMO versions, farmers fear non-GMO versions won't have the same yield capacity as the new hybrids.

Table 12: University Corn Variety Trials with GMO and Non-GMO Seed

Performance of early-maturity hybrids in North Central and Northeastern Ohio, 2015				
Total # varieties		**# non-GMO varieties**	**Average yield**	**Average non-GMO yield**
60		5	189*	184*
Short Season Vermont Corn Silage Variety Trial, 2014				
Total # varieties		**# non-GMO varieties**	**Average yield**	**Average non-GMO yield**
29		4	21**	24.4**
* Bushels/acre				
** Tons/acre @ 35% DM				
Sources: OSU, 2015 and Darby et al., 2014				

Two university yield trials compared the performance of GMO and non-GMO corn, one for silage and one for grain. The results appear in Table 12, above.

Yields of non-GMO corn have been shown to be comparable to GMO corn, and some non-GMO varieties outperform their GMO counterparts consistently. It seems that with reduced costs for non-GMO production and no yield drag, adequate production of non-GMO feedstuffs for a non-GMO dairy is an attainable goal.

Case Study

Hiland Natural, a Non-GMO Feed Company, Sugarcreek, Ohio

By Ruth Mischler, NCAT Sustainable Agriculture Intern

Dan Masters, a consultant with Hiland Naturals, a national non-GMO livestock feed company, began working 11 years ago with dairy farms who wanted to become non-GMO verified. Since that time Dan has worked with more than a hundred dairies and at least as many poultry operations who have made the transition to non-GMO feed.

HILAND NATURALS
PREMIUM NON-GMO LIVESTOCK FEED

Dan assists farmers throughout the non-GMO verification process. He helps the farmer create a farm plan, which is a document that details the feeding regime for their cows. The farm plan notes the source of feed, the type of feed, how much is fed, and how the feed is being used. Milk cows must be on non-GMO feedstuffs for one year prior to being verified, and heifers must be on non-GMO feed for their full life. In addition to documenting their feeding plan, farms will provide samples of feedstuffs for testing.

Testing is primarily done qualitatively, meaning that the presence of GMOs is either "detected" or "not detected" at a detection limit of 0.01%. If GMOs are detected, a quantitative sample is taken, which gives the percent of GMOs in a sample. The size of a sample needed varies with the crop species; for example: 100g for finished feeds/pellets, 50g for canola, and 200g for whole soybeans.

Dan works with farmers to take samples and test high-risk crops like corn, soybeans, and alfalfa. He also keeps records of the results for inspectors. Non-high-risk crops like grass hay or small grains are not tested, but the seed source (or fields, if grown on the farm) is documented. The goal is to provide traceability, transparency, and testing to ensure that all feedstuff going into the cow is non-GMO, so the product (milk) coming from the cow is veritably non-GMO.

The cost to become verified non-GMO varies, but is typically around $1,000 to $5,000. Consultants, like Dan, help a farmer through the verification process: writing the farm plan, testing feed stuff, collecting samples, working with third-party auditors (technical administrators), recordkeeping, and assisting in connecting to feed sources and markets. Dan's direct involvement and experience has helped farms successfully transition to non-GMO feed. He cautions, however, that location is an important consideration. Where the milk is produced, where the grain (or feed) is produced, where the milk is processed, and where there is consumer demand all need to come together to allow a successful transition to non-GMO verified products.

Despite the challenges producers face in transitioning to non-GMO feed, Dan sees a growing interest in non-GMO products in that "shoppers are becoming more aware and want to know what they are putting in their bodies." He sees the Non-GMO Project as a test-based verification protocol that is easy to document and record. The transparent verification process, with consistent monitoring, gives consumers confidence in what they are purchasing and also offers a clear pathway for farmers to market their product.

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Notes

Notes

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