Adding Value to Maine Grown Grains Through Enhanced Cleaning, Drying,and Storing Solutions

POSTHARVEST GRAIN HANDLING PROJECT REPORT

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Table of Contents

Flint Corn from Liberation Farms

Introduction

Maine's local and regional grain economy is sprouting new seeds for a vibrant future. Even in the midst of a health and economic crisis, farmers, producers, processors and consumers are valuing the importance of healthfully grown and processed grains for human consumption.

Growing and selling table grains successfully is complex, and requires attention to interrelated issues of soil health, thoughtful growing practices, postharvest strategies, processing facilities, and well-matched markets.

In the past ten years, Maine grain producers, processors, and value-added producers have been developing solid businesses and attracting regional and even national attention. Supportive groups like the Maine Grain Alliance (MGA), Slow Money Maine, the Maine Organic Farmers and Gardeners Association, Maine Farmland Trust, University of Maine Cooperative Extension, Coastal Enterprises Incorporated, Focus Maine, and the Maine Technology Institute have provided funding and technical assistance, along with educational and promotional activities, to build producer skills and consumer appetites. Many people remember Maine as the country's "breadbasket" and have been eager to support the return of that image. In a fairly concentrated time frame, the number of bakers and brewers has hugely increased, and it now seems that grain varieties and bread recipes are common conversational topics.

Current agency figures show that Maine has about 1,000 acres of organic grain production, and is the largest grain grower in the Northeast, with more than 51,724 acres of barley, oats, rye, and wheat, according to the 2017 Maine Agriculture Census. Most grain grown in Maine is not sold to the higher priced markets of food and malt grade grains, but rather to animal feed commodity markets.

In 2002, Jim Amaral, baker and owner of Borealis Breads in Maine, was instrumental in forming a partnership with a grain farmer and Cooperative Extension educator in Aroostook County, Matt Williams, to procure more Maine-grown grains for his artisan loaves. The rise of the local food movement made some bakers like Jim question whether their wheat flour could once again come from Maine. Borealis Breads partnered with Matt, and Aurora Mills and Farm was launched in Linneus, ME. The Williams' farm was then outfitted with equipment for cleaning and milling Matt's organic wheat, oats and spelt. Aurora Mills and Farm began to uncover the unmet desire for organic, locally grown grain among bakers, brewers and distributors.

In 2010, inspired by the Maine Grain Alliance's Kneading Conference and lack of statewide infrastructure for processing grain, Amber Lambke and Michael Scholz led an effort to research and develop a gristmill in Skowhegan. The resulting business, Maine Grains, is now a significant buyer of Maine-grown grains. Their products serve bakeries, restaurants, and food institutions across New England and New York. Maine Grains has helped inspire an agricultural renaissance in Skowhegan and has acted as an engine of transformation in the regional grain economy.

In addition to Maine's flour successes, the craft beer industry has swelled to more than 140 breweries, and boasts two malt facilities, Blue Ox Malthouse and Maine Malt House. Maine brewers are using millions of pounds of grains per year and the brewing industry is helping to drive rapid economic growth on farms by helping them plan for their future on-farm investments.

The Need For Better Postharvest Grain Handling

As the market has grown for food-grade and malt-grade grains, so too has the need for appropriately scaled on-farm post harvest grain handling. Postharvest spoilage of grains begins when grains are exposed to too much moisture, even in a short timeframe. The moisture level of the grain must be reduced rapidly. Grain seeds need to be maintained in viable condition for long market windows, without losing milling, malting and seed grade germination standards. The lack of infrastructure to help achieve these standards is one of the central bottlenecks in helping Maine-grown grains get to market.

The Maine Grain Alliance, with support from the Maine Technology Institute and Slow Money Maine, has led the work on the ground for enhanced cleaning, drying, and storing solutions. The

current project is a $194,000 effort (with more planned in 2021) to support seven Maine farms that already play a key role in the grain economy.

Even with an abundance of talented, resourceful farms, there is significant need to help further scale grain growing to meet market demand. MGA's post-harvest grain handling project is activating experts' knowledge from within our state and outside Maine to provide transfer of knowledge of innovative drying, cleaning, and storage infrastructure from across the world.

Thankfully, well known consultant, farmer, and orchardist Mark Fulford immediately lent his expertise as the Technical Consultant for the project. Mark has grown grains on research scale plots and small fields since 1982. As a worldwide agricultural consultant, Mark has recognized that the best way for farmers to capture higher margins is to handle as many aspects as possible at the end of the grain chain. He has observed that there is less room for postharvest error compared to other agricultural crops.

This project benefited greatly from the expertise of Tom Molloy, who served as Project Manager for this effort. Tom works as a Research Technician at the University of Maine where he conducts research in sustainable agriculture on farms and at the experiment station. His research interests include investigating alternative management strategies for weed control and small-grain production. As a state SARE outreach coordinator, Tom provides sustainable agriculture information and referrals to farmers and others in Maine.

Lastly, this effort would not have been possible without the tireless efforts of Bonnie Rukin and the Slow Money Maine community. Bonnie Rukin, who serves as a consultant for this project, has spent nearly a decade connecting grain-based businesses to funding and technical assistance through her work as founder of Slow Money Maine . Bonnie also draws upon personal experiences in the grain sector as she spent over 20 years as an organic farmer in Maine, and grew grain on a small scale. In her early work with Slow Money Maine, significant attention was given to infrastructure businesses that included processing facilities for vegetables, grains, and meat. Maine Grains in Skowhegan became a pivotal business to support; Amber Lambke, owner of Maine Grains and a founder of the Maine Grain Alliance, became a close partner in her food system endeavors.

Strategy

Building upon the successes of MGA's Maine Technology Institute feasibility report titled "Scaling Organic Grain Production to Meet Market Demand"[1], this project showcases the

[1] Hallweaver, C. (2017). *Scaling Organic Grain Production in Aroostook County.* A Report to Maine Technology Institute from the Maine Grain Alliance.

successes and challenges of farmers' firsthand experiences with new types of postharvest grain equipment. Our project's intent is to inspire participating farms to work cooperatively, to learn from one another, and to guide ascending grain farms in their pursuit of higher quality grains through improvements in infrastructure.

By providing knowledge transfer from industry experts of innovative drying, cleaning, and storage infrastructure, our project is giving farms the opportunity to access higher values for grains and enter new markets. Maine presents unique challenges for postharvest grain handling; we address that problem by integrating proven strategies and equipment infrastructure from successful models across the world. Our solution is different from current alternatives because the proposed pieces of equipment are scalable, require less capital outlay, and may be shared.

After many hours of research with experts and collaborative conversations with farmers, a strategy was developed specific to each farm, complementing prior postharvest grain handling investments, with an eye toward creating greater efficiencies and higher quality grain. Next, innovative pieces of equipment were identified for purchase by the Maine Grain Alliance. This project takes a very unique approach to the solution for each farm, in that the Maine Grain Alliance owns each piece of equipment purchased and shares it under contract with each farm.[2] In some cases, the innovative equipment solutions may live on a specific farm in perpetuity under contract. In other cases the equipment may be shared, either at a specific farm location or it may have been adapted to be mobile allowing it travel between farms through the state. Since 2014, the MGA has created a small fleet of mobile, shareable pieces of equipment. In addition to mobile combine, seed drill, screen cleaner, dryer, moisture reader, this year the MGA has added a mobile threshing machine. This small machine is powered by a gasoline engine and is small and light enough for 2 people to easily pick it up and put into the back of a pickup truck. This machine is perfect for threshing niche grain harvests that farms may not be able to run through their large systems.

Much of the equipment purchased as part of this project has previously never been used on a farm in Maine. Some items are brand new pieces of technology not known previously by the farm. In the cases where the equipment was known, it was not accessible because of capital costs. This project allows for dynamic pieces of farm infrastructure, already successful in other parts of the world, to be seen and used. By adding these multifaceted pieces of equipment and sharing technical expertise through our project team, MGA has enhanced and updated existing infrastructure on farms in Maine. In some cases, the new technologies replace less cost effective methods currently being used. The focus on improved drying, cleaning, and storing enhances all parts of our value chain. By adding low cost storing solutions, access to a greater variety of grains will become possible. The project integrates storage solutions designed to safely store dry

[2] See sample contract in Appendix C

agricultural commodities, guard against rodent attacks, and prevent the exchange of air and moisture.

Our project has provided, and will continue to provide, experimentation and technical support to improve and adapt the technological introductions to each farm's unique situation. No two farms are exactly alike so an 'off-the-shelf' approach is not enough to meet needs.

A great deal of time is spent calibrating new pieces of equipment and applications on farms. Our farmers participating in this effort are very talented in calibrating equipment and fabricating supplementary supporting infrastructure. Originally, the project team had hoped to host a series of on-farm demonstrations where farmers have a chance to provide process improvement lessons to visiting farmers. The COVID-19 pandemic cut short our efforts to organize these events as individuals were unable to safely travel. We were able to hold a field day in August of 2019 and visit with farms via online social media interviews, but our hope is that in the coming year we can reactivate this part of our project so as to spread the knowledge gleaning from this effort far and wide.

Additionally, the pandemic had uneven impacts on different sectors of the grain economy. The brewing industry was greatly disrupted with the closing many restaurants, bars, and taprooms for extended periods of 2020. Maine breweries are large purchasers of Maine malts made from Maine grown grains. Maine's milling industry had a period of expansive growth highlighting the successes of investment in the regional grain economy, as our state's mills were able to provide flour when other national flour companies' supply chains were upended. Farms felt the impacts of this disruption as did equipment suppliers. As a result, some of the qualitative and quantitative data we hoped to gather was delayed. While this project does capture very meaningful results and data, the Maine Grain Alliance's intention is continue engagement with our participating farms, guiding them through recording keeping efforts in the 2021 season so that successes and solutions can be shared with future adopters. The Maine Grain Alliance intends to write a follow up report detailing these assessments and provide a detailed webpage on the MGA site that houses all lessons learned with links to resources.

2020: A Unique Year For Growing

The year 2020 was an incredibly difficult growing year for many reasons. Project Manager Tom Molloy has said that it has been the strangest and most challenging weather year he has seen since managing field experiments. Much of Maine experienced a very cold and dry spring. The only moisture in Northern Maine in May of 2020 was from two snow storms with the last one dumping 5 inches of snow on May 15. In some cases farmers could have planted earlier, but many were trying to sort out the impact of COVID-19 on their markets and business.
Grains that were planted in early to mid-May received very little moisture during the critical early growth stages and up through flowering in mid to late June. By then the yield potential

was pretty much set and the grain crop was in very rough shape. Maine farms started to see more rainfall in July and August from quick thunderstorms that were very localized, but with no soaking rain events. The showers in July brought on a late flush of weeds, primarily Common Lambsquarters.. Drought conditions persisted for much of the state right up until mid-September at which point it began to rain incessantly, further complicating conditions for farms.

Overall, most of Maine's grain farms were under drought stress during critical parts of the growing season and endured severe drought conditions by the end of the summer. Yields were severely limited by the lack of moisture. Farmers reported (anecdotally) yield reductions of 50% and sometimes 75%. Because crops were stunted, weeds were able to take advantage of available sunlight when showers did pickup in July, leading to severe weed infestations in many conventional grain crops.

For organic growers, the drought was exceedingly difficult because of a lack of water and nitrogen stress (healthy microbial activity is required to release N from organic sources which can be limited by drought). Weeds are commonly a problem on organic farms, but with little competition from severely stunted crops, weeds were able to proliferate and were still very green at harvest.

Harvest was very challenging with some farms reporting cleaning out more weed material (seeds, stems, leaves) then harvested grain. One organic grower told Tom Molloy that he was "combining a field on faith that there was a crop in there somewhere".

This context is important to understand as the atypical nature of the season influenced some of this project's testing plans. The Maine Grain Alliance intends to continue with qualitative and quantitative assessment in 2021 with hopes of a better growing season.

Participating Farms

Some of the farms this project supports are serving as regional aggregators of grain and most grow a wide variety of grains focused on reaching higher value markets. The participating farms, Aurora Mills and Farm, Benedicta Grain Company, Lakeshore Farm, Liberation Farms, Rusted Rooster Farm, and Yost Family Farm, account for more than two thirds of organic grain production in Maine. Maine Malt House at Buck Farms, though not an organic farm, is also participating in the project and is an important contributor to agronomic advances in grain growing. By increasing efficiency, reducing spoilage, and unburdening these important farms of obstacles relating to postharvest practices, the entire grain economy will benefit.

Aurora Mills & Farm

A pioneer of Maine's local grain economy, Aurora Mills and Farm has grown its family owned, sustainable organic operations to serve customers across the Northeast. Sara Flewelling, alongside her father Matt Williams and husband Marcus, is ushering the next generation of success on their farm.

Aurora Mills and Farm has been very interested in innovative and sustainable equipment and infrastructure solutions. Mark Fulford, lead agricultural consultant for this project, began early discussions with the farm exploring the idea of a solar passive hot air exchange to dry grain. The idea would be to capture enough hot air inside of a greenhouse or large, plastic solar bubble dryer, and then to use fans to force the hot air through grain tanks. This approach could have significant environmental benefits, low cost, and replace some of the need for propane with renewable energy.

Aurora Mills and Farm had tested smaller scale solar bubble driers as a stand-alone method for drying down small batches of unique grains. MGA loaned a portable solar bubble dryer to the farm to test, but the humidity and resulting condensation created an environment that was not able to dry grain to the needed 12% moisture level required for milling.

Sara and Marcus Flewelleing, along with partner Matt Williams were interested in exploring other solar powered grain drying options on their farm. The business has a number of energy requirements given that there is a need to power the mill, cleaning equipment, drying equipment, grain conveyance, and the family homestead.

To explore the option of solar powered drying at Aurora Mills and Farm, the project management team connected with John Dunster of Revision Energy in Portland, Maine. The new approach explored the implementation of a possible solar array in combination with a series of eclectic powered drying equipment.

First project manager, Tom Molloy, worked alongside the farm to create a baseline set of assumptions for drying grain.

Assumptions to dry 1 acre of wheat with electricity:

- To dry from 18% to 13% one has to remove 3.63 lbs of water.
- It takes approximately 1200 BTUs to remove 1 lb. of water
- To dry one bushel from 18% to 13% = 4356 BTU
- Assuming 33 bushel per acre yield x 4356 BTU/bu = 144,000 BTU/acre

Revision Energy was able to share that one kwh= 3412 .1416 BTU, so 144,000 BTU would equal approximately 42.20 kwhs. A 500 acre farm focused on using its energy to dry down grain, would require 21,000 kwhs and only require about a 20KW system. Revision Energy shared that this could be easily installed on a farm and suggested that the build be larger to offset all the farm's electric usage.

Another consideration important to any solar option is to connect with the municipally owned utility providing electricity, in this instance Houlton Water Company. Our project asked about the limits and the net metering policy and carry over. The Houlton Water Company confirmed that they have a 100kw AC cap on any solar system with a one-for-one net metering program at about $0.11 per kWhs. The credits expire after 1 year.

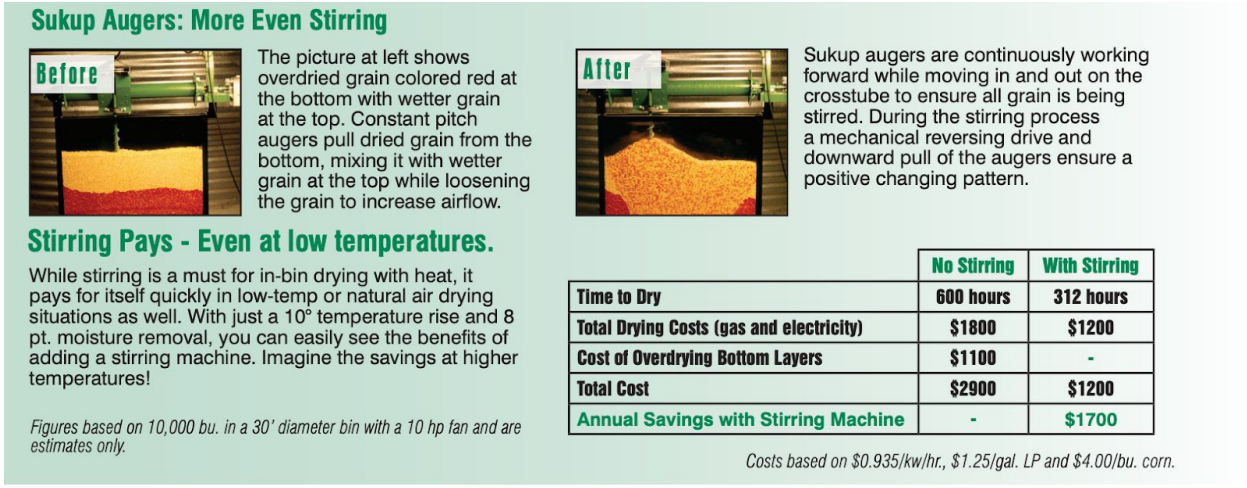
If a farm is in need of a full 100kw AC system, the footprint required on the ground would require a ½ acre or less, but would also need to account for shading. This size system would produce about 140,000 kwhs per year.

Next the project management team reached out to a leading expert in grain drying and storage, Dr. Kenneth Hellevang of North Dakota State University. Dr. Hellevang helped provide a comprehensive understanding of some of the considerations necessary to execute an innovative solar project of this nature. Before a solar energy system could be implemented a system of electric heating elements would need to be integrated alongside a way to effectively stir grains inside of the storage containers.

A number of tax incentives currently exist that help reduce the overall out-of-pocket cost of implementation of a solar array and grain drying project of this nature. However, to receive

these incentives the farm business must be the entity to expend the money in order to qualify for the incentives. Also, this postharvest grain handling project's intention is to provide innovative grain drying, cleaning, sorting, and storage equipment solutions vis-a-vis Maine Grain Alliance owned equipment. Given everything learned as part of this project it was determined Aurora Mills and Farm was in need of two critical pieces of equipment before any further solar solutions could be pursued. Both were within the scope of this project and are described below.

While the most efficient way to dry grain is to add heat, one runs the risk of overdrying the grain. A stirring machine is essential to prevent this overdrying. Stirring mixes the driest grain at the bottom of the bin with the wetter grain towards the top, resulting in a more uniform moisture content. University tests have shown less than 1% variation from top to bottom in stirred grain.[3] Stirring also loosens the grain, reducing static pressure and increasing airflow, so grain dries more quickly and efficiently. Tests conducted by a university in collaboration with Sukup (Sheffield, IA) show using a stirring machine in wet grain (a common obstacle in Maine) increases airflow by up to 33%. Stirring also breaks up spots that may be exceedingly hot and can result in extended storage life.[4]



[5]

After much research, two Sukup 15' Fastir Machines with two stir motors were purchased for installation inside Aurora Mills and Farm storage tanks. Each had 1.5 HP motors and include two 15' down augers for each stirring machine. Thanks to the resourcefulness of Marcus Flewelling, he and an associate were able to custom fit and adapt the machines to specific needs of the farm. They were able to install the equipment themselves.

[3] "Fastir® Stirring Machine." *Sukup*, www.sukup.com/products/fastir-stirring-machine.

[4] "Fastir® Stirring Machine." *Sukup*, www.sukup.com/products/fastir-stirring-machine.

[5]"Fastir® Stirring Machine." *Sukup*, www.sukup.com/products/fastir-stirring-machine.

Depiction of how the Fastir Stirring Machines work.

The second critical initiative needed was to finish an earlier innovative purchase by Aurora Mills, a chain and paddle based grain looping system. Previously, the farm had invested in this system to allow for dried grain to be conveyed from outdoor storage tanks directly to the mill. The loop system is intended to connect all of the equipment storage tanks to all of the cleaning equipment, eliminating the need to bag and move grain between pieces of equipment. The system also significantly reduces damaged grain compared to conventional augurs systems.

However, the farm needed an important specialized piece of equipment to make the system work, a Danfoss Variable Frequency Drive. The farm had not been able to purchase this highly specialized tool prior to this project. A variable frequency drive (VFD) is a type of motor controller that drives an electric motor by varying the frequency and voltage of its power supply. The VFD also has the capacity to control ramp-up and ramp-down of the motor during start or stop, respectively.[6] This particular unit was a match to complete the looping system as it has a 230 volt 1 PH input and three phase output rated to thirty horsepower. When using the VFD, the flow rate of the moving grain can be matched to the operating rate of each piece of cleaning equipment. Running conventional augurs at lower than max capacity significantly increases damage to grain, thus the loop system creates significant efficiencies and decreases damage to grain.

[6] "Drives." *Danfoss*, www.danfoss.com/en-us/about-danfoss/our-businesses/drives/.

The looping system at Aurora Mills and Farm can be see above the tanks

Another view showing the looping system at Aurora connecting to the mill and cleaning systems.

With these pieces of equipment now on the farm, Aurora Mills and Farm is already experiencing efficiencies, even before a further adaptation to solar. Marcus Flewelling has shared that he is seeing as much as 30% increased drying efficiency with the new grain tank stirring system. Additionally, the loop system is now operational thanks to the VFD. The system is currently running on a generator and needs to be hardwired, but stored grain now moves very efficienciently between storage tanks, cleaning systems and the mill. Previously, the operation required to be moved by tote and fed into cleaning machines and the flour mill by tote. The farm remains committed to exploring a solar array as a next step in the future and now has the critical postharvest equipment in hand to pursue this effort.

Benedicta Grain Company

Jake Dyer and Andrew Qualey at Benedicta Grain Company, utilizes sustainable farming methods such as crop rotation, cover cropping, addition of soil amendments, and crop diversity to improve and protect the soil. Jake is always interested in pursuing alternative cropping strategies to increase the long term viability of his farm and to diversify our crop rotation.

Benedicta Grain Company has been an early supplier of high quality food grade grains and has explored many different markets for its harvested grain. Though the farm has a cleaning system in place, to access certain markets, and to meaningfully improve the quality of the grain varieties being grown, the business was in need of an innovative piece of equipment that could separate out the smallest weed seeds that can infiltrate a year's harvest. After meeting with the project management team and independent research, it was determined the most effective solution for Benedicta Grain Company was a gravity table.

A gravity table consists of a reciprocating metal screen deck through which air is forced. The deck oscillates laterally and longitudinally, which causes the densest grain berries to travel farther along the deck before exiting the table. The less dense grain berries float more from the force of the air current than do the denser kernels and thus are more affected by the force of gravity. The less dense kernels travel the line of the deck incline and are deposited at a position corresponding to a shorter distance along the deck. A gravity table is able to separate grain by a wide range of kernel and test weight. It is highly effective at removing unwanted weed seed and sprouted kernels, which can occur in wet conditions common in Maine. Sprouting can occur right on the grain stalk in the field. By removing sprouted kernels from a farm's harvest, the quality of the grain is significantly improved. Also, shrunken and broken kernels are highly concentrated in the least dense separation, while small stones that can be picked up by a combine are separated in the more dense separation, vastly improving the food grade nature of harvested grain.

To date, very few farms in the Northeast possess an on-farm gravity table grain cleaner. A gravity table is highly specialized and is usually only found in advanced mills or grain processing centers. Organic farms can have significant problems with weeds, specifically wild radish which can't be cleaned out with conventional screen cleaners. With a gravity table now in place, a new range of selling options is opened to a farm, including selling higher quality milling and malting grade grains, and even the possibility of selling seed quality grain to seed companies. These markets offer higher prices for harvest grain.

Benedicta Grain Company is currently in the process of putting the gravity table on skids and completing installation. The farm plans to start using the equipment in January to clean the 2020 oat crop. In 2021, we intend to report on a number of quantitative and qualitative measurements to compare quality and efficiency between this year and year's past.

Lakeshore Farm

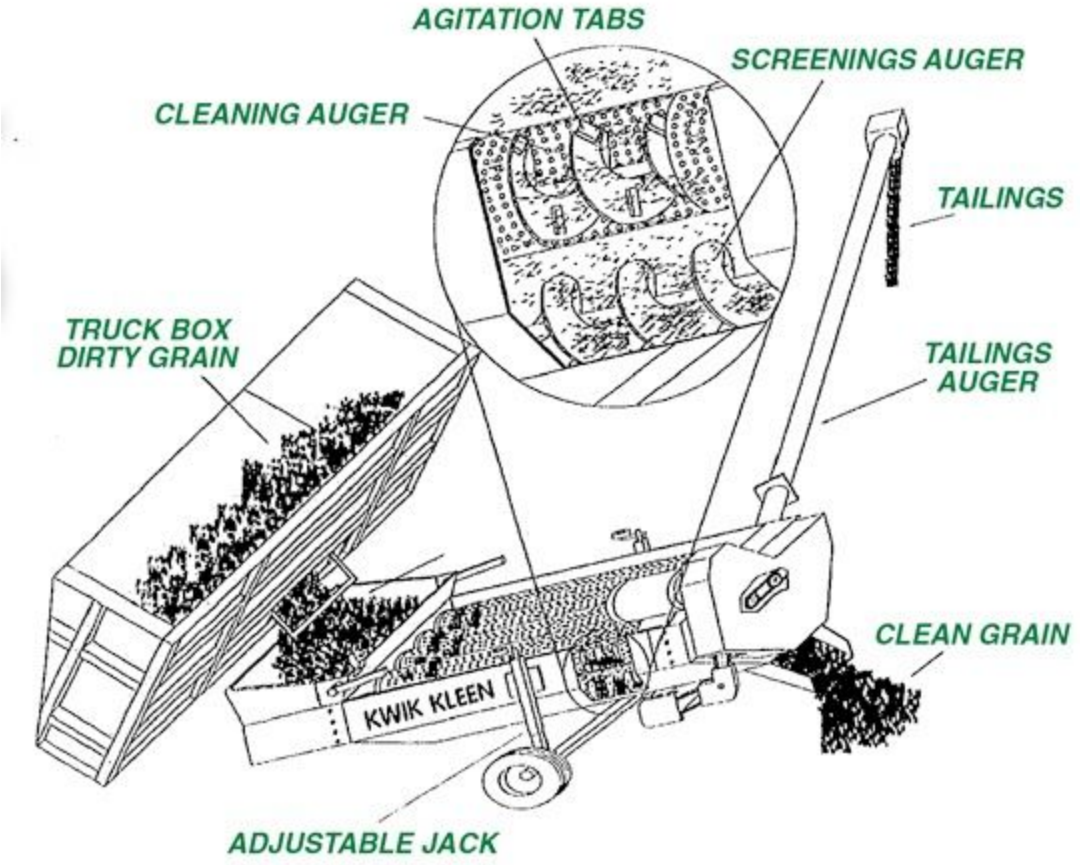
Dave Ouellette of Lakeshore Farm has been instrumental in promoting organic grain production in the St. John River Valley. He has steadily been improving his farm practices and purchasing important cleaning, drying and storage equipment which has allowed him to double grain production of organic oats, winter rye, triticale and buckwheat.

Being in far northern Maine with a short growing season, it has been a challenge for Lakeshore Farm to harvest spring planted crops to allow for timely planting of fall planted winter rye, a critical crop in the rotation. Since Lakeshore Farms is growing hundreds of acres of grain, it can not be cleaned at harvest over their conventional screen cleaner due to time and logistic constraints. . Additionally, the grain cannot be stored for long periods at high moisture. To address this bottleneck and the possibility of losing a large portion of a harvest during a wet season, this project took a two part complimentary approach.

First, without any option to dry grain by batch, the farm was particularly vulnerable to losing large portions of grain to spoilage. Two years ago the farm nearly lost an entire crop of grain to extraordinary wet conditions. If such an event were to occur again it could be disastrous. To address the need, this project purchased an in-field grain cleaning system. Rather than storing wet grain with weed seed in a bin and cleaning inside the barn, an in-field grain cleaning system removes unwanted wet seed and material right in the field, before it ever reaches a storage tank or a Clipper style screen grain cleaning system where it can gum up the machinery. The MGA purchased a Kwik-Kleen grain cleaner equipped with:

- A portable 2500 Bu/H machine
- 5- 6"Screens and Screening Augers
- 5Hp Electric Motor {1 or 3 Phase}
- 1 Year Warranty on parts

The Kwik-Kleen grain cleaner allows a farm to clean grain at harvest time. Clean grain dries and stores better, saving time and money. The Kwik Clean is compact so as to increase its versatility and be able to fit in confined areas, but still large enough to keep up with most harvest conditions. The equipment comes equipped with a variable speed control and grain feed rate adjustment. The majority of cleaning is done on the sides and tops of screen tubes. It also comes equipped with a spring-loaded hopper and easy-to-remove one-pin hitch that enables a farmer to back cleaner up to grain storage bins to clean stored grain if needed. It can be used for sizing and separating certain grains. In addition to ridding wet weed seed it removes alpha-toxins from corn and vomitoxins from small grains. The equipment can remove 3-4% of foreign material, down to 1% or less, before it ever enters another grain cleaning system like a Clipper screen grain cleaner.



Additionally, because the rich variety of grains grown at Lakeshore Farms, it was determined by the project management team and the farm that a portable, batch grain drying system would complement the in-field cleaner a great deal. As a result, this project has purchased a propane based recirculating batch grain dryer (model GT 245XL). On-farm grain drying utilizing a batch drying system is not a common practice of Maine farmers . This piece of equipment allows for drying of specific portions of fields or particular varieties of grains apart from the stored grains in larger bins. The drier has the capacity of 140 bushels an hour, perfect for the scale needed at Lakeshore Farms. It is also mobile and can be moved from location to location and shared.

Mobile GT245 XL Mobile Batch Dryer at Lakeshore Farm

These two pieces of postharvest grain handling have already improved quality, saved time, and money for Lakeshore Farms. With access to the Kwik Kleen field cleaner, Lakeshore Farm was able to clean its rye crop going into the storage tank. The result was that Lakeshore Farm took out a significant ("barrels full") amount of common lambsquarters seed and leaves. The farm has previously not had the ability to clean grain before entering the tank. In fact, it had never even been considered because the farm's large stationary Clipper screen cleaner would require so much time to operate and posed logistical constraints.

As mentioned previously, 2020 was anything but typical. Aroostook County experienced a severe drought for much of the growing season. Due to the dry conditions at harvest Lakeshore did not have to use the batch dryer. However in 2019, during a very wet year, Lakeshore Farm was not able to harvest its buckwheat in a timely manner which led to a very late planting of winter rye. This in turn led to significant overwintering mortality. If Lakeshore Farms had possessed a dryer in the fall of 2019, the farm could have planted rye up to three weeks earlier, perhaps helping prevent winter kill. Due to the poor stands of winter rye, there was a significant weed problem (which is not typically a problem in winter rye). From this example, one can

observe the cascading effect a wet season can cause without scalable cleaning and drying equipment.

Yost Family Farm

Innovation abounds at Yost Family Farm in Blaine, Maine. Tyler and Tristan Yost grow both organic and conventional crops and have even launched their own sunflower oil brand, Black Bear Sunflower Oil, made from sunflowers grown and cold pressed on their farm. The Yosts have grown grain for a variety of processors across the state, and also create feed blends. Yost farms is one of few farms in the state to grow grain both organically and conventionally. The farm grows a wide variety of grains to make their unique grain feed blends for livestock.

Early discussions with Tyler and Tristan Yost started this project toward the exploration of a self designed honeycomb style grain hopper system. The idea was to create a honeycomb design that allowed for easy mixing of grain varieties that would feed via a form of grain conveyance to a motor powered grinder/mill that helps process their grain and ready for sale as livestock feed. However, after exploring the ground work costs associated with pouring concrete we determined that the price would exceed the scope of this project. Consequently, we explored the next significant bottleneck to getting grain to market. In this instance, the difficulties in drying and sorting out wet vegetative debris mirrored the difficulties experienced at Lakeshore Farm. For this reason, the MGA purchased a second mobile Kwik Kleen grain cleaning system (see Lakeshore Farms for description of product).

Removable bearing plate on the Kwik Kleen for quick screen changes

Yost Family Farm had a similar constraint to Lakeshore Farm in that it has previously been difficult to clean grain robustly before going into a storage tank. Tyler Yost shared that he ran a lot of his early harvested crop across a traditional screen cleaner, before he was in possession of the Kwik Kleen system. Tyler stated that was "awful" because the weed material was so green it would stick to everything. The Yosts' would sometimes run harvested grain across the traditional screen cleaner as many as 3 times to get it clean enough to go to storage. After getting the Kwik Kleen cleaner, Tyler shared the difference was "like night and day." With just one pass across the field cleaner the grain was good to go into storage and because of its mobility and capacity the trucks could dump right into it and then into the tank.

The cleaner did not arrive on the farm until later in the 2020 harvest season. In 2021, with guidance of the project team, Yost Farms will be gathering data on increased efficiencies and throughput, as well as observation with regard to increased quality.

Liberation Farms

Liberation Farms is a groundbreaking initiative of the Somali Bantu Community Association (SBCA) in Lewiston. The SBCA is a 501(c)(3) nonprofit who provides vital transitional services,

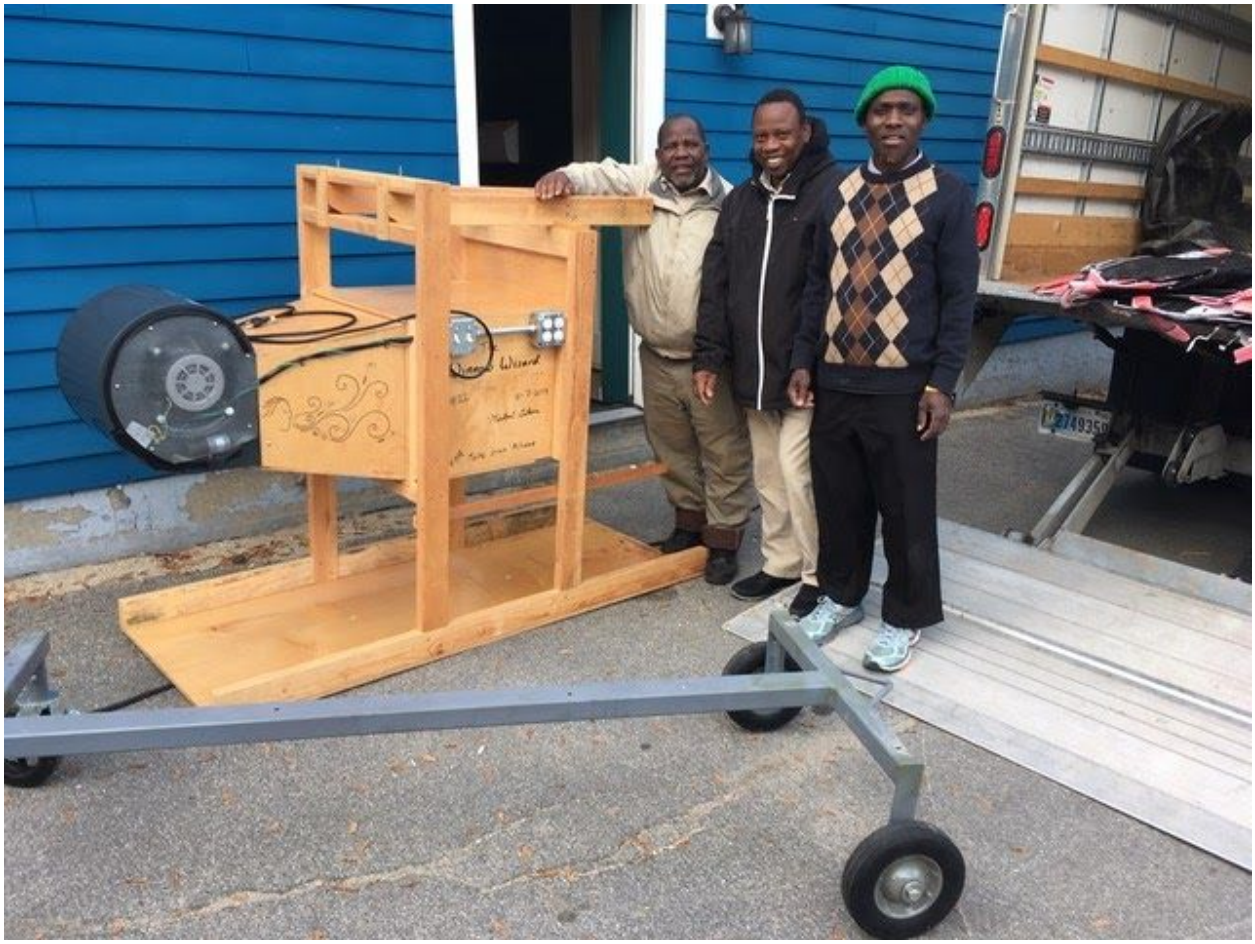
advocacy, and programming that empowers members of the refugee community to uphold their cultural identity and thrive in their new life in Maine. Liberation Farms is SBCA's largest program. The farm's mission is to provide new American farmers access to, and culturally-appropriate resources for, the means of sustainable food production for themselves, their families, and their communities. The farm has specialized in growing a white flint corn, brought to Maine from Somalia, and grown out over time by many skilled farming families.

Liberation Farms assists Somali Bantu family farmers by providing access to land, seeds, trainings, technical assistance, and marketing. There are more than 200 farmers at Liberation Farms. All of the farmers receive 1/10 of an acre to grow food for themselves and their families.

In addition to flint corn, Liberation Farms grows and distributes a variety of fresh produce to help build strong and healthy communities. The farm's fields are intercropped with vegetables that are mutually reinforcing of one another.

Farmers that choose to grow commercially self-organize into Iskashito groups. Iskashito is a traditional Somali method of cooperative growing where farmers work together on one piece of land and equitably share the profits of their combined labor and efforts. With regard to postharvest grain solutions for the farm, it has been important to consider the needs of this cooperative growing method. Farmers have needed greater equipment and infrastructure flexibility in separating harvested crops by farmer or family.

One of the first pieces of equipment purchased as part of this project was a Luterra laminar cleaner. Originally developed as an open sourced design by the Open Source Seed Initiative, the "Winnow Wizard" (as it is affectionately known) can perform precise density separations to remove hollow/immature seeds, difficult chaff/weed seeds, and heavier dirt/rocks. The Luterra uses a pressure differential across a series of perforated metal grates to create a steady, even, adjustable air flow. By changing grates and varying blower speed, a wide range of flexibility is afforded allowing for superb cleaning of brassicas, corn, and beans.



Muhidin Libah and Liberation Farms Farmers with the Luterra Laminar Grain Cleaner.

In contrast to traditional fanning mills, air separation occurs in a space that is easily seen allowing for continuous monitoring and tweaks during operation. Since it is highly visual, the machine is well suited for eliminating the potential for seed contamination between lots and separating by yields by farmer. It is a precise tool that has many similarities to a gravity table, but a cost that is much less. It is also a fairly small piece of equipment which has allowed for it to be moved across Maine to be trialed and demonstrated.

In November of 2019, Mark Fulford brought the Luterra cleaner to Liberation Farms to help clean harvest flint corn. At the time, Liberation Farms had limited covered building space at its farm and the cleaner had to be set up in an indoor office workroom. The winnowing chaff from the corn was vented right out the window. Once operational it takes only a few minutes to clean a 50 lb sack of flint corn. Muhidin Libah, executive director of the Somali Bantu Community Association, estimated the farm had 9000+ lbs to clean. After the success of the cleaning, even given a less than ideal space, farmers and the project team agreed that the Luterra cleaner should live in perpetuity on the farm. Unfortunately, there was no place to store the cleaner in 2019, so the project team made arrangements to store the cleaner elsewhere before it could permanently

live at Liberation Farms newly secure farm home at Little Jubba Agrian Commons, a 104 acre organic farm in Wales.

Cleaned Grain Exiting the Luterra Laminar Cleaner

Before going into storage the Luterra cleaner was trialed at Fedco Seeds, one of New England's leading seed companies. Tom Levesque was kind enough to trial the cleaner with a series of small seeds. Fedco is always in search of a grain cleaner that can efficiently clean all seed sizes, from chamomile to big dry beans. Tom used the Luterra to clean onion seed and saw very promising results. After a few adjustments, one can see how well the cleaner worked on very fine onion seed.

Before *After*

The Luterra Cleaner was returned to Liberation Farms and used extensively during the 2020 season to great effect.

Liberation Farms was also in need of a way to dry its corn, while also maintaining attribution of harvest corn to each farmer. This project has been exploring a variety of solar grain drying options, from solar arrays with electric heaters to inflatable and mobile solar grain drying units which can be used as stand alone dryers, with no fuels required. In 2017, in Lincolnville, Maine, a solar grain dryer outperformed both propane and super sack needle dryers by a very wide margin in trial runs of differing grain types. It took only twenty four hours to dry one ton of wheat four percentage points. In forty-eight hours, a sample was dried from sixteen percent moisture to nine percent.

The large GrainPro 50 Solar Bubble Dryer at Liberation Farms (see video in Appendix A).

These results led the project team to believe that a large scale solar bubble dryer would be very effective for the farming strategies applied at Liberation Farms. A large GrainPro 50 Electric Solar Bubble Dryer was purchased to help dry corn down to the necessary moisture level for market. At first it seemed the dryer was working well, but then the farm experienced significant issues with it. The weather had been very rainy with a lot of moisture in the air at harvest. Water began accumulating inside the bubble, which meant standing water was beginning to settle under the corn. Once this was noticed, it made for a hectic removal of the corn from the bubble. Thankfully the farm had access to a Whiting high tunnel, where they laid out the corn to redry it. Although the farm was doing everything right and turning the bubble off at night and during precipitation, there evidently was not enough sun or heat to keep the condensation at bay. Mark Fulford brought a corn sheller he owned right away to the farm to help get the corn off the cobbs. This project also purchased five low impact corn shellers to assist in the effort which will become very useful in future years.

The experience led to the farm and the project coming up with a new unique approach to drying flint corn at their new farm home in Wales, Maine. This winter a series of movable, customized nested drying tables will be built by Maine Grain Alliance staff and friends of the organization. The tables will be built of bench wire with screen and sideboards. The prototype was designed by Mark Fulford. The tables will reside inside the high tunnel during the drying season, and removed to allow for other crop uses during the year. The tables are being built to a specific 8ft by 8ft size to allow for the separation of harvested corn by farmer.

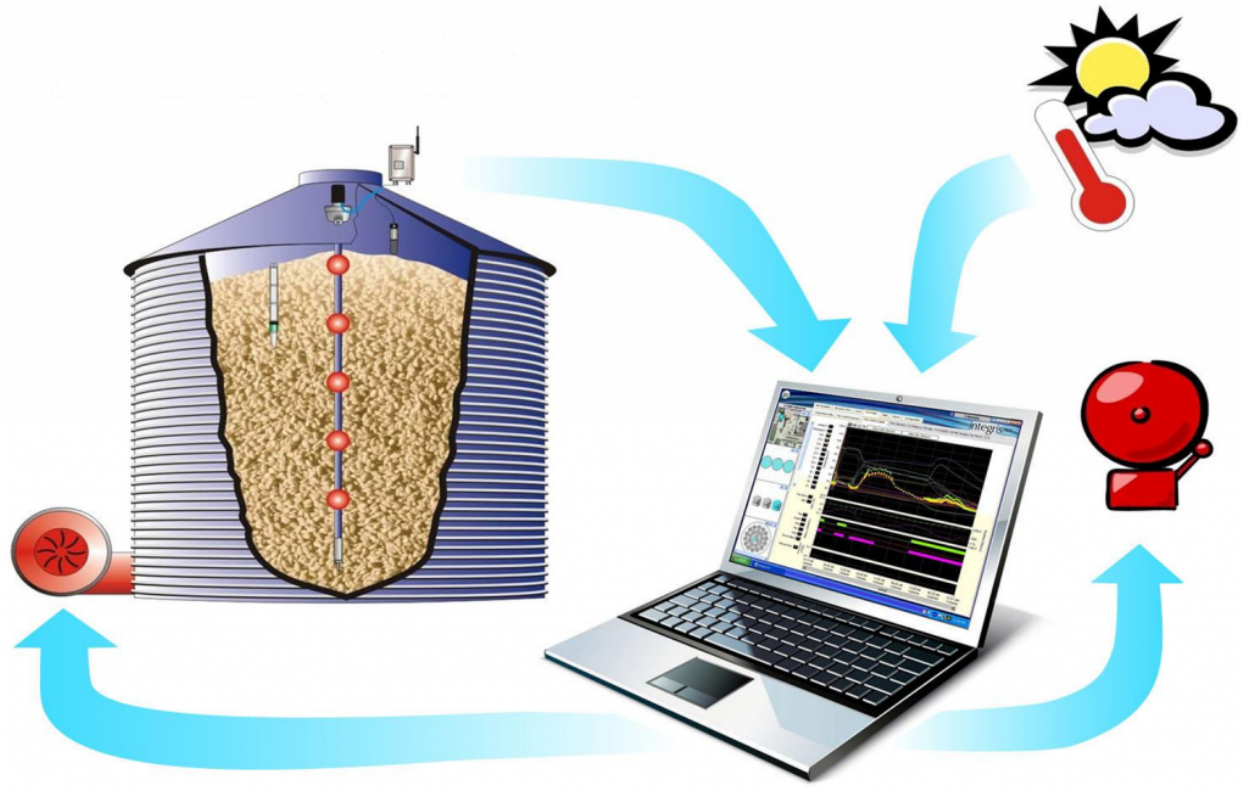
Even with the corn drying challenges experienced this year Liberatio Farms had excellent cleaning results resulting in a great quality crop. Amber Lambke of Maine Grains (a purchaser and processor of Liberation Farms flint corn) shared,"This year, we noticed the difference in the quality of the corn attributed to pre-cleaning on the farm such that the African White Flint corn is nearly mill ready when it comes to us. That not only helps preserve the quality and flavor of the corn in storage, but increases the efficiencies of production here at the mill.

We are eager to capture more data in 2021 of the effectiveness of the solutions provided on the farm.

Buck Farms

In 2014, drawing upon generations of potato farming experiences, Buck Farms decided to begin adding value to the exceptional malt barley by opening Maine Malt House. The malt house now provides high quality malt for the craft beer and spirits industry while also growing a variety of other grains and small seed crops for additional markets.

With a growing number of large grain tanks and the need to keep their grain at malt quality for long market windows, Buck Farms has needed a way to continually monitor and control their grain quality. With research from the project management team, Buck Farms, and the assistance of Mountain Breeze Farm in Greenfield, New Brunswick, an exceedingly advanced grain management solution was devised. With the purchase of a customized New StorMax Integris Grain temperature and moisture sensing system. The system includes a series of moisture sensing cables, temperature sensing cables with mounting and docking tools designed to fit their unique grain storage bins. The system also includes a deluxe hand held monitor to be able to monitor the tanks from inside of the cleaning facility.



These devices and sensors will allow Buck farms to proactively manage and control moisture content and temperature to deliver the highest possible quality for the most possible profit.

Features include:

- Automated Monitoring, Alarm & Control System
- Temperature Sensing

    - StorMax retractable temperature cables with 2-wire digital technology for maximum accuracy (+/- 0.5ºC or 1.0ºF) and reliability, as well as simplicity of installation and service.
- Moisture Sensing
    - The systems's moisture cable calculate moisture content by taking relative humidity and temperature measurements up through the grain (typically every 4′ to 6')—with accuracies up to +/-0.5%.
- Insect Detection
    - Measures insect numbers and densities for early detection and control. Also helps to improve, reduce and verify fumigation.
- Energy Savings
    - Drive down energy costs by as much as 80% by running fans only at the right time.
- Aeration Control
    - The system should greatly reduce spoilage and shrink, and achieve optimal moisture content—whether through drying or re-hydration by selecting only the right air.
- Real-time Visibility
- Inventory Management
    - Continuous Level Monitoring provides accurate indication of grain level and inventory.

Josh Buck, partner at Maine Malt House, shared that he is not aware of any Maine Farm who currently has had the opportunity to use this innovative technology. Josh stated, "The grain temperature and moisture sensing system will help us monitor our raw grains to ensure we maintain high quality before processing. We are one of the only farms that plans on storing grains for multiple years meaning we need to control the temperature of the grain through the changing seasons. To my knowledge, no other farm in Maine is using bin monitoring systems and we believe it will help us provide higher quality products to our customers."

The pandemic disruption created problems on a number of fronts, and some of the intended 2020 intended strategy had to be amended on the farm. The farm purchased a new grain bin and the StorMax Integris system from a leading equipment company in Canada, which presented its own obstacles as traveling internationally had been curtailed. Upon arrival, the Integris system could not be installed in another storage tank because it still housed previously harvested grain and the system requires set up with the bin empty. However, the extreme detail and reporting advantages of this system will allow for very detailed reporting that will be tabulated and shared as part of a second report in 2021.

Rusted Rooster Farm

The local grain economy has benefited greatly through Sean O'Donnell's talents at adapting equipment to fit the appropriate scale and needs of Maine farms. He and wife Sandra own Rusted Rooster Farm which now boasts a number of important pieces of post harvest grain handling equipment that helps prepare the six varieties of grain grown on the farm.

Sean has spent many years working to create a cleaning line that is completely adapted to the farm's needs. His hope is that each piece of equipment can feed directly into the next to create maximum efficiencies.

A very important piece of equipment that Rusted Rooster has previously invested in is a gravity powered spiral separator. Spiral separators use no power source and have stationary cores. They come in either open or closed units with a manual slide gate to control quality.

In comparison, a highly advanced rotary sorter allows for fine, precise tuning using a variable frequency drive. After much research with the project management team, and drawing up Sean's depth of knowledge, a dual core rotary sorter was purchased in support of Rusted Rooster Farm's cleaning system.

The dual core rotary sorter reduces a lot of work load off other machines. The sorter has rotating cores and precision technology to help filter out broken or misshapen debris, and they increase capacity of an operation. The sorter is highly adjustable with touch button technology. The dual core rotary cleaner is able to fit into Sean's cleaning line so that it can be matched up with the capacity of other pieces of equipment allowing for other machines to be run in tandem. With

Rusted Rooster's previous unit, the spiral sorter was a completely separate cleaning step which was a significant time and logistic hassle and sometimes because of constraints would not be possible to use.

A R2-595 2 Core Rotary Sorter from Profile Industries was shipped to Rusted Rooster Farm, but unfortunately arrived damaged and had to be returned. The company did send a new sorter, but there were significant delays in getting it to the farm. It has now arrived and Sean is working on setting it up in his cleaning line. He believes that all grain will now be able to be run through the machine. One interesting benefit of the rotary sorter is that it may allow for a new market for some of the discarded seed, specifically vetch which often grows as a weed amongst planted grain crops. Vetch fixes large amounts of nitrogen (N) that help meet N needs of the following crop, protects soil from erosion, helps improve soil tilth, and provides weed control during its vigorous growth in the spring and when left as a dead mulch at the soil surface. Vetch can be sold to Maine's leading seed companies for a premium price. As such this piece of equipment may open up a new market.

R2-595 2 Core Rotary Sorter Being Unpacked at Rusted Rooster Farm

In 2021, the Maine Grain Alliance and Rusted Rooster farm intend to tabulate quantitative and qualitative observations around efficiencies created as a result of the sorter. To our knowledge

there is no other dual core rotary sorter on a farm, mill or grain processing business. We will compile results along with other farms observations in a report later in the year.

A Shared, Mobile Almaz Laminar Airflow Grain Cleaner

Until the commencement of this project, no farm in Maine had yet employed an airflow separator to clean grain. The Almaz is a laminar airflow cleaner that does roughly twice the output of a traditional screen system (four tons vs two tons per hour). It can also separate seven grades of grain with no screens while commonly used cleaning systems can only do two with screen changes. At the suggestion of expert agricultural experts, the Almaz was the first piece of equipment purchased as part of this project.

Since the Almaz is a relatively lightweight piece of equipment with few moving parts, Mark Fulford felt it would be an ideal candidate to be retrofitted into a mobile piece of equipment. Mark was able to fabricate a mounting system that enabled the machine to be moved from farm to farm.

An early prototype to make the Almaz machine mobile.

Participating farmers have been able to see the benefits of this mobile cleaner firsthand. In the fall of 2019, Rusted Rooster Farm held a field day to demonstrate the laminar air flow grain cleaner to an audience of thirty visitors from inside and outside the state.

The same equipment has been used at Buck Farms and Aurora Mills and Farm in Aroostook County,to clean small grains, peas, and even mustard seed. A field trial of mustard cleaning found the grain cleaner to be very effective at separating wheat from mustard. A detailed description of the mustard cleaning written by Caleb Buck of Maine Malt House is provided below.

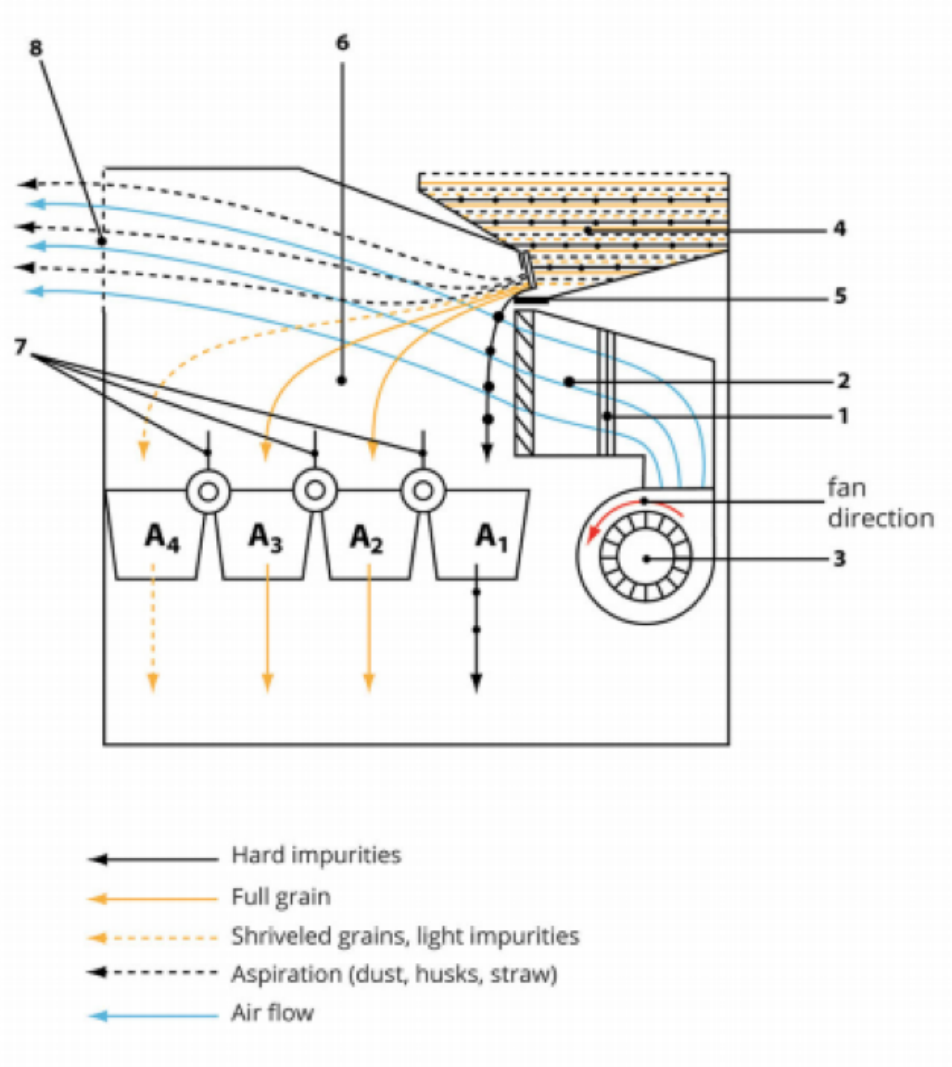
From Caleb Buck's Report

Cleaning Mustard Using The Almaz Grain Cleaner

One of the goals of the Maine Grain Alliance's Postharvest Grain Handling Project is to procure efficient and mobile cleaning, drying, and storage equipment that will enhance the quality of Maine grains to ensure consistent value in meeting market needs of farmers, millers, brewers, bakers and consumers. The Almaz Grain Cleaner is designed to clean and grade using one machine.

How the Almaz Grain Cleaner Works

While typical grain cleaners use screens and sieves to separate the desirable product from the non-desirable product, the Almaz uses laminar air flow to separate and grade. The separation method is quite simple: the Almaz produces a horizontal flow of smooth air in which the material is dropped through. The airflow will then carry the material a certain distance based on its relative density, as shown below:



Operation Principles of Almaz Grain Cleaner

Any rocks and other high density materials drop into tray A1 (don't get carried by the air flow). The desirable grain product gets carried into A2 & A3, while the lighter, undesirable grain is carried to tray A4 or out the outlet port (8). If calibrated properly, the user of this machine should be able to separate out the "good stuff" from the "bad stuff" and end up with a nice clean product.

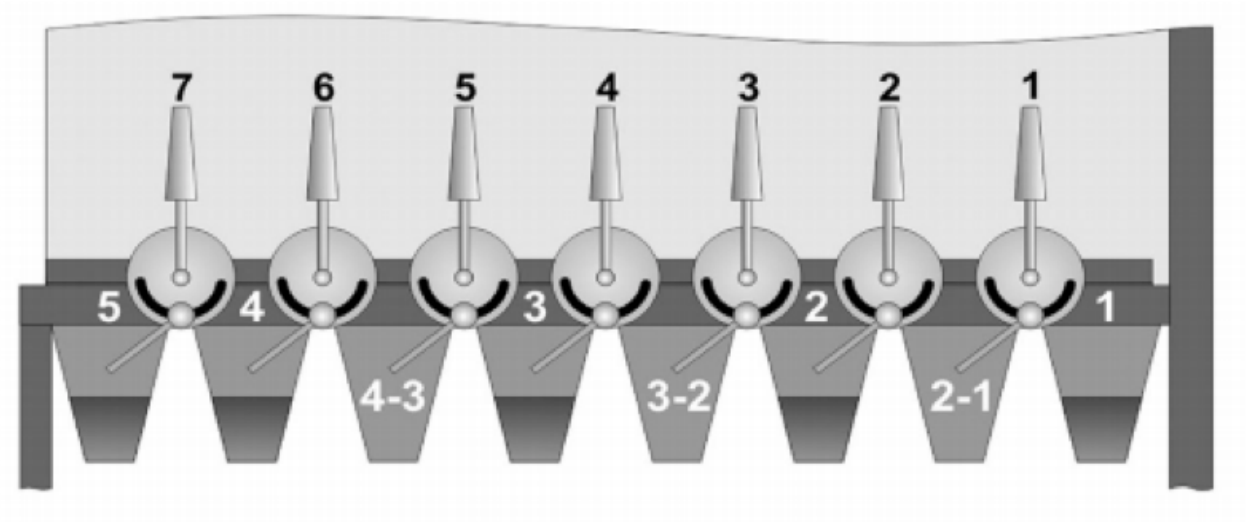
Cleaning

It was time to test out the principles of the Almaz Grain Cleaner. We had a truck load of mustard that contained weed seeds, wheat, chaf and other small foreign material. Before starting, we

configured the cleaner to be able to place an auger under it that would carry the cleaned product into a tote. We also set up a waste tote for the light debris that would be blown out the outlet port, and put tubs under the other trays that did not have the auger under them.

Set up for cleaning mustard

There are 3 variables that control the separation quality of the product: air flow velocity, gate setting (controls the speed at which product is cleaned), and the tray “knob” settings (controls the size and position of the separation trays as shown below).



Knobs that adjust tray settings on Almaz Grain Cleaner

After adjusting all of these settings to optimize our mustard cleaning ability, we cleaned at a rate of about 2600lbs/hour.

Effectiveness of Cleaning

The Almaz Grain Cleaner worked very well at separating the mustard from weed seeds, chaf, and smaller, discolored mustard seeds. However, we did have an issue separating the wheat from the mustard. This is because wheat has a similar density (weight per volume) as mustard. We determined that the wheat was slightly more dense than the average mustard seed and we were able to get most of it, along with about 4% good mustard into tray 1. From there we processed it through a small screen cleaner (shown in Figure 5) which separated the wheat and mustard so that we could save most of that 4% that was separated into a “bad stuff” tray.

Seed-A-Way Screen Cleaner

After we finished cleaning and we were left with a marketable product, we scaled our finished product and our waste to see how much shrink we had in the cleaning process. We removed 4.4% of the waste by weight. In conclusion, the Almaz Grain Cleaner was a valuable part of our mustard cleaning process!

Next Steps

The successes of this project can be seen in the Maine's grain fields and heard in the voices of Maine farmers. Our collaborative, innovative approach to providing solutions has sown the seeds for a much greater harvest of ideas in the months and years ahead.

As mentioned numerous times, the Maine Grain Alliance and participating farms intend to continue close contact. As equipment is used extensively in the months ahead preparing grain for a waiting market, this project will learn a great deal more about the efficiencies generated and how much more value farms are able to attain given a better quality crop. All information will be compiled and a subsequent report filed in 2021 with new learnings. The Maine Grain Alliance will make available all reports on our website on a dedicated page with links to relevant resources. We hope that the page will serve as a hub of information and community connector for farmers across the region. The Maine Grain Alliance will continue its support of farms in as many was as possible, including the option for further award by way of our Technical Assistance Grant Program available to all Maine-based grain businesses. Our next round funding will be announced in early 2021.

As we head toward another year marked by added complexities of national crises, we take solace in the notion that perhaps our farmers will meet fewer complexities when it is time to harvest grain, thanks to a dedicated, resourceful, resilient community. We look forward to updating you with progress on this project after the 2021 season's harvest.

Appendix A: Videos Produced Highlighting Project Work

An overview of the Maine Grain Alliance Project entitled "Adding Value to Maine Grown Grains Through Enhanced Cleaning, Drying, and Storing Solutions"

A conversation with Muhidin Libah, Executive Director of the Somali Bantu Community Association with highlights of some of the equipment provided as part of this project.

Appendix B: Process Detail for Farmers' Using an Almaz Grain Cleaner

ALMAZ Cleaning of Mustard Seed

The mustard seed lot that was being cleaned contained weed seeds, wheat, sclerotinia and chaf. It also contained discolored and mustard seeds. The objective was to adjust the Almaz separator so that 1-2 of the fractional selection trays contained only high grade mustard.

Process

Before starting, we knew we wanted to be able to place an auger under the Almaz that would carry the cleaned product into a tote. We decided to detach the Almaz from its base, rotate it 180 degrees, and re-attach it so that we would have the clearance underneath as seen in Figure 1. We also set up a waste tote for the light debris that would be blown out the side, and put tubs under the other trays.

Figure 1: The Almaz setup for cleaning mustard

To start with the process of dialing in for optimal cleaning of the mustard, we started with the flow gate closed and the fan turned to the lowest setting. After opening the gate to position 1, we

slowly started to turn the air flow up until there was very little mustard falling into tray 1. The mustard was relatively clean out of the combine and there was no heavy material that dropped in to tray 1. We soon realized that the wheat was a similar density to the mustard (maybe slightly more dense). The best route of action for us in this situation was to try to isolate the wheat to a single tray (tray 1) with minimal mustard loss. We adjusted knobs 1 and 2 to close off tray 2 and provide a larger tray 1 opening that we would use to catch the wheat. After making those adjustments, we started to turn up the air speed until there was wheat in tray 3 (the cleaned mustard tray that was going to the auger). We then dialed it back until we saw very little wheat in tray 3 and mostly in tray 1. The airflow setting remained on 3 - 00 (3 full revolutions of the dial). It was not possible to get a perfect cut off and we ended up having a small amount of wheat in the cleaned product.

Next, we adjusted knobs 3 and 4 to close off tray 4 and seperate the discolored (lighter density) mustard from the good quality mustard. This would result in a small amount of good mustard ending up in tray 5, mixed with the discolored mustard and sclerotinia. This tub would get dumped back into the machine to further clean out good mustard. And finally we closed off tray 6 and 8 and collected it all in a tub that was just chaf and weed seeds.

We eventually moved the gate opening to 1.5 for two reasons: to increase efficiency and because the chaf would partially plug the opening. The rate of cleaning was roughly 2600lbs/hr of cleaned product.

Figure 2: Almaz knob settings

About 4% of the total mustard ended up in tray 1 along with the wheat. To prevent the 4% loss in product, we ran all of the tray 1 product through a small screen cleaner, shown in Figure 3, which separated the wheat from the mustard.

Figure 3: Seed-A-Way screen cleaner for separating wheat

Results
Dirty weight: 19,360lbs
Clean weight: 18,500lbs
Total “waste” removed: 860lbs

Wheat removed: 36lbs

The dirty weight is subject to truck scales which may not be as precise as the pallet scales used for the clean weight.

Caleb Buck
Buck Farms/ Maine Malt House

Appendix C: Sample Equipment Contract

Contract between the Maine Grain Alliance and _____

Postharvest Grain Handling Equipment and Solutions

Equipment:
The equipment referred to in this agreement was all purchased by the Maine Grain Alliance (Alliance) as part of its Post Harvest Grain Handling Project and is subject to the Alliance's policies and procedures as related to that project:

List Equipment

Property management:
This agreement incorporates property management standards established by the Maine Grain Alliance:

1. A control system shall be in effect to ensure adequate safeguards to prevent loss, damage, or theft of the equipment. Any loss, damage, or theft of equipment shall be investigated and fully documented.
2. Adequate maintenance procedures shall be implemented to keep the equipment in good condition.
3. Adequate insurance shall be maintained on the equipment.
4. If no longer needed, the equipment shall be kept and reasonably maintained and safeguarded against damage until the Alliance can retrieve it and reassign it.

Rights and obligations:
1. _____ has the right to use the equipment for the purposes for which it was purchased until the equipment is no longer needed or is no longer usable.

2. _____ must notify the Alliance when the equipment is no longer needed or is no longer usable.

3. The Alliance has the right to periodically take a physical inventory of the equipment at least every year to verify its condition, current level of utilization, and continued need for the equipment.

Term:
This contract will remain in force until the equipment is no longer needed and turned back, or is no longer usable due to wear and tear from reasonable use.

Indemnification:
The farm agrees to indemnify and hold Maine Grain Alliance harmless from all claims losses expenses fees including attorneys fees costs and judgments that may be asserted against Maine Grain Alliance that result from the acts or omissions of the farm or its employees agents or representatives.

For _____	For Maine Grain Alliance
Signature:	Signature:
Printed Name and Title:	Printed Name and Title:
Date:	Date: