



NMSU Crop Thinner Project: A Model for Commercialization of University Intellectual Property



College of Agriculture and Home Economics
Cooperative Extension Service • Agricultural Experiment Station

In November 1998, the New Mexico Chile Task Force was formed to identify and implement ways to keep chile pepper production profitable in New Mexico and to maintain and enhance the research and development partnership between the New Mexico chile industry and New Mexico State University.

Chile Task Force reports will be issued periodically to consider issues of concern to the industry and to document the Task Force's progress in developing techniques and technologies to improve industry competitiveness in the 21st century global trade environment.



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NMSU Crop Thinner Project: A Model for Commercialization of University Intellectual Property¹

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Overview

The New Mexico State University (NMSU) crop thinner project was a four-year, multicollge initiative that encompassed the design, prototype development and commercialization of a crop-thinning machine for red chile. The Chile Task Force in the NMSU College of Agriculture and Home Economics initiated the project in 2002, when its members identified the need to address production problems associated with hand thinning of chile crops. Chile is overplanted by as much as 1,600 percent to hedge against possible seedling loss from wind, insect and disease damage, or poor stand establishment from low germination rates. The crops traditionally have been thinned to the desired plant population density by hand crews, using hoes. The cost of hiring hand crews is a major production expense, ranging from \$70--\$200 per acre, depending on geographic location. In recent years, hand thinning has become increasingly problematic due to liability issues and lack of labor availability at crucial times in the season. The task force identified mechanization as one viable solution to thinning-related problems.



To mechanize the thinning process, the task force enlisted the help of the Manufacturing Technology and Engineering Center (M-TEC) in the NMSU College of Engineering. M-TEC is a state-funded center charged with boosting economic development by providing New Mexico companies with engineering product development services. M-TEC engineers tested existing vegetable-thinning equipment in 2002, developed new equipment prototypes in 2003 and 2004, and moved into a commercialization stage in late 2004. This included applying for and receiving “patent pending” status. Through a competitive process, the university selected CEMCO, a Belen, N.M., manufacturer, to produce the equipment. The first thinner manufactured by CEMCO was tested from April to June, 2005. Three NMSU colleges (Engineering, Agriculture and Home Economics, and Business Administration and

¹This article was reviewed by Rich Phillips, senior project manager, College of Agriculture and Home Economics; Roy Pennock, GAPS research specialist, Cooperative Extension Service; and George Abernathy, New Mexico Chile Task Force consulting engineer and professor emeritus, Department of Civil Engineering; all at New Mexico State University, Las Cruces.

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Economics) cooperated with private industry to bring the thinner project to a successful conclusion. The project, one of the first involving technology transfer from the university to private industry, provided a “hands-on” opportunity for researchers and other university personnel to learn how to streamline the R&D and commercialization processes, while maintaining the support of project stakeholders in the private sector.

2002 Testing

The initial phase of the thinner project took place in Spring 2002 when M-TEC engineers researched and tested existing vegetable-thinning equipment. The main focus of testing was a machine built by John Deere in the late 1960s for thinning sugar beets. The John Deere thinner had a touch-plate sensor located directly behind a cutting blade. When a plant came in contact with the sensor plate, the cutting arm would activate hydraulically to remove a swath of plants. As the machine moved forward across the cut that it made, the blade would not be activated again until the next plant touched the sensor. This method of sensing each plant and then cutting based on plant location was the aspect of the John Deere design that appealed to chile growers. By sensing plant location in rows where spacing between seedlings was irregular, the machine would be less apt to remove desirable plants than a machine that thinned automatically at a set spacing.

M-TEC engineers determined that the basic concept employed by the John Deere thinner had merit, but the machine had too many limitations to be useful in thinning chile crops. A major limitation was availability. John Deere ceased production of the machines in the late 1960s, when most growers of major crops adopted precision planting. Precision planting allows growers to place seeds at any desired spacing. While this production practice is beneficial for strong plants such as cotton and sugar beets, plants such as chile cannot be planted in this manner because they are more susceptible to environmental damage. Another limitation of the John Deere thinner was that it could not thin plants taller than 2-3 inches. Chile growers prefer that plants be 4-8 inches tall before thinning. The machine also was very difficult to adjust and operate, since the plant row had to make physical contact with a sensor plate that was about 2 inches wide.

2003 and 2004 Prototypes

Following the 2002 testing, M-TEC engineers began designing a new crop thinning machine, incorporating all of the changes suggested during testing of the John Deere machine. It was designed to be manufactured easily and cost effectively using the resources available in the M-TEC shops. The electronic control system was designed using off-the-shelf, Programmable Logic Controller (PLC) components to allow the proposed cutting algorithm to be implemented quickly and easily. The initial design of the thinner was for a two-row machine, but engineers understood that the machine eventually would be expanded to a capacity of 12 or 15 rows.

The cutting algorithm varied significantly from the original John Deere unit by having a photoelectric sensor located approximately 24 inches in front of a cutting blade, as opposed to the existing method of a touch plate directly behind the blade. This allowed the machine

to “see” 24 inches of the crop row before deciding where to cut. The forward distance was measured by a 360-pulse-per-revolution shaft encoder mounted on a ground-activated wheel. This gave the machine’s position to the computer with a resolution of 1/10 inch. The inputs from all of the various sensors were fed into the PLC, which decided where to activate the cutting blade. A Liquid Crystal Display (LCD) was placed in the cab of the tractor, allowing the operator to make most adjustments from one convenient location.

The cutting mechanism of the machine was designed to closely mimic the action of hand hoeing. Using off-the-shelf components, engineers designed the hoe blade to swing back and forth in a pendulum motion, activated by a cylinder and supported by two base-mounted pillow-block bearings. The length of the hoe knife could be changed to any multiple of 2 inches, from a minimum of 2 inches to a maximum of 14 inches. This allowed the grower to thin plants to any desired spacing. During the 2003 thinning season, the prototype was powered by a pneumatic system, consisting of an air compressor and air cylinders to activate the blades. This was found to be a major limitation of the machine, since 2.5-inch diameter cylinders were needed to achieve the required cutting force. Cylinders that large require a huge air volume to constantly activate four to seven cuts per second. For the 2004 prototype testing, developers converted the system to hydraulics for more reliable and consistent operation. Since hydraulic cylinders operate at a much higher system pressure (approximately 700 PSI, compared to the pneumatic pressure of 100 PSI), 1.5-inch diameter cylinders were able to obtain the same cutting force as the larger pneumatic cylinders. The hydraulics were run from a power-take-off (PTO) pump so that the thinner could be used on any tractor without the need for a large volume of tractor hydraulics. Tractors typically have built-in “remote” hydraulic hookups from which an implement can obtain power. However, these remote hookups seldom are capable of operating at more than 25 gallons per minute (GPM), while a thinner with more than four-row capacity would require a 40-GPM hookup. The use of remote tractor hydraulics also introduced additional variables, such as whether the system was open-center or closed center. Engineers decided that the simplest and most universal solution was the use of a PTO pump. Using off-the-shelf PTO pumps, it is possible to operate a thinner with up to a 15-row capacity.

Testing of the prototype machines identified several weaknesses. As stated, in the 2003 testing, the machine could not run continuously because of inadequate air volume. In the 2004 testing, the conversion to hydraulics caused additional problems due to added force. The major problem was that the rod ends continuously broke off the hydraulic cylinders. The machine was never able to be field tested without engineer involvement.

Patent

To protect the ideas implemented in the thinning machine, NMSU chose to seek patent protection. In the U.S., patents are granted for novel ideas and provide the inventors with protection for 20 years. Manufacturers are more willing to produce patented inventions because they know that their competitors cannot immediately copy the product when it goes to market. To obtain a patent on the thinning machine, an officer from NMSU’s Intellectual Property Department and the inventors of the machine drafted a list of claims that were novel to the thinner and submitted them to the U.S. Patent and Trademark Office (USPTO).

Provisional patent status was granted, designating the thinner as “patent pending.” NMSU awaits patent approval from the USPTO.

Commercialization

During the 2003 machine testing phase, a manufacturer of mechanical thinners, Pickett of Burly, Idaho, expressed serious interest in manufacturing the NMSU thinner. Working through the university’s Intellectual Property officer, the task force made arrangements to begin transferring the thinner technology to Pickett. Approximately three months before the 2004 thinning season was scheduled to start, a final agreement between the university and Pickett had not been reached and negotiations were terminated. This left the university with no prototype machine to test during the 2004 season. Engineers hurriedly made improvements identified during the 2003 testing so that development could continue without interruption.

Immediately following the 2004 thinner testing season, NMSU reinitiated efforts to find a company to take over the project and begin manufacturing the implements. The task force and M-TEC enlisted the aid of NMSU’s Arrowhead Center, a private, nonprofit agency created by the College of Business Administration and Economics to commercialize university technology. Arrowhead oversaw the process of finding a company suitable for taking over the project. The first step in the commercialization process was meeting with the university’s Purchasing and Risk Management Department. They helped to create a Request for Proposals (RFP) to allow companies an equal opportunity to the rights of licensing the patent on the thinner. M-TEC engineers and task force researchers also prepared manufacturing information and cost-benefit reports so that interested companies would have information necessary to make their decisions to respond to the RFP. The Arrowhead Center also assigned a group of business college graduate students to prepare additional economic analyses of the project. According to the RFP, companies were asked to explain their intended plan for manufacturing, selling and servicing the thinners. It also asked for estimated sales prices and for percentages that companies would be willing to contribute back to NMSU to help fund future research initiatives.

Once the RFP was published, a prebid conference was scheduled. At the conference, interested manufacturers were invited to receive information about the project and to ask questions. All questions and answers were made public domain by an amendment to the RFP so that companies absent from the conference would not be disadvantaged in the proposal process. Interested manufacturers submitted proposals that were kept sealed until the published due date, at which time they were opened to be evaluated. Each of the proposals was evaluated and scored by a team of university and chile industry representatives to determine which best met RFP requirements. The team chose to accept the proposal submitted by CEMCO Inc., a manufacturer located in Belen, N.M. CEMCO’s proposal best met all of the criteria requested by the university. The main goal of the RFP process was to find a company with the ability to properly build and service the thinning machines, as well as offer them at a price affordable to growers.

Following the decision to proceed with CEMCO, M-TEC engineers began the process of bringing CEMCO engineers up to speed with the project, handing over all design information. CEMCO chose to have a subcontractor build the electronic control system so that it could focus on the mechanical portion of the project as well as sales and service.

The subcontractor they chose was Team Specialty Products, another New Mexico business, based in Albuquerque. During the RFP process, the university committed one engineer to help CEMCO and TSP through the first testing season. It was determined by TSP and CEMCO that the NMSU engineer should be devoted to rewriting the control software for implementation in a microcontroller instead of the PLC system used in the prototype. Converting the system to a microcontroller added numerous advantages including reduced system cost, enhanced ease of use, better component longevity and the ability to be easily expanded to any number of rows desired.

2005 Manufacturer's Model

The manufacturer's model, built by CEMCO with electronics from TSP, began as a two-row machine. The decision to build a two-row machine was based on task force members' advice that it would be easier to find a grower to purchase a smaller machine than a larger, more expensive machine. When CEMCO unveiled the machine at the 2005 New Mexico Chile Conference, it immediately became aware that there was no interest in the two-row machine. They expanded the machine to a four-row machine, but the first grower who committed to buying a machine wanted a six-row machine. CEMCO then expanded the machine to be capable of thinning six rows.

CEMCO delivered the six-row machine to W.R. Johnson and Sons Farm and Ranch in Columbus, N.M., where it was operated on green chile fields, using an 8-inch blade. During the season CEMCO, TSP and M-TEC engineers identified and corrected minor problems in the machine. The product development life cycle generally requires that new products be tested, prototyped and modeled before a finished product is ready for the consumer. The problems encountered by CEMCO and TSP were typical of those expected during product development. The season was very successful, as the Johnsons were able to use the machine for all of their thinning requirements, with the exception of one field that had to be thinned while the machine was receiving upgrades in CEMCO's Belen manufacturing facility. By the end of the season, all problems in the system were addressed, and the machine was able to run consistently without engineer involvement.

Project Lessons Learned

Many lessons were learned throughout the four years that NMSU was involved in the thinner project. The first lesson is that the university should not limit itself to dealing with a single company during the technology transfer process. The failure to complete a technology transfer with Pickett during 2003 would have cost researchers a year of testing had they not been able to make prototype improvements in time for the 2004 thinning season. The RFP process completed after the 2004 season allowed the university to have a backup company in the event that CEMCO dropped out of the process.

Another lesson learned from the thinner project was that the university should devote enough time to a project to ensure that the design is fully operable before attempting to commercialize the product. With the thinner, an additional iteration of the design would have greatly simplified the technology transfer process. Instead, M-TEC engineers gave CEMCO the existing design with a disclaimer that described the problems that had been encountered in the latest round of testing with recommendations on how to correct them. This forced

CEMCO to “tinker” with the design more than was desirable. For example, at one point in the manufacturing process, CEMCO specified tubing that was too small to handle the required load, causing a structural failure. In another instance, it tried to convert the hydraulic system to an open-center system from a closed-center system. The open-center hydraulic system caused the machine to operate much too slowly and had to be replaced after the first five minutes of testing in the CEMCO shop.

Because the Chile Task Force is a joint industry-university initiative, it is important that member-growers be able to monitor research and development projects. Project demonstration allows growers to make suggestions that aid in development and help build project support from stakeholders. During the 2004 testing of the thinner prototype, the emphasis on showing the machine to as many growers as possible detracted from time available for researchers to identify problems and devise solutions; their “window of opportunity” was limited to only a short part of the growing season when seedlings were of appropriate thinning height. Nearly half the season was spent transporting the machine and fitting it to new tractors, rather than field testing. From a development standpoint, much more could have been learned if the machine were demonstrated only on two or three large, carefully selected farms during the season.

A final lesson learned from the thinner project is that the university should relinquish the project and stay in the background from a sales standpoint. Rather than recommending how many machines of what size should be built, the university should hand over the design and support the manufacturer with technical assistance. CEMCO’s frustration was understandable when, at the university’s recommendation, it built two-row and four-row machines, only to find no one willing to buy them. The initial purchase was a six-row machine.

Conclusions

The thinner project has been a great success for many organizations. It has been a good model for university commercialization of a research project, good for Chile growers because it will save them money at the bottom line and good for CEMCO since it has been able to diversify its product line. The project also has been a good example of how a university can pull together expertise from many different departments and colleges to achieve the ultimate goal of boosting economic development in New Mexico.

The project underwent several stages, from the initial needs assessment, to the testing of existing equipment, to the design and prototyping of new equipment, and finally to the commercialization and manufacturing stages. Heeding the lessons learned throughout the project, the university may be able to build on this model for future commercialization of university-designed research projects.

Notes

Notes

New Mexico Chile Task Force Publication List

- Report 1:** An Industry-University Response to Global Competition
- Report 2:** Chile Seed Germination as Affected by Temperature and Salinity
- Report 3:** Yield and Quality of Machine-Harvested Red Chile Peppers
- Report 4:** Chile Seed Quality
- Report 5:** Guidelines for Chile Seed Crop Production
- Report 6:** Improving Chile Harvesting and Cleaning Technologies
- Report 7:** Farm Labor Employers' Handbook
- Report 8:** New Mexico's Chile Pepper Industry: Chile Types and Product Sourcing
- Report 9:** Economic Impact of Southern New Mexico Vegetable Production and Processing
- Report 10:** Chile Pepper Growers' Notes: 2003
- Report 11:** Developing New Marketing Strategies for the Southwestern Chile Industry
- Report 12:** Incidence of the Beet Leafhopper, *Circulifer tenellus* (Homoptera: Cicadellidae), in New Mexico Chile
- Report 13:** Plant Spacing/Plant Populations for Machine Harvest
- Report 14:** Economic Return to Adoption of Mechanical Thinning
- Report 15:** U.S. Imports and Exports of Chile Peppers and Pepper Products: Frequently Asked Questions
- Report 16:** International Trade in Chile Peppers: Data from the Global Trade Atlas
- Report 17:** Basic Research on the Use of Polarization to Sort Chile Peppers
- Report 18:** An Analysis of Farm Labor Contracting in New Mexico
- Report 19:** Use of Kaolin to Suppress Beet Curly Top Virus in Chile Peppers
- Report 20:** Using a Color Sorter to Remove Sticks from Mechanically Harvested Red Chile
- Report 21:** Regional Branding in a Global Marketplace
- Report 22:** Refinement and Testing of Mechanical Cleaners for Red Chile
- Report 23:** NMSU Crop Thinner Project: A Model for Commercialization of University Intellectual Property
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