Economic Return to Adoption of Mechanical Thinning: The Case of New Mexico Chile

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Abstract

Facing expanding foreign competition and increasingly more stringent labor and environmental laws, today's vegetable producer faces a challenging business environment. One way in which vegetable producers have attempted to stay competitive is through the adoption of new technologies. This paper examines the economic returns available to chile pepper producers willing to adopt mechanical thinning as a substitute for either contracted hand thinning or transplanting.

Introduction

Sandwiched between rapidly expanding foreign competitors and increasingly more stringent laws regarding environmental and labor issues, today's vegetable producer faces a challenging business environment. In no other vegetable industry has this difficult environment been more evident than in the fresh and processed chile pepper industry. Facing predictions of ultimate demise, industry representatives combined forces with New Mexico State University's College of Agriculture and Home Economics in 1998 to form the New Mexico Chile Task Force.

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The New Mexico Chile Task Force, housed in the Department of Extension Plant Sciences at New Mexico State University, is a consortium of growers, processors, crop consultants, supply and equipment specialists, state and federal agricultural specialists, and NMSU researchers and extension specialists. The most recent accomplishment of the chile task force, involving collaborations between members of the task force and engineers at New Mexico State University's Manufacturing Technology and Engineering Center (M-TEC), is the development of a mechanical vegetable thinner.

While the introduction of new technology in agriculture often creates anticipation and expectations among stakeholders (Goss 1979), it has yet to be determined whether the mechanical thinner developed by New Mexico State University can provide economic returns sufficient to entice producers to adopt the technology. This paper examines the economic returns available to producers willing to adopt mechanical thinning as a substitute for either contracted hand thinning or transplanting, in which case thinning is not required. The analysis uses New Mexico State University's Cost and Returns Estimates as a basis for determining possible economic returns (Hawkes et al. 2004).

New Mexico Chile Production

Chile peppers[1], a signature crop for New Mexico, have been cultivated in the state for four centuries (Hall and Skaggs 2003). New Mexico is the leading producer of chile peppers in the United States, with harvested acres tripling those of its closest competitor, California. In 2002, the Census of Agriculture reported a total of 4,748 farms producing 42,666 acres of chile peppers. Of these 42,666 acres, New Mexico harvested 16,659 acres.

Unlike many other vegetable and row crops, a majority of chile pepper plants are open pollinated. While a number of theories may be posited concerning the industry's reluctance to explore hybridization, it is likely the hesitancy relates to production costs and cropping practices. Chile pepper plant survival in New Mexico is susceptible to a number of elements including: early plant disease (e.g., curly top virus), salt damage related to relatively poor soil quality, and wind damage from high winds common in early spring. By maintaining an open pollinated planting system, producers are implicitly utilizing an effective and inexpensive crop insurance program. That is, producers over-plant chile acreage using relatively cheap seeds (approximately $18 per pound planted at an average rate of 5 pounds per acre), wait for any damage associated with production deterrents identified above, and then thin the crop to a desired plant stand. The cropping practices used by the industry alleviate, to some degree, problems associated with disease, salt, and wind damage, but they make crop thinning a necessity.

Mechanical Vegetable Thinning – History

To compensate for poor seed germination, the result of soil types and poor environmental conditions related to planting windows (issues related to optimal times for planting), vegetable farmers have often planted more seeds than necessary in order to achieve a desirable final plant stand.[2] These over-planted crops have historically been hand thinned after plant establishment to achieve optimal plant densities. Often hand thinning has been performed by low cost foreign labor (primarily Mexican nationals).

The termination of the Bracero program in 1964 resulted in the unavailability of many Mexican workers who had worked under the program. The void of foreign laborers in the years following the Bracero program led to the development of a number of mechanical vegetable thinners, several of which were commercially produced. These early mechanical thinners used a variety of technologies to sense plant material and selectively thin vegetable crops. These sensing devices included: electric photo eye, photocells recognizing plant color, and electric conducing circuits. While these mechanical thinners enjoyed some adoption, the technology at that time was inadequate for producing a machine that could successfully compete with hand thinning and a vast majority of vegetable growers discontinued use soon after their introduction (Inman 2004).

Mechanical Vegetable Thinning – Current Climate

Recent labor issues and pressure from low-cost foreign producers have led many growers in recent years to once again rethink the traditional production management practice of hand thinning. Three areas of mechanization that can reduce or eliminate the need for hand thinning, and that have been or are currently being developed, include: precision planting, transplanting, and mechanical weeding and thinning.

Precision planting

With the introduction of high-cost hybrid seeds, many large-scale commercial producers have adopted some form of precision planting, although the U.S. adoption of advanced variable rate planting is scattered with adoption most likely to occur in high-value crops (Lowenberg-DeBoer 2003). While precision planting insures optimal plant stands in the absence of adverse conditions, it does not eliminate problems associated with early plant diseases, poor soil quality, and poor weather conditions.

Transplanting

Transplanting vegetable crops is a growing practice for many vegetable industries. Many vegetables, including celery, seedless watermelon, bell peppers, fresh market tomatoes, and cauliflower are commonly transplanted (Katz 2002). An increasing number of vegetable producers have turned to transplanting as a way of combating problems associated not only with thinning, but also with germination rates, pest and disease control, post-emergent environmental conditions, and high cost hybrid seeds (Bosland, Bailey, and Cotter 1999 and Katz 2002).

Mechanical Weeding and Thinning

Researchers are increasingly examining ways in which mechanization technologies can be used to reduce post-planting hand labor in vegetable production. An example of this work is the automatic weeder being developed by researchers at the University of California at Davis (UC Davis). The weeder uses computer algorithms to analyze digitalized images of crops and weeds within a crop row and isolate targeted weeds. These weeds are then killed using high speed streams of herbicide or other weed deterrents. While the automatic weeder is not commercially viable today (accuracy and speed of the machine must be improved), it is expected that the implement will be ready for commercial development within the next three years (Lee 2003).

The New Mexico State University prototype thinner, the basis of this analysis, uses a standard closed-loop, self-contained hydraulic system to operate cutting blades that sweep back and forth across crop rows in a pendulum fashion. Sensors located at the front of the thinner detect plant material and signal computer controlled hydraulic values to open and shut. Initial field tests indicated that the thinner could be operated at a speed of 2.0 miles per hour, translating into an effective accomplishment rate of approximately 1.5 acres per hour (for the two-row prototype).

Economic Returns to Mechanical Thinning

One of the principal reasons why the early thinners of the 1960s and 70s failed to attract a wide following among vegetable farmers was the inability of these thinners to provide economic returns equal to or greater than those obtained from using hand labor. In this section we explore the economic returns associated with the vegetable thinner developed by the New Mexico Chile Task Force in comparison with returns associated with traditional hand labor and transplanting technologies.[3]

Assumptions

The analysis summarized in this section is based on New Mexico State University's Cost and Returns Estimates published by New Mexico State University's Cooperative Extension Service (Hawkes et al. 2004).[4] The cost and return estimates, which use data collected from knowledgeable producers, state and federal agency professionals, and others interested in crop production have been published for over 25 years (Sullivan et al. 1986). Currently, a total of 49 different crop cost and return estimates representing assumptions and growing conditions specific to different growing regions within the state are produced and disseminated annually.

The analysis performed here uses underlying cost and return assumptions and calculations developed for Dona Ana and Sierra counties. In 2002 these two counties combined for a total 5,462 acres of harvested chile peppers.[5] This harvested acreage represented 33 percent of all New Mexico harvested chile acreage in 2002 (USDA 2004). Literally hundreds of assumptions are made in calculating the cost and returns associated with a particular crop. Table 1 presents some of the significant assumptions made in the analysis presented here.[6]

Economic Returns

Using the NMSU Crop Cost and Returns Estimates as a basis for analysis, with mechanical thinning and transplanting assumptions from Table 1, chile producers operating a 500-acre farm, 30 acres of which are planted in chile peppers may expect to earn an estimated $4.04 per acre over hand thinning with adoption of mechanical thinning. Expected differences in returns relative to transplanting (with assumptions from above) are estimated at $20.97 per acre.[97] The present value of the savings (relative to hand thinning) associated with adoption of mechanical thinning (again assuming 30 acres of planted crop), taken over the life of the thinner, assumed to be 15 years, is equal to $1,214.50. This figure does not account for the risk that hand harvesting crews might not be available on the date needed.

The economic return reported above is a function of a wide range of variables, many of which may vary from producer to producer. The following sections examined changes in economic returns that result from changes in underlying assumptions (sensitivity analysis). In each case, all variables except those specifically identified in the section are set at the default values reported in the NMSU Crop Cost and Returns Estimates for 2004.

Economic Returns & Thinner Price. The mechanical thinner evaluated here is not yet commercially available. The commercial availability of the thinner is expected sometime during 2004. The default price of the thinner used for this analysis, $5,000 per row or $10,000 for a two-row machine, was estimated based on initial conversations with several agricultural equipment manufacturers. Figure 1 shows a variety of economic returns that may be expected depending on the price that the thinner will eventually command. The thinner price at which the present value of the returns (discounted over the expected life of the thinner) is equal to zero is $10,947.68. At this price, $10,947.68, the annual differences in economic returns resulting from adoption of the mechanical thinner (discounted over 15 years at a rate of 6.5 %) will just compensate the producer for the purchase of the mechanical thinner today. In a general sense, this value may be considered the most that a producer, fitting the assumptions of the budget, e.g., producing 30 acres of chile, would be willing to pay for the mechanical thinner.[9]

Economic Returns & Acreage. Cost savings (resulting in increases in farm profits) associated with adoption of mechanical thinning increase with increases in planted chile pepper acreage. Figure 2 shows how returns to land and risk associated with mechanical thinning (as opposed to hand thinning) increase as chile pepper acreage increases.[10] The breakeven point, in terms of the number of acres on which the thinner is used, at which the mechanical thinner becomes more profitable than hand thinning is 27.1 acres. Substantial savings may be realized as acreage levels increase as indicated by a $27.93 per acre savings when total chile acreage is equal to 100 acres. At this acreage level (100 acres), the breakeven price for the thinner, the price at which present value of annual returns associated with adoption of the mechanical thinner equal zero, is $26,751.

Economic Returns & Contracted Hand Labor Price. The variability of availability and price of contracted hand labor varies significantly across geographic locations. Anecdotal evidence suggests that contracted labor prices for hand thinning can vary anywhere from $35 per acre up to $200 per acre depending on season, year, and geographic location.[11] Figure 3 shows the sensitivity of differences between economic returns to mechanical thinning and hand thinning as the price of contracted labor increases. The breakeven point (in terms of contracted hand labor rates for thinning), at which mechanical thinning would no longer provide returns in excess of those related to contracted hand labor, is $66.38 per acre.

Economic Returns & Fuel Price. Increases in fuel prices will diminish economic returns. The breakeven point, in terms of the price of diesel fuel, at which the mechanical thinner becomes less profitable than hand thinning (again using all Cost and Return default values) is $2.22. At this fuel price, holding all other variables constant, hand thinning becomes economically more attractive than mechanical thinning.

Economic Returns & Equipment Operator Labor Price. The rate at which the operator running the thinner is paid will affect the overall economic return to mechanical thinning. For purposes of this analysis, equipment operator rates include not only wages, but also allowances associated with downtime, liability insurance, benefits, and supervision and management ($5.95 base plus $10.71 in other allowances, e.g., supervision expense, per hour). Relative to other costs associated with mechanical thinning, changes in equipment operator labor rates have a minimal effect on the returns to mechanical thinning. In the given base wage range provided in the sensitivity analysis, mechanical thinning has a continual advantage over contracted hand thinning. The breakeven point (relative to equipment operator labor rates), at which mechanical thinning would no longer provide returns in excess of those related to contracted hand labor, is $9.75 per hour.

Economic Returns & Equipment Interest Rates. Interest rates associated with financing equipment (or opportunity cost of self-financing) will alter return estimates generated in this analysis. The breakeven point at which mechanical thinning would no longer provide returns in excess of those related to contracted hand labor is 8.54 percent.

Conclusions & Further Research

Conclusions

A number of forces surrounding the vegetable industry are encouraging producers and researchers to once again examine the feasibility of substituting capital for labor in the production process. While earlier attempts to mechanize crop thinning failed, today's computer technologies promise to further mechanize vegetable production.

This paper has examined the economic returns associated with adoption of mechanical thinning using a thinner developed by researchers at New Mexico State University. Based on underlying information associated with New Mexico State University's Cost and Return Estimates, adoption of mechanical thinning in the chile industry appears to be feasible. Findings in this study are consistent with others relating to technology adoption, as larger producers are expected to obtain greater rewards in terms of their returns to adopting mechanized technologies.

Further Research

The analysis here focuses on economic returns associated with the adoption of a two-row mechanical thinner. Additional work examining economic returns associated with mechanical thinning as they relate to a larger machine, e.g., a 4-row machine, may be conducted. Assuming fuel and repair costs remain relatively constant with an increase in the size of machinery used to thin, returns to a machine able to effectively operate at a faster rate (more acres per hour) would provide increased economic returns for producers adopting the machinery.

This analysis also focuses only on chile pepper production and the returns associated with adopting mechanical thinning technologies for chile peppers. The thinner developed by New Mexico State University can easily be adapted to other vegetable / row crops (e.g., sugar beets, lettuce, and spinach). Additional analysis using cost and return estimates for these crops needs to be conducted.

While the analysis provided in this paper can provide a starting point for producer analysis of the feasibility of adopting mechanical thinning for their specific operation, additional work needs to be done. It is unlikely that the assumptions used in this analysis will actually be realized. Future research may include extensions of the analysis provided here to incorporate risk associated with key variables (e.g., fuel costs, accomplishment rates, etc.).

Endnotes

[1] In this paper, reference to chile or chile peppers will refer to the Census of Agriculture classification of chile peppers not including Bell peppers.

[2] Other crops that have been over-planted and then thinned to a final stand after seed germination include: sugar beets, lettuce, cauliflower, broccoli, celery, tomatoes, and cotton. Technology improvements have led producers of some crops to eliminate the practice of over-planting and its related requirement of thinning, e.g., celery and cauliflower are now primarily transplanted and cotton is generally planted using precision planting (Inman 2004, Barnes 2004).

[3] In this study, we look only at the economic returns associated with mechanical thinning as they relate to green and red chile production.

[4] These cost and return estimates, which assume above average management, are not meant to fit any farm in particular and must be adjusted to represent individual business and operating practices.

[5] Includes all pepper varieties except bell peppers.

[6] Yields are assumed to remain constant across thinning alternatives. Additional information regarding differences in yields may be examined in future research. For a complete identification of all values assumed within the analysis see Hawkes et al., 2004.

[7] The analysis here assumes that yields remain constant across the three technologies. The analysis also assumes all other production inputs (e.g., irrigation water) remain the same across the three technologies. These assumptions are likely to be erroneous for differences in transplants and direct seeded crops (Bosland, Bailey, and Cotter 1997 and Katz 2002).

[8] This is an estimate as the analysis assumes thinner and tractor repairs costs remain constant over the life of the thinner.

[9] This "willingness to pay" figure does not account for any type of risk behavior. E.g., some producers may be willing to pay more for the mechanical thinner as a way to avoid possible liabilities associated with hand labor.

[10] In this analysis, total farm acreage increases from below 500 acres (when chile acreage is less than 30 acres) to 570 acres when chile acreage is 100 acres. In Figure 1, a slight decrease in returns to thinning is evident between 70 and 80 acres of chile. It is at this point a third tractor must be obtained to accommodate the increased size of the hypothesized farm.

[11] Information based on informal survey of producers during 2004 Chile Pepper Conference held in Las Cruces, New Mexico and conversations with producers in the Southwest.

[12] Assumes tractor will have a total of 557 hours of annual use for all crops produced on farm (20 hours associated with thinning 30 acres of chile, 30 hours associated with transplanting 30 acres of chile).

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Table 1. Cost and Return Estimation Assumption

Land Use	
Total crop acreage	500 acres
Green chile acreage	15 acres
Red chile acreage	15 acres
Basic Costs	
Labor & Management	
Equipment operator wage rate	$5.95 per hour
Vegetable crop supervision	$1.00 per acre
Purchased Inputs	
Chile seed	5 lbs per acre @ $18 per lb
Chile seedlings	$0.025/seedling @ 13,000 seedlings per acre
Diesel fuel	$1.50 per gallon
Contracted hand labor	$70 per acre
Economic Rates	
Operating capital interest rate	6.5 percent
Equipment interest rate	6.5 percent
General Overhead (includes mileage, domestic electricity, telephone, etc.)	$30,548 (500 acre total)
Equipment	
Tractor (for thinner & transplanter)	140 hp with 557 annual hours of use[i]
Thinner accomplishment rate (2-row)	1.5 acres per hour
Transplanter accomplishment rate (4-row)	1 acre per hour
Operators	
Thinner	1 operator
Transplanting	7 operators / laborers

Figure 1. Economic Returns to Mechanical Thinning Sensitivity to Changes in Mechanical Thinner Price

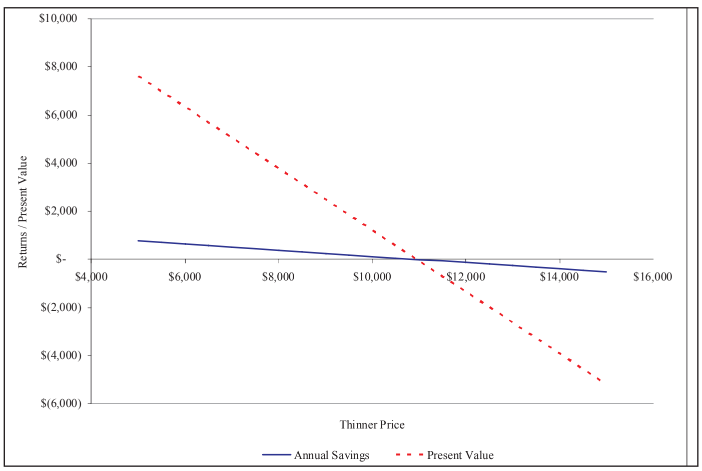

Figure 2. Economic Returns to Mechanical Thinning Sensitivity to Changes in Chile Acreage

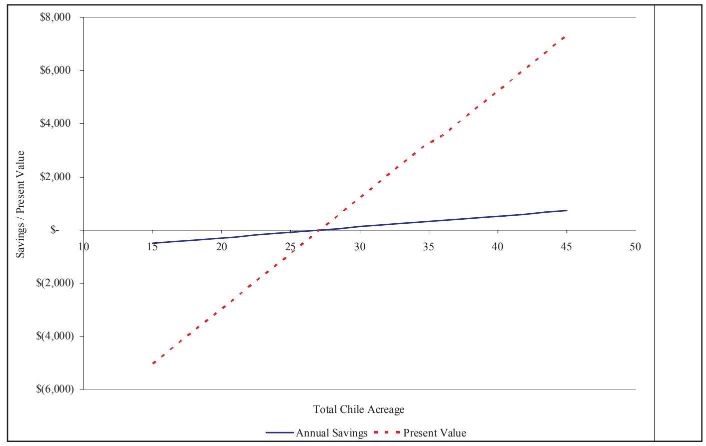

Figure 3. Economic Returns to Mechanical Thinning Sensitivity to Changes in Contracted Hand Labor Rates