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Economics of Drip Irrigation for Apple Orchards in New York State

Charles H. Cuykendall
Gerald B. White

Department of Agricultural, Resource, and Managerial Economics
College of Agriculture and Life Sciences
Cornell University, Ithaca, New York 14853-7801

ABSTRACT

In an average growing season in the Northeast, rainfall is somewhat less than is required for optimal performance of fruit crops. The shortage of moisture during critical periods of crop growth and fruit development affects both yields and sizing of produce, thus affecting receipts through both volume of production and average price. Seasons in which moisture is a severe limiting factor affecting profitability occur perhaps two or three years in ten for individual growers in the Northeast.

Today's apple growers need investment and cost guidelines to determine the economics of getting trees into production as soon as possible and to avoid periods of drought during the productive life of orchards. Research was undertaken to determine drip irrigation investment and costs in an apple orchard. This project was designed to assist growers in determining the investment, fixed and variable costs and expected returns from drip irrigation.

Irrigation suppliers provided typical equipment needs and investment costs for various drip irrigation designs. Economic worksheets were developed to assist growers in estimating fixed and variable costs of drip irrigation. The economics of yield data were applied to replicated multi-year irrigation studies to assist growers in determining yield response from drip irrigation.

Net present value (NPV) methodology was used to determine the discounted break-even investment results from published responses to drip irrigation. Growers with typical drip irrigation systems and various water sources can expect investments in drip irrigation of $464 to $880 per acre with 10 acre blocks of trees. Based upon seven years of data from the New York State Agricultural Experiment Station average yield increases due to irrigation were 117 bushels per acre, resulting in a break-even investment of around $2,000 per acre.

Growers who were interviewed were unable to quantify the benefits and costs of drip irrigation but were convinced of positive yield and quality responses from drip irrigation. This analysis has proved the economic rational for the investment in microirrigation.

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Introduction

Many New York fruit growers face the economic decisions required to expand acreage and/or replace existing trees. The investments required in high density apple orchards often exceed $7,000 per acre with little to no economic return for the first two to three years. The additional investment of $464 to $880 per acre for drip irrigation must be considered since it is crucial that the investment in the planting system yields the fastest possible returns. The benefits of irrigation include: better tree survival, earlier fruit production, greater yields, more efficient distribution of nutrients, less plant stress, reduced yield variability and improved fruit quality.

The objective of this study was to gather information from growers, experiment stations, published reports, and plant scientists to establish a methodology for educators and growers to evaluate the economics of irrigation. This was done by presenting a format for individual growers to analyze their own specific set of resource mix of land, labor, capital and water. This method uses the costs and returns as reported on selected orchards and at various experiment stations and analysis of the economic response to drip irrigation.

Drip irrigation was chosen for this study because of the often limited on-farm water supply and the need to minimize the wetting of the leaf surfaces in order to minimize the spread of plant diseases. Drip irrigation is the application of water through small emitters directly onto or below the soil surface, usually at or near the plant to be irrigated. An analysis of trickle irrigation (a general irrigation term for slow, low volume, frequent water applications to the soil) versus overhead traveler irrigation was reported by J.W. Worthington (9). In their study in Eastern United States they reported the trickle system used 54 percent less water, 74 percent less energy and 50 percent less investment while the labor cost remained the same. If an orchard is operated in a location with limited water supply there are few alternatives except drip irrigation. Irrigation is not new to New York as a special US Census report in 1955 reported over 58,000 acres under irrigation of some kind and on relatively high value crops (5). The latest US Census of Agriculture information available is 1992, and it indicates that the number of farms in New York

State using irrigation has increased while the total acres irrigated have decreased to 46,600 acres. When the 1997 Census data is available it likely will show an increase in both farms and acreage under irrigation due to the technology of microirrigation. Microirrigation includes any low volume application of water to the soil whether by drip, trickle, or micro-sprinkler/sprayers.

Methodology

To determine microirrigation needs and available data, a meeting, followed by several consultation sessions, was held with faculty members of Cornell University. Those contributing to this project represented research and extension staff from the following departments: Fruit and Vegetable Science; Floriculture and Ornamental Horticulture; Agricultural and Biological Engineering; Agricultural, Resource, and Managerial Economics; Horticultural Sciences; and Cornell Cooperative Extension. From these meetings priorities were set, a survey form was developed, and a list of microirrigation users with potential cost and yield data was compiled.

A three-page farm survey on microirrigation was completed on four Central New York fruit farms. The results of this survey clearly indicated that the selected operators could not easily and accurately quantify their microirrigation investments, operating costs or yield response. Since this project was to assist other potential growers in their investment and cost and benefit decisions the written survey results were of limited value. To obtain additional data a total of six on-farm visits were made by the authors where specific data were gathered on microirrigation investments and operating costs. Since the farms did not have a non-irrigated control plot where water was not applied under similar soils, varieties, and management practices, the authors selected and used yield data from replicated, multi-year microirrigation projects as published at a New York State Agricultural Experiment Station.

To supplement the various investment data received from on-farm interviews, the authors contacted various local microirrigation suppliers and asked them to design a typical system for establishment of a new ten acre orchard. In addition, the data from the Irrigation Workshop sponsored by Cornell Cooperative Extension of Chemung, Cortland, Tioga, and Tompkins counties was drawn upon to provide system costs and investments using various water sources and irrigation methods. Many research projects today are designed not only to reduce costs, but also to protect the environment as well. Drip irrigation seems to contribute to both of these objectives. In addition to increasing productivity, drip irrigation, as reported by D.W. Wolfe (8), may produce a more consistent quality product, conserve energy and water, and reduce fertilizer and pesticide leaching to ground water. Geohring et al (2) reported that drip irrigation improved efficiency of nitrogen use on peppers thus reducing both cost and runoff.

The typical investments for various systems were determined, then the operating and fixed costs were assigned. The yield response to microirrigation as reported from controlled experiments was converted to dollars per acre; then the net present value was determined using net present value analysis methods (1).

In the following sections, estimated costs, investments, and response to irrigation are presented. The tables include columns for individual growers to analyze their system or projections for their cost analysis of microirrigation.

Investment in Drip Irrigation

The variables that determine the irrigation system, power source and ultimately the amount of capital investment include:

a. water source: distance from desired use, elevation differential, availability
b. acres to be irrigated and frequency of application
c. type of crop and soil
d. existing equipment on the farm

Some reasonable estimates can be determined from systems on neighboring farms with similar conditions and from companies who sell and design irrigation supplies.

Local irrigation suppliers provided some typical investment amounts for drip irrigation of apple orchards (Table 1). The examples shown are for establishing a new 10 acre block with 15 mil tape or tube distribution and a readily available electrical power source. The estimated life for the tape system was assumed to be seven years. The few growers we interviewed did not know how long the tape would last, but after five years were experiencing no abnormal repair cost nor obsolescence. Most of the apple growers interviewed indicated that they were using the pressure compensating tube system because of less mechanical damage and ability to handle hillier terrains. We estimated the life of pressure compensating tube at 15 years.

Table 1.

***Investment in Drip Irrigation Equipment for Apple Orchards*[1]**

	Tape	Tube	Your Farm
3HP Submersible electric pump	$1,300	$1,300	$_______
Electrical line up to 500' for service	300	300	_______
Filter and check valve	100	100	_______
1200 feet 2" poly pipe (60¢/ft.)	720	720	_______
1000 feet 1½" poly pipe (37¢/ft.)	370	370	_______
Fittings, valves, and clamps	250	250	_______
30,000 feet 15 mil tape or press. comp. tube	900	4,200	_______
Fittings and pressure regulator	100	100	_______
Trencher	200	200	_______
Labor (4 man days)	400	400	_______
Other:*____________________			
TOTAL	$4,640	$7,940	$_______
Per Acre	$464	$794	$_______

*Your "other" should include if applicable:

1. In place of electric investments, you may have 5HP gas pump, fittings and suction approximating $800.
2. Filter and check valves for pond or stream would cost $900 additional.
3. Additional footage of materials for higher density.

[1]Existing 30 gpm well will supply 3 zones, on nearly level 10 acre field with 14' row width.

The investment costs per acre are only typical guidelines. The investment costs of the water source, power source, filters, valves and many other fittings are fixed costs and do not vary with acreage. One will find a range in the per acre investments, but most growers surveyed were irrigating about ten acres with each system, or in a ten acre zone. Some growers were able to mount their pump, sand filter, suction and discharge hose on a two-wheel flat trailer and move this $2,000 - $3,000 investment to other fields that had an available water source. This lowered their fixed costs significantly as they were able to irrigate more acres with the same portable microirrigation power and filter source.

Annual operating costs will vary dependent upon the frequency of irrigation, amount of water applied per irrigation, number of zones irrigated, and the degree of mechanization. In general, the variable costs are proportionate to the amount of water pumped. The most important variable cost is labor, which is used for monitoring, repair, maintenance and any required hose or pipe moving. The fixed costs will occur regardless of amount of water used and will generally be the depreciation and interest costs based upon the amount of investment.

Depreciation often amounts to two-thirds to three-quarters of the fixed costs. It can be argued that the more a line is used the faster it wears out, but realistically a system is depreciated over a straight line basis over the estimated life. In reality, most of the growers do not know how long the system will last as they have not replaced them but rather have expanded coverage to other acres.

Operating Costs

These costs vary with the design of the system, intensity of use, degree of mechanization, water source, mechanical damage and age of the installation. To get an economic evaluation of the irrigation system, the operating costs, as well as the additional revenues generated, must be estimated accurately.

Typical operating costs are listed in Table 2. The power source includes electric, gas or diesel fuel. Repair costs have been reported as minor in the earlier years. Labor costs are variable and depend upon the system. Growers reported labor cost of detecting leaks, but once found, the cost of repair is minor for plastic inserts or plugs compared to the labor expended in routine checking of the system.

Table 2.

Operating Costs (per acre) for Drip Irrigation

	Typical	Your Farm
Power Source	$15.00	$ ________
Repairs	40.00	________
Labor: Spring, Summer, Fall	68.00	________
Additional Fertilizer, Pesticide and Application Cost	--.--	________
Additional Product Harvesting, Hauling and Marketing[1]	--.--	________
City Water Metered		________
Total	$123.00	$ ________

[1]Wide variations dependent upon year and variety, use harvest and hauling costs of $1.00 per bushel.

Hired labor and management labor can fall into either or both operating and fixed cost allocations. Much of the labor hired to operate and manage this important technology is fixed. When asked to estimate total labor requirements for the system many growers allocated a spring start up time, a weekly operating and scouting time, plus a fall shut down. Labor and management costs were allocated at a rate of $8.50 per hour in the typical cost column. This rate was based upon average New York hired labor rates reported by New York Agricultural Statistics 1996, adjusted for inflation and fringe benefits.

When any management operational change in methodology or a new technology like microirrigation is adopted, it should result in increased salable product or quality. When the microirrigation results in increased yield, the costs to harvest, haul and market an additional product must be included in your total costs analysis.

Those irrigation systems with a direct water charge, like a city meter, should include this as an operating cost. Growers with city water experienced no filter costs, but more in labor and piping charges to get the water to the desired location. For this study, total operating costs (Table 2) were estimated at $123 per acre. You are encouraged to estimate your costs based upon your system configuration.

Fertigation

According to Stiles et al (6), with fertigation, nutrients dissolved in water can be more quickly delivered to the root zone of apple trees. This is an additional benefit of microirrigation that effects yield, quality and growth. The fertigation cost variable has many different options. Some growers applied only nitrogen through irrigation, some only potassium, some both, and the rest none. Those that applied fertilizer through irrigation felt that they must purchase easily soluble nutrients and closely monitor the system for any leaks or "blowouts". Those who used fertigation reported reduced costs of application but higher initial investment costs of electrical technology and chemical storage. In experiments at Geneva, New York, Robinson and Stiles (4) reported early apple tree performance can be significantly improved with fertigation.

Fixed Costs

Apple growers who already have an investment in irrigation equipment can often adapt existing water sources and power sources into use for microirrigation. Those who design and purchase a new system must allocate costs based on the life of the system as shown in Table 3. An interest or opportunity cost of capital, based upon half the investment costs, has been allocated at 8 percent in Table 3. There is little difference in the fixed cost allocation between the projections for the tape versus pressure compensating tube systems.

Table 3.

Fixed Cost (per acre) for Irrigation System

Annualized Fixed Costs	15 mil tape[1]	Pressure Compensating Tubing[2]	Your Farm
Depreciation	$66.00	$53.00	$ ________
Interest[3]	19.00	32.00	________
Insurance	--.--	--.--	________
Total	$75.00	$85.00	________

[1]Based on 7 year life and $464 per acre investment on 10 acres.
[2]Based on 15 year life and $794 per acre investment on 10 acres.
[3]Based on 8 percent cost of borrowed funds.

Annual Costs

Annual costs are the sum of operating costs (Table 2) and fixed costs (Table 3). Investment decisions are made based upon estimation of both fixed and variable costs plus the projected net additional receipts as shown in Table 5. Many factors, such as fruit quality improvement, timeliness to market, and risk evasion are hard to quantify, but should enter in to the decision to acquire new technologies like drip irrigation. Any technology that on paper indicates a break-even may be well worth the risk reduction afforded by the ability to make timely applications of water to reduce drought in a very dry period.

Yield Response

Robinson and Stiles (3) have reported that apple orchard management using Cornell recommendations and trickle (tube) irrigation has resulted in excellent early tree development and greater yields per acre. Table 4 shows the effect of trickle irrigation on yield over the first seven production years of an apple orchard. In every year, irrigation resulted in increased yield and the amount of increase was dependent upon stage of development and natural rainfall for the season.

Table 4.

Effect of Irrigation on Average Yield of 'Redchief Delicious', 'Mutsu' and 'Empire' Apple Trees Over the First Eight Years (with Preplant and Annual NKB[1] at 419 Trees per Acre)[2]

	Bu/Acre								
Years	87	88	89	90*	91*	92*	93	94*	Accum/Yr.*
No Irrigation	0	18	233	429	381	436	470	742	385
With Irrigation	0	24	302	676	586	698	503	937	531

*Significantly different within years at the 5 percent level.

(1) Nitrogen, Potassium, Boron.

(2) Robinson, Terence and Warren Stiles, 1995. Maximizing the Performance of Young Apple Trees. NY Fruit Quarterly 3(2): 10-16.

Economics of Drip Irrigation - New Planting

Table 4 indicates the annual and accumulated yield increase due to trickle irrigation. A partial budget of additional receipts and estimated additional costs was used in Table 5A and 5B to construct net revenues and net present value at a 10 percent discount factor. A seven year planning horizon was used for the analysis because that is the projected life of the 15 mil tape system. Credit was given for the remaining estimated salvage value of the pump on the tape system in Table 5A and for the pump and tube system in Table 5B.

For the tape system the present value method at a 10 percent discount factor, shows a value of $1,558 after an initial drip investment of $464 per acre. If a loan was obtained to invest in the system, repayment of the investment would require returns in the fourth and fifth year to retire the debt after no repayment for the first three years. Full farm analysis would be used to see if the current cash flow could service the additional debt until year four. The analysis indicates that in present value terms, a grower could spend up to $2,022 per acre for drip irrigation system, and break even!

Table 5A.

Net Present Value of Installation of Drip Irrigation (Tape) with Apple Orchard Establishment (1 Acre)

Year	Inc. Yield Bu./Acre	$ Additional Receipts[1]	$ Additional Costs[2]	$ Net Revenue	10 Percent Discount	NPV $	Cum. NPV $
0	(Initial Investment)				1.000	-464	-464
1	X	X	123	-123	.9091	-112	-576
2	6	36	129	-93	.8264	-77	-653
3	69	414	192	222	.7513	167	-486
4	247	1,482	370	1,112	.6830	759	273
5	205	1,230	328	902	.6209	560	833
6	262	1,572	385	1,187	.5645	670	1,503
7	33	198	156	42	.5132	22	1,525
7	(salvage value for pump $65)				.5132	33	1,558
Totals	822	4,932	1,683	3,249		1,558	

[1]Calculated on $6.00 net per bushel, orchard run price.
[2]Includes operating costs of $123.00/ac. and harvest costs at $1.00 per bushel (7).

For the pressure compensating tube system the present value method shows a value of $1,412 after an initial drip investment of $794 per acre. The analysis indicates that in present value terms, a grower could spend up to $2,206 per acre for the pressure compensating tube system and break even.

The net present value, based upon the yield response reported, is $1,412 to $1,558 at a 10 percent discount factor. Since the net present value is positive, it will return more than the 10 percent used in the analysis. Based upon the strong positive value, it would pay to make the investment even if the projected returns are significantly less or additional costs are higher over the projected life.

Table 5B.

Net Present Value of Installation of Drip Irrigation (Tube) with Apple Orchard Establishment (1 Acre)

Year	Inc. Yield Bu./Acre	$ Additional Receipts[1]	$ Additional Costs[2]	$ Net Revenue	10 Percent Discount	NPV $	Cum. NPV $
0	(Initial Investment)				1.000	-794	-794
1	X	X	123	-123	.9091	-112	-906
2	6	36	129	-93	.8264	-77	-983
3	69	414	192	222	.7513	167	-816
4	247	1,482	370	1,112	.6830	759	-57
5	205	1,230	328	902	.6209	560	503
6	262	1,572	385	1,187	.5645	670	1,173
7	33	198	156	42	.5132	22	1,195
7	(salvage value for pump and tubing $423)				.5132	217	1,412
Totals	822	4,932	1,683	3,249		1,412	

[1]Calculated on $6.00 net per bushel, orchard run price.
[2]Includes operating costs of $123.00/ac. and harvest costs at $1.00 per bushel (7).

In any net present value analysis it is important to select a discount rate appropriate for the farm investment. In this study the internal rate of return would be between 35 and 45 percent, far above the cost of capital for most farms; thus one would conclude that either investment is economical.

In addition to the increased yield benefits, trickle irrigation often increases the returns due to a better pack out. In a report by Robinson and Stiles (3) average fruit size over six years was increased by 3 – 6 percent, and with fertigation fruit size increased 6 – 18 percent. Robinson and Stiles (4)(6) also reported that trickle irrigation increased shoot growth and trunk cross-sectional area.

Economics of Drip Irrigation - Existing Planting

Due to limited land resources and the high cost of orchard establishment some growers are installing trickle irrigation on established orchards. The data in Table 6 indicates a yield sensitivity that net average yield increases of 60 to 86 bushels per acre (with no improvement in quality) would be needed to break-even on an investment of $1,000 per acre in an established orchard. The additional investment cost is assumed for labor and tubing around mature trees.

The first seven production years, as reported in Table 4, had an average increase of 146 bu. per acre per year due to irrigation. (This study had the benefit of orchard establishment with irrigation and the response may be similar, but the effect of establishment with irrigation may over state results when used to determine effect on mature trees.) While additional yields of 60 to 86 bushels per acre seem possible with the adoption of irrigation on an established planting, it is not a certainty that such increases will occur.

Table 6.
Average Yield Increase Per Acre Required at Various Prices for 5 Year Irrigation Investment[1] Recovery From Existing Apple Orchards

Price/ Bushel	5 Production Years Yield Increase/ Yr.	Gross Additional Receipts	Nominal Value of Net Ret.[2]	10 Percent Discount Factor[3]	Present Value
$5.50	86.0 bu.	$473	$264	3.791	$1,000
$6.50	70.4 bu.	$458	$264	3.791	$1,000
$7.50	59.5 bu.	$446	$264	3.791	$1,000

[1]Assumes higher initial investment to add tubes to an existing orchard.
[2]Gross receipts minus harvesting costs of additional fruit (at $1.00 per bushel) and additional operating costs at $123.00 per acre.
[3]Present value factor of $1.00 received annually at the end of each year for five years.

Summary and Implications

Interviews of apple growers, research associates, suppliers and published research were obtained to provide data on the adaptation and results of microirrigation of apple orchards. All growers reported positive results with microirrigation, but were unable to quantify their costs and benefits. They reported that the consequences of too little water availability in drought years easily offset the investment and operating costs of a microirrigation system.

The response curve to microirrigation is very favorable under typical New York State moisture conditions and one can justify the investment and costs if water is available. Wide variations exist in costs due to the source of water, location of water and power, and the topography to be irrigated.

Our analysis showed that both pressure compensating tubing (15 year projected life) or 15 mil tape (7 year projected life) were profitable investments. The tape reached a discounted payback in the fourth year and the tubing in the fifth year of the investment. Furthermore, we found that the breakeven yield increase necessary for irrigation (using pressure compensating tubing) was 60 bushels to 86 bushels per acre for orchard run prices of $7.50 down to $5.50 per bushel. These yield increases of approximately 10 percent should be attainable in most farm situations, especially where soils are limiting because they are shallow, sandy, or subject to poor nutrition.

While most growers have installed the pressure compensating tubing, the tape system has a place in farm situations where the area to be planted is level and where capital is limited. Much of the benefit from drip irrigation is realized in the first five years of a new planting, and the tape system permits the attainment of these early benefits for much less investment.

Growers will continually face increased investment costs in additional and reestablished orchards. To mitigate the economic risk of drought and to get more rapid production they will be likely to adopt microirrigation. Growers who have existing irrigation systems will continue to add more zones of irrigation dependent upon their available water supply.

This provides a methodology to make an informed estimate about combining your specific set of resources in your farm. Many times the irrigation investment decision is driven by risk reduction, alternative investments, debt capacity, and most importantly, water availability. The reduction in water requirements with microirrigation systems compared to overhead irrigation, which wets the total area, has made microirrigation an economic and an environmentally friendly alternative. All of the progressive farmers surveyed were convinced that microirrigation pays on their farms, but they had little data to prove their assumption. This analysis has provided the economic rational for the investment in microirrigation.

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