

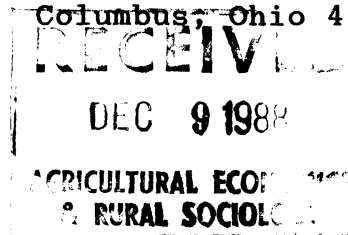
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TRAVELER GUN IRRIGATION OF FIELD GROWN NURSERY STOCK

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Abstract

The objective of this study was to determine annual irrigation costs for field-grown plants in Ohio by species of plant and size of firm. This objective was accomplished by synthesizing two model field nurseries using an economic engineering approach. Once the nurseries were simulated, growing space was divided into five equal parts with each segment being assigned a plant group. In the 50-acre nursery each group was allocated 8 acres of field production plus corresponding space in the propagation house, overwintering facility, holding area, and field bed area. In the 200-acre nursery each plant group was allocated 35 acres plus corresponding space in the central facility. In each plant group, one specific species was chosen as representative for the group.

Total costs of installing irrigation systems were estimated at about \$82,500 for a 50-acre field nursery and \$167,800 for a 200-acre field nursery. Total annual costs for irrigating the 50-acre nursery were \$15,095. Irrigation costs per salable plant (represents the total costs of irrigating the plant from the time it is placed in the field bed as a liner until sale) were \$0.73 for slow growing evergreens (*Taxus*), \$0.52 for fast growing evergreens (*Juniperus*), \$0.49 for deciduous shrubs (*Viburnum*), \$1.62 for shade trees (*Acer rubrum*), \$1.11 for ornamental trees (*Malus*), and averaged \$0.73 for all species. In the 50-acre nursery, costs of irrigation were approximately 3.3% of the total costs of production. In the 200-acre nursery total annual costs of irrigation were \$35,355. Per salable plant costs were \$0.39 for slow growing evergreens (*Taxus*), \$0.28 for fast growing evergreens (*Juniperus*), \$0.26 for deciduous shrubs (*Viburnum*), \$0.86 for shade trees (*Acer rubrum*), \$0.59 for ornamental trees (*Malus*), and averaged \$0.39 for all species. Costs of irrigation were about 2.9% of total annual costs for the 200-acre nursery.

Costs of irrigation averaged approximately 87% higher per salable plant in the 50-acre nursery than in the 200-acre.

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Large-size commercial field nurseries use equipment and labor more efficiently than small-sized nurseries. As a result, large nurseries have a lower cost of irrigation per salable plant.

Introduction

The drought of 1988 and to a lesser degree 1987 have caused nurserymen to contemplate either installing new field irrigation systems or expanding current ones. Irrigation is relatively expensive and the cost/benefits are not well known. In fact, cost/benefits are difficult to determine. In a "normal" Ohio year, most field plants grow reasonably well. Research is lacking to determine how much better they would do, in a normal year, if regular waterings were applied. In a drought year, like 1988, non-irrigated plants may suffer severe damage and perhaps death. Surviving plants may never reach their potential.

There are several general irrigation methods for watering field grown nursery plants. Some of them are: traveler gun, set, central pivot, and trickle. This article examines the traveler gun, currently the most popular method of field irrigation of nursery crops.

Traveler systems are often grouped into two categories: "cable tow" and "drum type". The drum type is currently the most popular for nursery production and is the one that will be examined in detail. First, however, we will describe how the cable tow system works.

The cable tow system has been in use in the United States for a longer period than the drum. The machine is self-contained, operates on wheels, and is powered either by water pressure or an internal combustion engine. It is towed across an irrigation surface by a winch and cable. The cable is anchored on one side of the field and the traveler unit moves across the surface, irrigating as it moves. A rubber hose which supplies the water under pressure to the sprinkler gun is dragged behind the traveler unit.

The "drum" is the "traveler" system of preference for the nursery industry. Instead of the entire unit moving across the field (as was the case for the "cable tow"), normally the drum and pump unit remains stationary and only the sprinkler gun mounted on two wheels or skids is pulled across the field.

Drum units have a polyethylene hose mounted on a drum or reel. Polyethylene hose diameters range from less than 1.5 to over 5 inches and range in length from less than 400 to over 1500 feet. Capacity ranges from less than 30 to over 900 gallons per minute. A large unit can irrigate as many as 35 acres with 1" of

water in a 20 hour day. They are usually operated with one person who can be employed the majority of his or her time in another capacity. Many of the modern units have fairly sophisticated features: powered by efficient water driven turbine, piston, or bellows motors, constant travel speeds, automatic shut down upon ending a "irrigation run", full circle swivels, mechanical gun cart lift for traveling, ability to expel water from the tubing and to reel-in the polyethylene tube without irrigating, adjustable wheel widths for both the main unit and the wheels or sleds on the gun sprinkler, and high clearance carts for clearance.

The main advantages of drum traveler units are high irrigation capacity, easy mobility, rapid installation, and low labor requirements. Their major drawbacks are fairly rapid application of water that can lead to runoff and erosion.

Materials and Methods

In the study, two model firms were simulated using the conceptual framework of economic engineering wherein the "best proven practice" was included in each model. The analysis is based on conditions in central Ohio. The complete synthesis included developing an appropriate production cycle of plants produced; schematic drawings of the physical layout, lists of machinery and equipment and other items, and budgets for fixed and variable costs.

Data for this study were obtained in the late Summer of 1988 from nursery irrigation suppliers. The basic goals in simulating the irrigation facilities were to minimize labor expenses, and keep future expansion possible.

A model irrigation system was simulated for both a 50-acre and a 200-acre field nursery. The nursery operations were assumed to produce a diverse line of nursery stock each having its own unique production cycle. Commonly grown nursery stock was divided into five cultural groups. While not all inclusive, the groups do permit developing a range of per unit costs related to input costs and cultural factors. For analytical purposes, it was assumed that each cultural group would occupy 20 percent of the field growing area (i.e., 50-acre nursery = 8 acres per group, 200-acre nursery = 35 acres). In addition to the field growing area, the 50-acre nursery had 10 acres and the 200-acre nursery 25 acres of production facilities including overwintering houses, propagation facilities, shipping area, holding area, liner bed area, pond, supply shed, machinery storage, machine shop, office, and rest rooms. The irrigation analysis includes field production and the corresponding irrigation requirements for winter storage, holding area, and liner bed area. It does not include budgets for watering in the propagation house.

Cost budgets for irrigation were for direct costs associated with irrigation. Items for management and other items indirectly related were not included. It was reasoned, that in the case of irrigation, these other costs would have been incurred whether or not a nursery irrigated.

Capital requirements for establishing the irrigation systems were first determined (Tables 1-4). Second, annual fixed costs were calculated (Tables 5-6). Third, Irrigation time requirements were determined (Table 7). Fourth, annual variable costs were determined for each of the two different-sized nurseries (Tables 8 & 9). Fifth, summaries were made for annual fixed and variable costs according to size of nursery (Table 10). Sixth, Summaries were made for total costs of irrigation per salable plant based on species of plant and size of nursery.

Total annual irrigation costs consist of both fixed and variable factors. Fixed costs are primarily made up of implicit costs such as depreciation of buildings and equipment, interest charges (both for borrowed and equity capital), insurance, and taxes. Many nurserymen do not adequately consider fixed costs when computing costs of production. Fixed items are often considered as residual claimants on income.

Variable costs are comprised of all expenses that vary with the amount of irrigation being applied. Variable costs are explicit, obvious, and normally paid out yearly. Variable costs were subdivided into the following categories: repairs, operating, and labor.

Repairs. Repairs per hour of irrigation system usage were based on percent of new cost over the life of the asset.

Operating. Operating costs (electricity) were based on an estimate of 8 cents per pump horsepower per hour, \$1.10 per gallon of gasoline and 15% of the gasoline cost for tractor filters and lubrication.

Labor. It was estimated that it requires approximately 1 1/2 hours of labor to set up a 5-10 hour irrigation run. While the gun is irrigating, it would require no or a minimum amount of supervision. To take into account supervision, getting to and from the field, etc. labor was budgeted at 1/4 the time the gun would be operating. Labor cost was estimated at a basic cost of \$5.60. In addition 32% was added for taxes and fringe benefits making a total of \$7.20 per hour.

Cost Summaries. After all irrigation cost factors were determined, they were summarized based upon cost per salable plant by size of nursery.

Results and Discussion

Total costs of installing the irrigation systems were \$82,486 for the 50-acre nursery and \$167,833 for the 200-acre nursery (Tables 1 thru 4). Annual fixed, variable, and total irrigation costs for the two-sized field nurseries were \$15,097 for the 50-acre (\$301.94 per overall acre or \$377.43 per field acre) and \$35,354 for the 200-acre (\$176.77 per overall acre or \$202.02 per field acre)(Tables 5 thru 10). In the 50-acre nursery irrigation costs per salable plant were \$0.73 per 18-24" slow growing evergreen (*Taxus*), \$0.52 per 18-24" fast growing evergreen (*Juniperus*), \$0.49 per 3-4' tall deciduous shrub (*Viburnum*), \$1.62 per 2" diameter shade tree (*Acer Rubrum*), and \$1.11 per 5-6' tall (1 1/2" diameter) ornamental tree (*Malus*) Cost per salable plant produced averaged \$0.73 (Table 11). In the 200-acre nursery irrigation costs per salable plant were \$0.39 per 18-24" slow growing evergreen (*Taxus*), \$0.28 per 18-24" fast growing evergreen (*Juniperus*), \$0.26 per 3-4' tall deciduous shrub (*Viburnum*), \$0.86 per 2" diameter shade tree (*Acer Rubrum*), and \$0.59 per 5-6' (1 1/2" diameter) ornamental tree (*Malus*). Cost of irrigation per salable plant produced averaged \$0.39 (Table 12). It averaged 87% more to irrigate a salable plant in the 50-acre nursery than was the case in the 200-acre nursery. Large-size commercial field nurseries use equipment and labor more efficiently than small-size nurseries. As a result, large nurseries have a lower cost of irrigation per salable plant.

In 1985, in an earlier study (1), total costs of producing the same combinations of field grown plants averaged \$20.34 per salable plant in the 50-acre nursery and \$12.43 in the 200-acre. If we assume 10% inflation since 1985, the cost would be \$22.37 in the 50-acre and \$13.67 in the 200-acre. If we compare our average cost of irrigation with total costs of production, cost of irrigation per salable plant was 3.3 percent of total cost for the 50-acre nursery and 2.9% for the 200-acre nursery. Individual nurserymen will have to determine whether a 2-4% increase in the cost of production for irrigation would be justified for additional plant growth and survival.

Literature Cited

- 1, Taylor, Reed D., Harold H. Kneen, Elton M. Smith, David E. Hahn, and Stanley Uchida. 1986. Costs of establishing and operating field nurseries differentiated by size of firm and species of plant in U.S.D.A. plant hardiness zones five and six.

TABLE 1.--Cost of Irrigation System (Traveler Gun) for a 50 and 200 Acre Field Nursery, U.S.D.A. Plant Hardiness Zones Five and Six, 1988.

Item	50 Acre Field Nursery*	200 Acre Field Nursery**
	Total Cost (dollars)	Total Cost (dollars)
Winter Storage and Holding Area***		
Inground irrigation system	7,442	19,488
Above ground irrigation system		
Polyhouse structures	1,113	4,267
Holding area	1,563	5,423
Subtotal (Winter storage and holding area)	10,118	29,178
Field/Bed Irrigation****		
Inground irrigation system	12,636	38,943
Above ground irrigation system	2,275	5,396
Tractor	3,808	7,615
Traveler gun	15,000	22,000
Subtotal (field irrigation)	33,719	73,954
TOTAL (Not including well, pump, and pond)	40,029	95,517
Cost of well*****	14,175	15,750
Cost of pump (50-acre = 40 HP, 200-acre = 100 HP)****	16,874	22,701
Cost of the pond	7,600	26,250
Total for irrigation system	82,486	167,833

*50 acres total

**200 acres total

***For details, see Table 3

****For details, see Table 2

*****For details, see Table 4

TABLE 2.--Cost of Bed and Field Irrigation (Traveler Gun) for a 50 and 200 Acre Field Nursery, U.S.D.A. Plant Hardiness Zones Five and Six, 1988.

Item	Unit	Cost Per Unit (dollars)	50 Acre Field Nursery*		200 Acre Field Nursery**	
			Quantity Needed	Total Cost (dollars)	Quantity Needed	Total Cost (dollars)
Field/Bed Irrigation						
Inground Irrigation System						
8" pipe, PVC mainline pipe	foot	4.50	450	2,025	4,372	19,674
6" pipe, PVC mainline pipe	foot	2.62	1,659	4,347	1,008	2,641
4" pipe, PVC upright pipe	foot	1.33	32	43	64	85
Hydrant	each	180.00	8	1,440	16	2,880
Additional required equipment, estimated at 25% of pipe & hydrant value				1,964		6,320
Installation charges						
for 6" and 8" pipe	foot	1.35	2,056	2,777	5,380	7,263
for 4" pipe	foot	1.26	32	40	64	80
Subtotal (inground irrigation system)				12,636		38,943
Above Ground Irrigation System						
3" pipe, Aluminum portable latchless	foot	1.98	820	1,624	1,940	3,841
Additional required equipment, estimated at 25% of pipe value				406		960
Sprinkler risers 3/4" x 48"	each	7.00	14	98	34	238
Rotating sprinkler, #30BH Rainbird, nozzle size 5/32" x 3/32"	each	10.50	14	147	34	357
Subtotal (above ground irrigation system)				2,275		5,396
Tractor, 34 hp, gas fuel	each	15,230	1/4	3,808	1/2	7,615
Traveler Gun 70-225 gpm	each	15,000	1	15,000		
Traveler Gun 450-500 gpm	each	22,000			1	22,000
TOTAL BED AND FIELD IRRIGATION				33,719		73,954

*50 acres total

**200 acres total

TABLE 3.--Cost of Irrigation System for the Winter Storage and Holding Area for a 50 and 200 Acre Field Nursery, U.S.D.A. Plant Hardiness Zones Five and Six, 1988.

Item	Unit	Cost Per Unit (dollars)	50 Acre Field Nursery*		200 Acre Field Nursery**	
			Quantity Needed	Total Cost (dollars)	Quantity Needed	Total Cost (dollars)
Inground Irrigation System						
8" pipe, PVC	foot	4.50	506	2,277	1,656	7,452
6" pipe, PVC	foot	2.62	640	1,677	1,089	2,853
4" pipe, PVC	foot	1.33	379	504	1,114	1,482
2" pipe, PVC	foot	0.52	36	19	124	65
Additional required equipment, estimated at 20% of pipe value				895		2,370
Installation charges for 6" and 8" pipe	foot	1.35	1,146	1,547	2,745	3,706
for 2" and 4" pipe	foot	1.26	415	523	1,238	1,560
Subtotal				7,442		19,488
Above Ground Irrigation System						
1. Polyhouse structures-storage						
1-frost free hydrant 1" @ \$60.00						
200 ft of 1" PVC pipe @ \$0.24/foot = \$48.00						
Installation labor/parts, estimated at 30% of pipe cost = \$14.40						
10-rotating sprinklers, Nelson Whizhead 5/64" nozzels @ \$5.25 = \$52.20						
	polyhouse	174.60	5	1,113***	21	4,267***
2. Holding area						
3" pipe, latchless aluminum	foot	1.85	600	1,110	2,080	3,848
Additional fittings 25% of pipe cost				278		962
Pipe riser 3/4" diameter x 48"	each	7.00	10	70	35	245
Rotating sprinkler, #30BH Rainbird, Nozzle size 5/32" x 3/32"	each	10.50	10	105	35	368
Subtotal (Above ground irrigation system for storage and holding area)				2,676		9,690
Total				10,118		29,178

*50 acres total

**200 acres total

***Cost includes extra frost free hydrants used in other areas (4 in the 50-acre nursery and 10 in the 200-acre nursery)

TABLE 4. Specifications and Costs of Installing 20, 40, 75, and 100 H.P. Electric Well Pumps and an 80 Foot Well, U.S.D.A. Climatic Zones Five and Six, 1988.

Specifications (dollars)	Horse Power			
	20	40	75	100
	----- dollars -----			
Pump - above ground, lineshaft, 1,800 RPM				
Basic electric motor, 3 phase, 220 volt	1,680	2,310	3,675	4,291
Discharge head - 6" x 1" collar	998	998		
8" x 1" collar			1,256	1,256
Standard 10' length, inner column, 80' depth	2,100	2,205	3,990	4,541
Pipe and suction pipe	357	357	357	357
Pump bowl assembly - 9 stage, 8" pump	2,520			
4 stage, 10" pump		2,310		
3 stage, 12" pump			2,822	2,822
Air line guage	47	47	47	47
Well seal, well plate, cement	368	368	368	368
Electrical equipment	92	92	92	92
Installation fee	1,050	1,050	1,050	1,050
Right angle gear drive, auxillary power source** using a tractor	1,470	1,785	1,995	1,995
Subtotal	10,682	11,522	15,652	16,819
+ Freight @ 10%	1,068	1,152	1,565	1,682
+ Building	4,200	4,200	4,200	4,200
Total cost for pump, including shelter	15,950	16,874	21,417	22,701
Well Drilling				
Casting diameter, 12"	12,600			
14" O.D.		14,175		
16" O.D.			15,750	15,750
Total cost for well	12,600	14,175	15,750	15,750
TOTAL	28,550	31,049	37,167	38,451

*A 20 H.P. pump can supply 300 gallons of water per minute at 55 psi given the specifications and site location.

A 40 H.P. pump can supply 500 gallons of water per minute at 55 psi given the specifications and site location.

A 75 or 100 H.P. pump can supply 900 gallons of water per minute at 65 psi given the specifications and site location

**The right angle drive would operate with the largest nursery tractor (60 - 100 HP). It would be used for pumping water from the well to the pond, and in a separate operation from the pond into the irrigation system.

Table 5.--Annual Fixed Costs (Dollars) for a Traveler Gun Irrigation System for a 50 acre* Field Nursery, U.S.D.A. Plant Hardiness Zones Five and Six, 1988

Item	Description	Cost	Useful Life (Yrs)	Annual Costs			Total
				Depreciation**	Interest***	Insurance and Taxes****	
Land Improvements	Pond	7,600	20	--	456	152	608
Machinery and Equipment							
Permanent irrigation/well pump	40 HP electric pump	31,049	20	1,397	2,049	117	3,563
Inground irrigation/bed area	PVC pipe/valves	12,636	20	569	834	48	1,451
Above ground irrigation/bed area	Aluminum pipe/valves & sprinklerheads	2,275	5	410	150	9	569
Inground irrigation storage/holding	PVC pipe/valves	7,442	20	335	491	28	854
Above ground irr. storage/holding	Aluminum pipe/valves & sprinklerheads	2,676	5	482	177	10	669
Tractor, 34 hp (1/4 of a unit)	Gas fuel	3,808	10	343	251	14	608
Traveler gun - field irrigation	70-225 gallons per minute	15,000	10	1,350	990	57	2,397
Portable irrigation pump	40 HP P.T.O irrigation pump/foot valve	500	10	45	33	2	80
Total Annual Fixed Costs				4,931	5,431	437	10,799

*Fifty acre total, 40 acres growing space, 10 acres production facilities, holding area, field bed area, roads, etc.

**Depreciation was estimated by dividing initial cost adjusted for a 10% salvage value, by the years of useful life.

***Interest costs for land improvements was estimated by taking 12% of the average value based on initial value. Interest cost on machinery and equipment was estimated by taking 12% of the average value based on initial cost and salvage value. It was calculated as $((\text{initial value plus salvage value})/2) \times .12$.

****Insurance and taxes.

Land improvements--Only taxes are assessed, at a rate of \$20.00 per \$1000.00 of market value.

Machinery and equipment--Taxes are not assessed in state of Ohio on personal property. Insurance, \$500.00 deductible, at \$3.78 per \$1000.00 of initial value.

Table 6.--Annual Fixed Costs (Dollars) for a Traveler Gun Irrigation System for a 200 acre* Field Nursery, U.S.D.A. Plant Hardiness Zones Five and Six, 1988

Item	Description	Cost	Useful Life (Yrs)	Annual Costs			Total	
				Depreciation**	Interest***	Insurance and Taxes****		
Land Improvements	Pond	26,250	20	--	1,575	525	2,100	
Machinery and Equipment								
Permanent irrigation/well pump	100 HP electric pump	48,951	20	2,203	3,231	185	5,619	
Inground irrigation/bed area	PVC pipe/valves	38,943	20	1,752	2,570	147	4,469	
Above ground irrigation/bed area	Aluminum pipe/valves & sprinklerheads	5,396	5	971	356	20	1,347	
Inground irrigation storage/holding	PVC pipe/valves	19,488	20	877	1,286	74	2,237	
Above ground irr. storage/holding	Aluminum pipe/valves & sprinklerheads	9,690	5	1,744	640	37	2,421	
Tractor, 34 hp (1/2 of a unit)	Gas fuel	7,615	10	685	502	29	1,216	
Traveler gun - field irrigation	450-500 gallons per minute	22,000	10	1,980	1,452	83	3,515	
Portable irrigation pump	40 HP P.T.O irrigation pump/foot valve	500	10	45	33	2	80	
Total Annual Fixed Costs					10,257	11,645	1,102	23,004

*two hundred acre total, 175 acres growing space, 25 acres production facilities, holding area, field bed area, roads, etc.

**Depreciation was estimated by dividing initial cost adjusted for a 10% salvage value, by the years of useful life.

***Interest costs for land improvements was estimated by taking 12% of the average value based on initial value. Interest cost on machinery and equipment was estimated by taking 12% of the average value based on initial cost and salvage value. It was calculated as $((\text{initial value plus salvage value})/2) \times .12$.

****Insurance and taxes.

Land improvements--Only taxes are assessed, at a rate of \$20.00 per \$1000.00 of market value.

Machinery and equipment--Taxes are not assessed in state of Ohio on personal property. Insurance, \$500.00 deductible, at \$3.78 per \$1000.00 of initial value.

TABLE 7.--Time Requirements* for Field Irrigation (Traveler Gun) for a 50 and 200 Acre Field Nursery, U.S.D.A. Plant Hardiness Zones Five and Six, 1988.

Type of Crop	50 Acre Field Nursery**				200 Acre Field Nursery***			
	Hours/ acre	Irrigated Acres	Man Hours	Pump Hours	Hours/ acre	Irrigated Acres	Man Hours	Pump Hours
	----- per irrigation -----							
Slow growing Evergreens (Taxus)	2.0	6.9	3.5	13.8	1.0	30	7.5	30
Fast growing Evergreens (Junipers)	2.0	6.4	3.2	12.8	1.0	28	7.0	28
Deciduous Shrubs (Viburnum)	2.0	6.0	3.0	12.0	1.0	27	6.8	27
Shade Trees (Acer rubrum)	2.0	6.4	3.2	12.8	1.0	28	7.0	28
Ornamental Trees (Malus)	2.0	6.0	3.0	12.0	1.0	27	6.8	27
Total per irrigation		31.5	15.9	63.4		170	35.1	140
x 6 irrigations/year		189	95.4	380		1,020	210	840

*Assumptions

1. In a average year, a nursery would apply approximately 6 to 7 acre inches of water. The systems have the capacity to apply 12-15 acre inches in a dry season.
2. Irrigate every year except cover crop year.
4. If fields are properly arranged, it will take approximatly 10 hours per pull. It requires about 1 1/2 hrs of labor to set up a pull. We estimated labor at 1/4 the pump hours to take into account getting to and from the field and handling the set up.

**50 acres total. The 50-acre nursery would use a traveler gun with a maximum capacity of 225 gallons per minute.

***200 acres total. The 100-acre nursery would use a traveler gun with a maximum capacity of 483 gallons per minute.

TABLE 8.--Estimated Variable Cost for Field Irrigation (Traveler Gun) for a 50-acre Field Nursery, U.S.D.A. Plant Hardiness Zones Five and Six, 1988.

Item Number	Item	New Cost (dollars)	Expected Life (years)	Estimated Annual Use (hours)	Estimated Cost per Hour of Use			Total Variable Costs (dollars)
					Repairs*	Operating**	Total (dollars)	
1	Permanent irrigation, well+pump	24,474	20	425***	0.29	3.20	3.49	4,483
2	Inground irr. bed-field	12,636	20	380	0.67		0.67	255
3	Above ground irr. bed-fiel	2,275	5	380	0.48		0.48	182
4	Inground irr. storage/hold	7,442	20	60	2.48		2.48	149
5	Above ground irr. S. & H.	2,676	5	60	3.57		3.57	214
6	Traveler	15,000	10	380	1.58		1.58	600
7	Portable irr. pump (emergency)	500	10	--	--	--	--	
8	Tractor, 34 hp (1/4 of a unit)	3,808	10	106	3.23	2.92	6.15	652
	Labor#			106			7.20	763
TOTAL								4,298

*Repairs per hour were based on percent of new cost over the life of the asset. Percent factors used were: 10 for item number 1, 40 for numbers 2 thru 7, and 90 for item 8. The total was then divided by the estimated total number of hours the equipment would be used over its total life (i.e. the well & pump would be used 8,500 hours over a 20 year period).

**Operating cost was estimated at 8 cents per pump horsepower per hour. A 40 Horse power pump would therefore cost \$3.20 per hour for electricity and lubrication, gasoline for the tractor was estimated at \$1.10 per gallon, and 15% of the cost of gasoline was allocated for lubrication and filters.

***It was estimated that 1/4 (15 hours) of the time the storage and holding area is being irrigated it would occur concurrently with field irrigation. The other 3/4 (45 hours) of the time, the pump would need to be run for the storage and holding area only.

#Labor was estimated at 1/4 the pump hours. Average basic wage before withholding taxes and fringes \$5.60, taxes and fringes add 32% or \$1.80 for a total of \$7.20.

TABLE 9.--Estimated Variable Cost for Field Irrigation (Traveler Gun) for a 200-acre Field Nursery, U.S.D.A. Plant Hardiness Zones Five and Six, 1988.

Item Number	Item	New Cost (dollars)	Expected Life (years)	Estimated Annual Use (hours)	Estimated Cost per Hour of Use			Total Variable Costs (dollars)
					Repairs* (dollars)	Operating**	Total (dollars)	
1	Permanent irrigation, well+pump	48,951	20	870***	0.28	8.00	8.28	7,204
2	Inground irr. bed-field	38,943	20	840	0.93		0.93	781
3	Above ground irr. bed-fiel	5,396	5	840	0.51		0.51	428
4	Inground irr. storage/hold	19,488	20	60	6.49		6.49	389
5	Above ground irr. S. & H.	9,690	5	60	12.92		12.92	775
6	Traveler	22,000	10	840	1.05		1.05	882
7	Portable irr. pump (emergency)	500	10	--	--	--	--	
8	Tractor, 34 hp (1/2 of a unit)	7,615	10	218	3.14	2.92	6.06	1,321
	Labor#			218			7.20	1,570
TOTAL								12,350

*Repairs per hour were based on percent of new cost over the life of the asset. Percent factors used were: 10 for item number 1, 40 for numbers 2 thru 7, and 90 for item 8. The total was then divided by the estimated total number of hours the equipment would be used over its total life (i.e. the well & pump would be used 17,400 hours over a 20 year period).

**Operating cost was estimated at 8 cents per pump horsepower per hour. A 100 Horse power pump would therefore cost \$8.00 per hour for electricity and lubrication, gasoline for the tractor was estimated at \$1.10 per gallon, and 15% of the cost of gasoline was allocated for lubrication and filters.

***It was estimated that 1/4 (15 hours) of the time the storage and holding area is being irrigated it would occur concurrently with field irrigation. The other 3/4 (45 hours) of the time, the pump would need to be run for the storage and holding area only.

#Labor was estimated at 1/4 the pump hours. Average basic wage before withholding taxes and fringes \$5.60, taxes and fringes add 32% or \$1.80 for a total of \$7.20.

TABLE 10.--Summary of Fixed and Variable Costs (dollars) for irrigation for a 50 Acre* and 200 Acre** Field Nursery, U.S.D.A. Plant Hardiness Zones Five and Six, 1985.

	50 Acre Field Nursery			200 Acre Field Nursery		
	Total for Nursery	Per Overall Acre	Per Field Acre***	Total for Nursery	Per Overall Acre	Per Field Acre***
Fixed Costs	10,799	215.98	269.98	23,004	115.02	131.45
Variable Costs	4,298	85.96	107.45	12,350	61.75	70.57
TOTAL	15,097	301.94	377.43	35,354	176.77	202.02

*50 acres total with 40 acres of field growing space, and 10 acres of production facilities, holding area, field bed area, roads etc.

**200 acres total with 175 acres of field growing space, and 25 acres of production facilities, holding area, field bed area, roads etc.

***Includes prorated share of costs for irrigation in the overwintering and holding areas.

TABLE 11.--Summary of Total Costs per Salable Plant of Irrigating (Traveler Gun) 50 and 200-Acre Field Nurseries, U.S.D.A. Plant Hardiness Zones Five and Six, 1988.

Item	Description	Size of Salable Plant	50 Acre Field Nursery			200 Acre Field Nursery		
			Salable Plants Produced per annum	Total Annual Cost for Irrigation (dollars)	Cost per [#] Salable Plant (dollars)	Salable Plants Produced per annum	Total Annual Cost for Irrigation (dollars)	Cost per [#] Salable Plant (dollars)
I	Slow Growing Evergreens - Taxus	18-24"	4,140	3,019	0.73	18,156	7,071	0.39
II	Fast Growing Evergreens - Juniperus	18-24"	5,810	3,019	0.52	25,418	7,071	0.28
III	Deciduous Shrubs - Viburnum	3-4'	6,208	3,019	0.49	27,162	7,071	0.26
IV	Shade Tree - Acer rubrum	2" diameter	1,869	3,019	1.62	8,177	7,071	0.86
V	Ornamental Tree - Malus	5-6' (1 1/2")	2,732	3,019	1.11	11,954	7,071	0.59
TOTAL			20,759	15,095	0.73	90,867	35,355	0.39

*50 acres total with 40 acres of field growing space, and 10 acres of production facilities, holding area, field bed area, roads etc. Each plant category was assigned 20% of the field production area or 8 acres.

**200 acres total with 175 acres of field growing space, and 25 acres of production facilities, holding area, field bed area, roads etc. Each plant category was assigned 20% of the field production area or 35 acres.

#This represents the total cost for irrigation of the salable plant. In the small nursery, for example, the 8 acres used for producing Slow Growing Evergreens contains a seven-year rotation. Only 1/7 of the area is harvested each year. In addition to field production, Taxus plants spend three years in the propagation house, and three years in liner beds.