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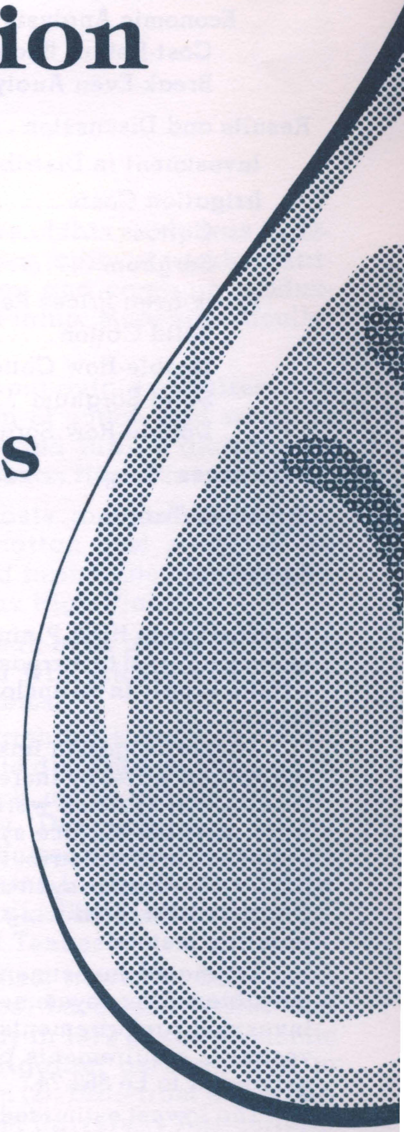
Economic Analysis of Trickle Distribution Systems

Texas High Plains



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Summary

The Texas High Plains is a major agricultural producing area that is using irrigation to increase production. The source of water for irrigation is a finite supply in an enclosed aquifer. This supply will be exhausted in the future.

Trickle irrigation has been developed which could extend the life of the ground water by increasing the efficiency of water use. Fifteen trickle distribution systems were evaluated in this study. Three of the systems were movable surface systems, and twelve were automated subsurface systems. Furrow distribution systems are the conventional methods, and a furrow distribution system was included in the analysis. The systems were evaluated for producing cotton and sorghum in solid and double-row planting methods.

Estimated investment ranged from $49.19 to $60.61 per acre for the movable surface systems. For automated subsurface systems, estimated investment requirements per acre ranged from $562.57 to $1,860.17. Investment requirements per acre for the furrow distribution system was estimated to be $62.74.

The lowest estimated costs per acre for cotton for the movable trickle distribution systems were $36.39, $35.37 for the furrow system and $97.48 for the automated subsurface trickle systems. For sorghum, the lowest estimated costs per acre were $34.20 and $122.80 for the furrow and automated subsurface systems, respectively.

Break-even prices for the furrow systems were less than any of the trickle systems for cotton. The break-even price for the furrow system was only $.001 less per pound than some of the movable surface systems. Break-even prices for automated subsurface trickle systems were higher than similar calculations for furrow systems. The results were similar for sorghum.

ECONOMIC ANALYSIS OF TRICKLE DISTRIBUTION SYSTEMS TEXAS HIGH PLAINS

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The major source of water for irrigation in the Texas High Plains is ground water. Ground water is being mined from an aquifer in the area called the Ogallala which is geologically isolated from major sources of recharge.

The furrow irrigation system is the traditional method for applying irrigation water in the Texas High Plains. Currently, 78 percent of the acreage in the region is irrigated by furrow systems. The application efficiency for furrow systems in this region has been estimated to be as low as 50 percent (1).

Trickle (drip) irrigation is a method for distributing water that has been demonstrated to increase efficiency when compared to other methods of distribution. Water is distributed evenly in small quantities through orifices. With subsurface systems, evaporation and seepage can be reduced.

The economic benefits accruing from irrigated crop production to the economy of the Texas High Plains may be extended into the future by a more efficient system of distribution. Results from research have shown that less water is required for trickle irrigation than for furrow irrigation systems to produce comparable crop yields. Therefore, the withdrawal rate of water from the Ogallala aquifer might be reduced, thus, increasing the number of years that water would be available for irrigation from the Ogallala. A major purpose of this study was to determine the economic feasibility for using trickle irrigation in the production of row crops.

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The overall objective of this study was to determine the economic feasibility of trickle distribution systems in cotton and sorghum production in the Texas High Plains. More specifically, the objectives were

1. To determine input-output requirements in the production of cotton and sorghum by using trickle and furrow distribution systems in the Texas High Plains.
2. To determine costs and returns in the production of cotton and sorghum by using trickle and furrow distribution systems in the Texas High Plains.
3. To determine break-even prices for cotton and for sorghum with trickle and furrow distribution systems.

Considerable research work has been completed concerning trickle distribution systems in foreign countries, such as Israel, Australia, Mexico, England, Italy, Denmark, and Japan. Studies of trickle distribution systems have been conducted in many states in the United States including Utah, Hawaii, California, Arizona, Michigan, Florida, and Texas.

Few economic studies, however, have been conducted for row crops. Lacewell, Wilke, and Baush completed a study in 1972 on the economic implications of sub-irrigation as compared to furrow systems in cotton (2). Data from the experiments at the Texas A&M University Agricultural Research and Extension Center at Lubbock were used to estimate yields, costs, and returns. A conclusion of the study was that before sub-irrigation would be economically feasible in the production of row crops, fixed cost per acre would have to be reduced.

Experiments at the Texas A&M University Research and Extension Center at Lubbock have shown that crop yields using trickle irrigation systems can be high with relatively low levels of water. Water application rates of less than 7-acre inches resulted in yields of nearly 2-½ bales of cotton per acre in 1973 (11).

Methods and Materials

Study Area

The study area included portions of 5 counties in the Texas Panhandle (Bailey, Parmer, Castro, Lamb, and Hale Counties) and is composed of approximately 510,000 acres of medium-textured soils (5, 6). The area is relatively homogenous with respect to soils, weather, and supply of ground water (Figure 1). Average annual precipitation for the study area from 1963 to 1973 ranged from slightly under 16.0 inches in the northwest portion to more than 19.0 inches in the southeast portion, for an average of 17.44 inches (10). The average growing season for the study area from 1964 to 1973 ranged from 201 days in southeast sections to 187 days in northwest sections, with an average of 197 days (10).

Approximately 475,600 acres of cropland are included in the study area, approximately 85 percent of which is irrigated (4, 5). Major crops grown in the area are cotton and sorghum. About 22 percent of the irrigated cropland in the area was used for cotton and 40 percent for sorghum in 1968. Minor crops in the area include corn, wheat, forage crops, soybeans, castors, and vegetables.

Procedures

Systems

Three movable-surface trickle distribution systems, twelve automated subsurface trickle distribution systems, and one furrow distribution system were evaluated in the study. The trickle distribution systems were designed for pump capacities of 60, 120, and 180 gallons per minute (GPM). Pumping units were based on lift, pumping pressure, and system capacity of the different trickle systems.[1]

The furrow distribution system was designed for a 700 gallon per minute well. The selected well yield was chosen to be representative for the study area (4). Well depth for all distribution systems was assumed to be 227 feet with a lift of 200 feet (9).

[1]*Leon New, irrigation specialist with The Texas Agricultural Extension Service, determined the electric submersible motors and pumps for the selected wells.*

Movable-Surface Trickle Distribution Systems: Each lateral was designed to apply 0.1 acre-inch of water in 24 hours (Table 1). Pump capacities for movable-surface distribution systems 1, 2, and 3 were 60, 120, and 180 GPM, respectively; the surface area irrigated by the three systems was 32, 64, and 96 acres, respectively.

Automated Subsurface Trickle Distribution Systems: Electric controls were used to automate the subsurface distribution systems. Tensionmeters were connected to a control box at the well. The control box initiates the pump and opens solenoid valves in the moisture short area. Flow dividers alternate the flow of water into the laterals in the area.

Subsurface systems were designed with laterals and emitters which were 12 to 15 inches below the surface. Emitters and laterals were spaced 40 inches apart for subsurface systems 4 through 9 (Table 1). For subsurface systems 10 through 15, emitters and laterals were spaced 80 inches apart. Emitters in the designs with 80-inch spacings were designed for greater flow rates.

Subsurface distribution systems were designed for two water application rates (0.2 and 0.1 inch per day), three pump capacities (60, 120, and 180 gallons per minute), and three sizes of systems from 16 to 96 acres (Table 1). Automated-subsurface distribution systems were evaluated for solid and double-row cotton, as well as for sorghum.

Furrow System: The furrow distribution system contained 1,637 feet of underground pipe with risers every 200 feet. Twelve joints of gated aluminum pipe which were 20 feet long were included (4, 7). The well was designed to water approximately 96 acres (3). The irrigation efficiency was assumed to be 75 percent for furrow distribution systems.

Economic Analysis

Two methods of economic analysis were used to evaluate the variables in this study.

Cost-Return Budgets: Cost-return budgets were developed for cotton and sorghum. Irrigated and dryland crop enterprises were included (Table 2).

Representative prices for resources for early 1975 were used to develop costs of production. Information for prices of inputs were determined through interviews with agricultural input supply firms and custom operators in the study area.

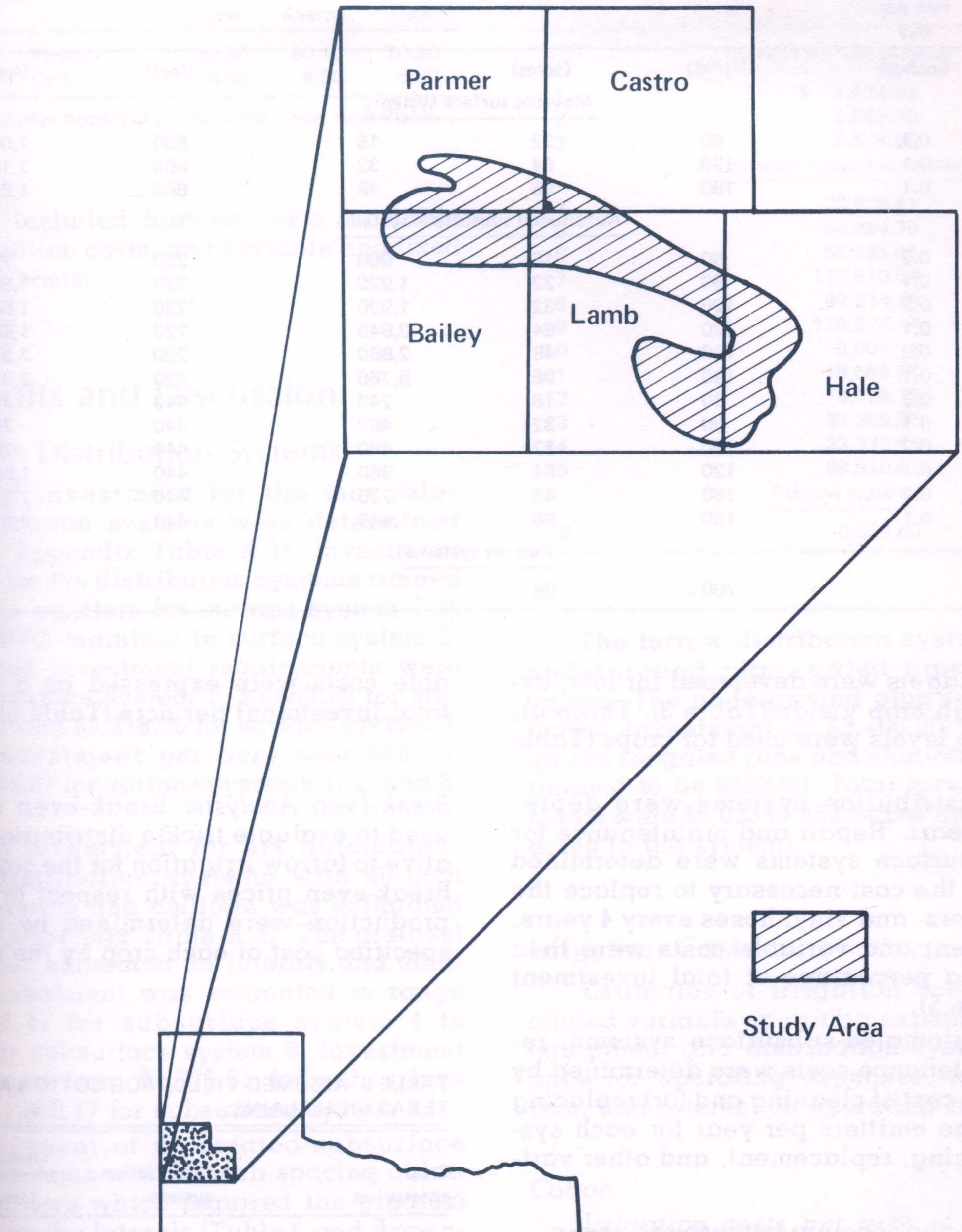

Figure 1. Study Area

TABLE 1. CHARACTERISTICS OF SELECTED DISTRIBUTION SYSTEMS, TEXAS HIGH PLAINS

System	Water application rate per day	Pump capacity	Size of design	Number of laterals	Length of laterals	Dimension of design	
						Width	Length
	(inches)	(GPM)	(acres)		(feet)	(feet)	(feet)
			Movable surface systems				
1	0.1	60	32	16	660	1,068	1,320
2	0.1	120	64	32	660	2,133	1,320
3	0.1	180	96	48	660	1,600	2,400
			Automated subsurface systems				
4	0.2	60	16	960	220	792	880
5	0.1	60	32	1,920	220	1,584	880
6	0.2	120	32	1,920	220	1,584	880
7	0.1	120	64	3,840	220	1,584	1,760
8	0.2	180	48	2,880	220	2,376	880
9	0.1	180	96	5,760	220	2,376	1,760
10	0.2	60	16	240	440	792	880
11	0.1	60	32	480	440	792	1,760
12	0.2	120	32	480	440	792	1,760
13	0.1	120	64	960	440	1,584	1,760
14	0.2	180	48	720	440	2,376	880
15	0.1	180	96	1,440	440	2,376	1,760
			Furrow systems				
16		700	96				

Cost-return budgets were developed for low, average, and high crop yields (Table 3). Three alternative price levels were used for crops (Table 4).

Trickle distribution systems were depreciated for 15 years. Repair and maintenance for the movable-surface systems were determined by estimating the cost necessary to replace the laterals, emitters, and vinyl hoses every 4 years. The replacement and variable costs were then expressed as a percentage of total investment per acre (Table 5).

For the automated-subsurface systems, repair and maintenance costs were determined by estimating the cost of cleaning and (or) replacing 4 percent of the emitters per year for each system. The cleaning, replacement, and other variable costs were expressed as a percentage total investment per acre (Table 5).

TABLE 2. COTTON AND SORGHUM ENTERPRISES, TEXAS HIGH PLAINS

Crop	Planting pattern	Water applied (Ac. In.)	Distribution system
Cotton	Solid	Dryland	[1]
Cotton	Solid	4	Movable-surface
Cotton	Solid	7	Automated-subsurface
Cotton	Solid	14	Furrow
Cotton	Double-row	7	Automated-subsurface
Cotton	Double-row	14	Furrow
Sorghum	Solid	Dryland	[1]
Sorghum	Solid	9	Automated-subsurface
Sorghum	Solid	14	Furrow
Sorghum	Double-row	9	Automated-subsurface
Sorghum	Double-row	14	Furrow

[1] Does not apply to dryland production.

Break-Even Analysis: Break-even analysis w used to evaluate trickle distribution systems r ative to furrow irrigation for the crop enterprise Break-even prices with respect to total costs production were determined by dividing to specified cost of each crop by the specified cr

TABLE 3. ASSUMED YIELDS FOR COTTON AND SORGHUM TEXAS HIGH PLAINS

Crop enterprises	Distribution system	Yields in pounds per a		
		Low	Average	Hi
	Cotton			
Solid dryland	[1]	200	250	30
Solid irrigated	M.S.S.[2]	500	625	75
	A.S.U.S.[3]	500	625	75
	Furrow	500	625	75
Double-row irrigation	A.S.U.S.	625	750	87
	Furrow	625	750	87
	Sorghum			
Solid dryland	[1]	1000	1500	200
Solid irrigated	A.S.U.S.	5000	5500	600
	Furrow	5000	5500	600
Double-row irrigation	A.S.U.S.	5500	6000	650
	Furrow	5500	6000	650

[1] Does not apply to dryland production.
[2] Movable-surface systems.
[3] Automated subsurface system.

TABLE 4. ASSUMED PRICES FOR COTTON AND SORGHUM, TEXAS HIGH PLAINS, 1975[1]

Commodity	Unit	Level of prices		
		Low	Average	High
Cotton lint	Pound	$0.30	$0.40	$0.50
Sorghum	Cwt.	4.00	4.50	5.00

[1]These are representative historical prices in the Texas High Plains, 1975.

yield, which included harvest costs, variable and fixed irrigation costs, and variable and fixed non-irrigation costs.

Results and Discussion

Investment in Distribution Systems

Estimated investment for the movable-surface distribution systems were determined (Table 6 and Appendix Table A.1). Investment requirements for the distribution systems ranged from $66.00 for emitters for surface system 1 to $1,825.20 for PVC mainline in surface system 3. Total estimated investment requirements were $1,574.03 for surface system 1, $3,562.70 for surface system 2, and $5,818.96 for surface system 3. Estimated investment per acre was $49.19, $55.67, and $60.61 for surface systems 1, 2, and 3, respectively.

Required investment for six automated-subsurface distribution systems with 40-inch spacing of laterals and emitters was estimated (Table 6 and Appendix Table A.2). The greatest investment was estimated for laterals and emitters. Total investment was estimated to range from $26,826.41 for subsurface system 4 to $178,576.44 for subsurface system 9. Investment per acre ranged from $1,676.65 for subsurface system 4 to $1,860.17 for subsurface system 9.

The component of automated-subsurface distribution systems with 80-inch spacing of laterals and emitters which required the greatest investment was the laterals (Table 6 and Appendix Table A.3). Investment per acre ranged from $562.57 for subsurface system 10 to $716.78 for subsurface system 15.

TABLE 5. REPAIR AND MAINTENANCE PERCENTAGE ESTIMATES FOR TRICKLE DISTRIBUTION SYSTEMS, 15 YEARS OF LIFE, TEXAS HIGH PLAINS

System	Percent of original investment
Movable-surface	147
Automated-subsurface[1]	81
Automated-subsurface[2]	61

[1]40-inch spacings.
[2]80-inch spacings.

TABLE 6. ESTIMATED INVESTMENT FOR IRRIGATION DISTRIBUTION SYSTEMS, TEXAS HIGH PLAINS, 1975

System	Investment	
	Total	Per acre
	Movable surface systems	
1	$ 1,574.03	$ 49.19
2	3,562.70	55.67
3	5,818.96	60.61
	Automated subsurface systems	
4	26,826.41	1,676.65
5	54,464.20	1,702.01
6	56,531.88	1,766.62
7	112,510.04	1,757.97
8	89,374.23	1,861.96
9	178,576.44	1,860.17
10	9,001.12	562.57
11	18,589.98	580.94
12	19,128.72	597.77
13	39,355.97	614.94
14	33,322.43	694.22
15	68,810.63	716.78
	Furrow system	
16	6,023.00	62.74

The furrow distribution system consisted of underground pipe, gated pipe, and shut-off valves. The underground pipe required an estimated investment of $5,400.00. Investment required for gated pipe and shut-off valves was estimated to be $623.00. Total investment requirements were $6,023 or $62.74 per acre (assuming 96 acres in the system).

Irrigation Costs

Estimates of irrigation costs per acre included variable operating expenses of irrigation equipment and distribution system, hail insurance for operating expenses, labor, depreciation, and interest on operating capital.[2]

Cotton

Irrigation costs per acre of land for cotton with the furrow distribution system was estimated to be $35.37 (Table 7). Irrigation costs for the movable-surface distribution systems ranged from $36.39 per acre for surface system 3 to $41.96 for surface system 1. Surface system 3 had higher per acre irrigation costs ($36.39) than the furrow distribution system ($35.37).

Estimated irrigation costs per acre for automated-subsurface distribution systems with 40-inch spacing of laterals and emitters (systems 4 through 9) ranged from $268.50 for subsurface

[2]Costs for hail insurance were included for expenses directly associated with irrigation.

TABLE 7. ESTIMATED IRRIGATION COSTS PER ACRE OF LAND FOR DISTRIBUTION SYSTEMS, TEXAS HIGH PLAINS, 1975[1]

System[2]	Costs per acre	
	Cotton	Sorghum
	Movable surface systems	
1	$ 41.96	NA
2	37.43	NA
3	36.39	NA
	Automated subsurface systems	
4	269.44	338.62
5	276.09	347.05
6	269.32	338.16
7	268.50	337.43
8	279.27	356.56
9	278.91	350.05
10	105.56	133.21
11	107.99	136.30
12	97.48	122.80
13	99.74	125.67
14	106.56	134.08
15	109.27	137.62
	Furrow system	
16	35.37	34.20

[1]Costs included variable costs of irrigation equipment, hail insurance, interest on operating capital, depreciation on machinery and equipment and labor. Unallocated overhead costs such as pickup expenses, taxes, insurance and depreciation on buildings, and interest on investment in land were not included. Costs for hail insurance were included for expenses directly associated with irrigation.
[2]Systems 1 through 3 were not evaluated for irrigated sorghum.

NOTE: NA means not applicable. Movable surface systems were not included in the analysis for sorghum.

system 7 to $279.27 for subsurface system 8. The estimated cost for subsurface system 8 of $279.27 per acre was the highest for all distribution systems. Estimated irrigation costs per acre with automated-subsurface distribution systems with 80-inch spacing of laterals and emitters (systems 10 through 15) ranged from $97.48 for subsurface system 12 to $109.27 for subsurface system 15.

Sorghum

Irrigation costs per acre of land for sorghum with the furrow distribution system were estimated to be $34.20 (Table 7). Irrigation costs per acre with automated-subsurface distribution systems with 40-inch spacing of laterals and emitters (systems 4 through 9) varied from $337.43 for subsurface system 7 to $356.56 for subsurface system 8. The irrigation cost for subsurface system 8 of $356.56 per acre was the highest for all distribution systems.

Per acre irrigation costs for subsurface distribution systems 10 through 15 ranged from an estimated $122.80 per acre for subsurface system 12 to $137.62 for subsurface system 15. The irrigation cost per acre with subsurface distribution system 12 was the lowest for all trickle systems.

Break-Even Prices Per Unit of Output

Break-even prices per unit of output with respect to total costs and total variable cost were estimated for solid cotton, double-row cotton, solid sorghum, and double-row sorghum.

Solid Cotton

Break-even prices for total costs of production for surface systems 1, 2, and 3 ranged from $.259 to $.270 per pound at a yield of 500 pounds per acre. The break-even price for total cost of production for the furrow distribution system was $.257 per pound. Subsurface systems 10 through 15 had higher break-even prices for total costs which ranged from $.381 per pound for subsurface system 12 to $.40 for subsurface system 14 (Table 8).

For the yields of 625 pounds per acre, break-even prices for total costs of production for surface systems 1, 2, and 3 ranged from $.213 to $.222 cents per pound. Break-even price for total costs with the furrow system was $.211 per pound. Subsurface distribution systems 10 through 15 had break-even prices for total costs which ranged from $.311 to $.33 per pound.

At the high yield per acre (750 pounds), break-even prices for total costs and subsurface systems 1, 2, and 3 ranged from $.182 to $.189 per pound and the furrow system had a break-even price of $.181 per pound. Subsurface distribution systems 10 through 15 had break-even prices for total costs which ranged from $.263 to $.279 per pound. The lowest break-even price for total costs ($.181) was estimated for the furrow distribution system. The highest break-even price was $.279 with subsurface system 15.

Double-Row Cotton

For the low yield level (625 pounds per acre), break-even prices for total costs of production for subsurface distribution systems 10 through 15 ranged from $.317 to $.356 per pound (Table 8). The furrow distribution system had the lowest break-even price for total cost which was $.218 per pound. Break-even price for total variable costs was the lowest with the furrow distribution system ($.179 per pound), and the range for subsurface systems 10 through 15 was from $.194 to $.200 per pound.

With yields of 750 pounds per acre, break-even price for total costs of production with the furrow system was $.186 per pound. Subsurface distribution systems 10 through 15 had break-even prices for total costs which ranged from $.269 to $.285 per pound. Break-even prices for total variable costs of production for subsurface systems 10 through 15 ranged from $.166 to $.172

TABLE 8. ESTIMATED BREAK-EVEN PRICES PER POUND FOR SOLID AND DOUBLE-ROW IRRIGATED COTTON FOR SELECTED YIELDS, TEXAS HIGH PLAINS, 1975[1]

System	Break-even prices for solid		Break-even prices for double-row	
	Total cost	Variable cost	Total cost	Variable cost
	— 500 pounds per acre —		— 625 pounds per acre —	
1[2]	$ .270	$ .208	$ NA	$ NA
2[2]	.261	.208	NA	NA
3[2]	.259	.209	NA	NA
10[4]	.398	.231	.330	.196
11[4]	x	x	.334	.198
12[4]	.381	.229	.317	.194
13[4]	.386	.230	.321	.195
14[4]	.400	.235	.332	.199
15[4]	x	x	.356	.200
16[2]	.257	.210	.218	.179
	— 625 pounds per acre —		— 750 pounds per acre —	
1[2]	.222	.172	NA	NA
2[2]	.215	.172	NA	NA
3[2]	.213	.173	NA	NA
10[3]	.324	.191	.280	.168
11	.327[4]	.192[4]	.283[3]	.169[3]
12[3]	.311	.188	.269	.166
13[3]	.314	.190	.272	.167
14	.325[4]	.193[4]	.281[3]	.170[3]
15	.330[4]	.195[4]	.285[3]	.172[3]
16[2]	.211	.174	.186	.163
	— 750 pounds per acre		— 875 pounds per acre —	
1[2]	.189	.148	NA	NA
2[2]	.183	.148	NA	NA
3[2]	.182	.148	NA	NA
10[3]	.274	.163	.244	.148
11[3]	.277	.165	.246	.149
12	.263[3]	.162[3]	.234	.147
13	.266[3]	.163[3]	.237	.147
14[3]	.276	.166	.245	.150
15[3]	.279	.167	.248	.151
16[2]	.181	.149	.163	.136

[1]Notation "x" designated where net returns of irrigated solid cotton did not exceed dryland net returns at any specified price.
[2]Break-even prices where net returns from irrigated solid cotton exceeded dryland net returns at specified lint prices of $.30, $.40, and $.50 per pound.
[3]Break-even prices where net return from irrigated cotton exceeded dryland net returns at a specified lint price of $.40 and $.50 per pound.
[4]Break-even prices where net returns from irrigated cotton exceeded dryland net returns at a specified lint price of $.50 per pound.
NOTE: NA means not applicable. Movable surface systems were not included in the analysis for double-row cotton production.

per pound. Break-even price for total variable costs was the lowest with the furrow distribution system ($.163 per pound).

Subsurface distribution systems 10 through 15 had break-even prices for total costs which ranged from $.234 to $.248 per pound for the high yield level (875 pounds per acre). Break-even prices for total cost with the furrow distribution was $.163 per pound. Subsurface distribution systems 10 through 15 had break-even prices for total variable costs which ranged from $.147 to $.151 per pound. Break-even price for total variable costs for the furrow distribution system was $.136 per pound.

Solid Sorghum

The estimated break-even prices per hundredweight were determined for total costs and total variable costs in the production of irrigated solid sorghum (Table 9). At the low-yield level (5,000 pounds per acre), break-even prices for total costs of production for subsurface systems 10 through 15 ranged from $4.22 to $4.52 per hundredweight. Sorghum irrigated with a furrow system had the lowest break-even price for total costs which was $2.45 per hundredweight. The break-even price for total variable costs was the lowest with the furrow distribution system ($2.02 per hundredweight), and the range for subsurface systems 10 through 15 was from $.236 to $.245 per hundredweight.

Break-even price for total costs of production at the average yield level (5,500 pounds per acre) for the furrow distribution system was the lowest at $2.26 per hundredweight. Sorghum production with subsurface systems 10 through 15 had break-even prices for total costs which ranged

TABLE 9. ESTIMATED BREAK-EVEN PRICES PER HUNDREDWEIGHT FOR SOLID AND DOUBLE-ROW IRRIGATED SORGHUM FOR SELECTED YIELDS, TEXAS HIGH PLAINS, 1975

System	Break-even prices for solid		Break-even prices for double-row	
	Total cost	Variable cost	Total cost	Variable cost
	– 5,000 pounds per acre –		– 5,500 pounds per acre –	
10	$ 4.43[3]	$ 2.39[3]	$ 4.10[2]	$ 2.24[2]
11	4.49[3]	2.42[3]	4.16[2]	2.26[2]
12	4.22[2]	2.36[2]	3.91[1]	2.21[1]
13	4.28[2]	2.38[2]	3.96[1]	2.23[1]
14	4.45[3]	2.43[3]	4.11[2]	2.27[2]
15	4.52[3]	2.45[3]	4.18[2]	2.30[2]
16[1]	2.45	2.02	2.30	1.90
	– 5,500 pounds per acre –		– 6,000 pounds per acre –	
10	4.06[3]	2.21[3]	3.79[2]	2.08[2]
11	4.11[3]	2.23[3]	3.84[2]	2.10[2]
12	3.87[2]	2.18[2]	3.61[1]	2.05[1]
13	3.92[2]	2.19[2]	3.66[1]	2.07[1]
14	4.07[3]	2.24[3]	3.80[2]	2.11[2]
15	2.14[3]	2.26[3]	3.86[2]	2.13[2]
16[1]	2.26	1.87	2.14	1.77
	– 6,000 pounds per acre –		– 6,500 pounds per acre –	
10	3.75[3]	2.05[3]	3.52[2]	1.95[2]
11	3.80[3]	2.07[3]	3.57[2]	1.97[2]
12	3.57[2]	2.02[2]	3.36[1]	1.92[1]
13	3.62[2]	2.04[2]	3.41[1]	1.94[1]
14	3.76[3]	2.08[3]	3.54[2]	1.99[2]
15	3.82[3]	2.10[3]	3.59[2]	2.00[2]
16[1]	2.10	1.74	2.00	1.66

[1] Break-even prices where net returns from irrigated sorghum exceeded dryland net returns at specified prices of $4.00, $4.50, and $5.00 per hundredweight.
[2] Break-even prices where net returns from irrigated sorghum exceeded dryland net returns at specified prices of $4.00 and $5.00 per hundredweight.
[3] Break-even prices where net returns from irrigated sorghum exceeded dryland net returns at a specified price of $5.00 per hundredweight.

from $3.87 to $4.14 per hundredweight. Break-even prices for total variable costs of production for subsurface systems 10 through 15 ranged from $2.18 to $2.26 per hundredweight. Break-even price for total variable cost was the lowest with the furrow distribution system ($1.87 per hundredweight).

At the high-yield level (6,000 pounds per acre), break-even prices for total costs of production for subsurface systems 10 through 15 ranged from $3.57 to $3.82 per hundredweight. The furrow distribution system had a break-even price for total costs which was $2.10 per hundredweight. Break-even prices for total variable costs of production for subsurface systems 10 through 15 ranged from $2.02 to $2.10 per hundredweight. The break-even price for total variable costs with the furrow system was the lowest at $1.74 per hundredweight.

Double-Row Sorghum

Break-even prices for total costs of production for subsurface systems 10 through 15 for the low-yield level (5,500 pounds per acre) ranged from $3.91 to $4.18 per hundredweight (Table 9). Furrow irrigated sorghum had the lowest break-even price for total costs ($2.30 per hundredweight). The break-even price for total variable costs of production was the lowest for the furrow distribution system ($1.90 per hundredweight), and the range for subsurface systems 10 through 15 was estimated to be from $2.21 to $2.30 per hundredweight.

Break-even price for total costs of production at the average yield level (6,000 pounds per acre) for the furrow distribution system was the lowest at $2.14 per hundredweight. Sorghum production with subsurface systems 10 through 15 had break-even prices for total costs which ranged from $3.61 to $3.86 per hundredweight. Break-even prices for total variable costs of production for subsurface systems 10 through 15 ranged from $2.05 to $2.13 per hundredweight. Furrow irrigated sorghum had the lowest break-even price for total variable costs of production ($1.77 per hundredweight).

At the high-yield level (6,500 pounds per acre), break-even prices for total costs of production for subsurface systems 10 through 15 ranged from $3.36 to $3.59 per hundredweight. Sorghum production with the furrow distribution system had a break-even price which was the lowest at $2.00 per hundredweight. Break-even prices for total variable costs of production for subsurface systems 10 through 15 ranged from $1.92 to $2.00 per hundredweight. The break-even price for total variable costs for the furrow system was the lowest at $1.66 per hundredweight.

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Appendix Tables

APPENDIX TABLE A.1. ESTIMATED INVESTMENT FOR MOVABLE-SURFACE TRICKLE DISTRIBUTION SYSTEMS, TEXAS HIGH PLAINS, 1975

Item	Movable-surface systems		
	Number 1	Number 2	Number 3
PVC mainline	$ 285.00	$ 929.20	$1,825.20
Laterals	464.64	929.28	1,393.92
Emitters	66.00	132.00	198.00
Installation labor	74.80	151.80	228.80
Trenching and backfilling	190.00	404.00	856.00
Filtration system	198.00	396.00	444.00
Other items[1]	295.59	640.20	873.04
Total investment	1,574.03	3,562.70	5,818.96
Investment per acre[2]	49.19	55.67	60.61

[1] Included all items, not listed in separate categories such as ells, tees, glue, etc.

[2] Systems 1, 2, and 3 were designed for 32, 64, and 96 acres, respectively.

APPENDIX TABLE A.2. ESTIMATED INVESTMENT FOR AUTOMATED-SUBSURFACE TRICKLE DISTRIBUTION SYSTEMS, TEXAS HIGH PLAINS, 1975

Item	Automated-subsurface systems[1]					
	Number 4	Number 5	Number 6	Number 7	Number 8	Number 9
PVC mainline	$ 785.68	$ 2,337.32	$ 3,330.88	$ 7,154.56	$10,350.48	$ 21,774.56
PVC submainline	414.00	828.00	2,108.70	4,217.40	3,195.00	6,390.00
Laterals	8,448.00	16,896.00	16,896.00	33,792.00	25,344.00	50,688.00
Emitters	7,603.20	15,206.40	15,206.40	30,412.80	22,809.60	45,619.20
Electrical system	4,909.35	10,089.80	8,909.65	17,128.98	12,707.45	24,569.50
Installation labor	2,426.60	4,842.20	4,804.80	9,603.00	7,176.40	14,348.40
Trenching and backfilling	341.60	658.40	743.75	1,597.00	1,060.50	2,231.00
Sandseparator(s)	150.00	150.00	300.00	300.00	300.00	300.00
Other items[2]	1,747.98	3,456.08	4,231.70	8,304.30	6,430.80	12,655.78
Total investment	26,826.41	54,464.20	56,531.88	112,510.04	89,374.23	178,576.44
Investment per acre[3]	1,676.65	1,702.01	1,766.62	1,757.97	1,861.96	1,860.17

[1] The automated-subsurface systems listed were designed with laterals and emitters on 40-inch spacing.

[2] Included all items not listed in separate categories such as ells, tees, glue, etc.

[3] Systems 4, 5, 6, 7, 8, and 9 were designed for 16, 32, 32, 64, 48, and 96 acres, respectively.

APPENDIX TABLE A.3. ESTIMATED INVESTMENT FOR AUTOMATED-SUBSURFACE TRICKLE DISTRIBUTION SYSTEMS, TEXAS HIGH PLAINS, 1975

Item	Automated-subsurface systems[1]					
	Number 10	Number 11	Number 12	Number 13	Number 14	Number 15
PVC mainline	$ 349.60	$ 1,104.00	$ 1,684.80	$ 4,480.00	$ 6,298.00	$14,743.20
Laterals	4,224.00	8,448.00	8,448.00	16,896.00	12,672.00	25,344.00
Emitters	1,900.80	3,801.60	3,801.60	7,603.20	5,702.40	11,404.80
Electrical system	957.34	2,132.88	1,838.80	3,717.60	2,746.95	5,615.15
Installation labor	646.80	1,280.40	1,280.40	2,530.00	1,905.20	3,792.80
Trenching and backfilling	152.00	480.00	480.00	1,000.00	742.00	1,704.00
Sandseparator(s)	150.00	150.00	300.00	300.00	300.00	300.00
Other items[2]	620.58	1,193.10	1,295.12	2,829.17	2,955.88	5,906.68
Total investment	9,001.12	18,589.98	19,128.72	39,355.97	33,322.43	68,810.63
Investment per acre[3]	562.57	580.94	597.77	614.94	694.22	716.78

[1] The automated-subsurface systems listed were designed with laterals and emitters on 80-inch spacing.

[2] Included all items not listed in separate categories such as ells, tees, glue, etc.

[3] *Systems 10, 11, 12, 13, 14, and 15 were designed for 16, 32, 32, 64, 48, and 96 acres, respectively.*

APPENDIX TABLE B.1. ESTIMATED NET RETURNS FOR SOLID AND DOUBLE-ROW IRRIGATED COTTON FOR SELECTED PRICES AND YIELDS, TEXAS HIGH PLAINS, 1975[1]

Lint price per pound	System[2]	Net returns per acre: Solid	Net returns per acre: Double-row
		– 500 pounds per acre –	– 625 pounds per acre –
$.30	1	$14.78	$ NA
	2	19.31	NA
	3	20.35	NA
	16	21.37	51.45
.40	1	64.78	NA
	2	69.31	NA
	3	70.35	NA
	10	x	43.76
	11	x	41.33
	12	x	51.84
	13	x	49.58
	14	x	42.76
	15	x	40.05
	16	71.37	113.95
.50	1	114.78	NA
	2	119.31	NA
	3	120.35	NA
	10	51.18	106.16
	11	x	103.83
	12	50.26	114.34
	13	57.00	112.08
	14	50.18	105.26
	15	x	102.55
	16	121.37	176.45
		– 625 pounds per acre –	– 750 pounds per acre –
$.30	1	48.86	$ NA
	2	53.39	NA
	3	54.43	NA
	12	x	23.41
	16	55.45	85.52
.40	1	111.36	NA
	2	115.89	NA
	3	116.93	NA
	10	47.76	90.33
	11	x	87.90
	12	55.84	98.41
	13	53.58	96.15
	14	x	89.43
	15	x	86.62
	16	117.95	160.52
.50	1	173.86	NA
	2	178.39	NA
	3	179.43	NA
	10	110.26	165.33
	11	107.83	162.90
	12	118.34	173.41
	13	116.08	171.15
	14	109.26	164.43
	15	106.55	161.62
	16	180.45	235.52

APPENDIX TABLE B.1. continued

Lint price per pound	System[2]	Net returns per acre: Solid	Net returns per acre: Double-row
		– 750 pounds per acre –	– 875 pounds per acre –
$.30	1	82.93	$ NA
	2	87.46	NA
	3	88.50	NA
	10	x	49.30
	11	x	46.87
	12	x	57.38
	13	x	55.12
	14	x	48.30
	15	x	45.59
	16	89.52	119.49
.40	1	157.93	NA
	2	162.46	NA
	3	163.50	NA
	10	94.33	136.80
	11	91.90	134.37
	12	102.41	144.88
	13	100.15	142.62
	14	93.33	135.80
	15	90.62	133.09
	16	164.52	206.99
.50	1	232.93	NA
	2	237.46	NA
	3	238.50	NA
	10	169.33	224.30
	11	166.90	221.87
	12	177.41	232.38
	13	175.15	230.12
	14	168.33	223.30
	15	165.62	220.59
	16	239.52	294.49

[1] Yield comparisons of irrigated and dryland cotton were as follows:

	Solid irrigated	Double-row irrigated	Dryland
Low yield	500 lbs.	625 lbs.	200 lbs.
Average yield	625 lbs.	750 lbs.	250 lbs.
High yield	750 lbs.	875 lbs.	300 lbs.

Dryland net returns were as follows:

Yield	Price	Net Returns
200 lbs.	$.30	$ 8.94
	.40	28.94
	.50	48.94
250 lbs.	.30	22.61
	.40	47.61
	.50	72.61
300 lbs.	.30	36.18
	.40	66.18
	.50	96.18

Notation "x" designated net returns of irrigated cotton which did not exceed dryland net returns at the specified price. NA means not applicable. Movable surface systems were not included in the analysis for double-row cotton production.

[2] Systems not appearing in the table under each specified price and quantity have been omitted because the net returns of dryland cotton exceeded the net returns of the enterprise with which that system was associated.

APPENDIX TABLE B.2 ESTIMATED NET RETURNS FOR SOLID AND DOUBLE-ROW IRRIGATED SORGHUM FOR SELECTED PRICES AND YIELDS, TEXAS HIGH PLAINS, 1975[1]

Sorghum price per pound	System[2]	Net returns per acre Solid	Double-row
		– 5,000 pounds per acre –	– 5,500 pounds per acre –
$4.00	12	$ x	$ 4.96
	13	x	2.09
	16	77.61	93.56
4.50	10	x	22.05
	11	x	18.96
	12	14.01	32.46
	13	11.14	29.59
	14	x	21.18
	15	x	17.64
	16	102.61	121.06
5.00	10	28.60	49.55
	11	25.51	46.46
	12	39.01	59.56
	13	36.14	57.09
	14	27.73	48.68
	15	24.19	45.14
	16	127.61	148.56
		– 5,500 pounds per acre –	– 6,000 pounds per acre –
$4.00	12	x	23.21
	13	x	20.34
	16	95.86	111.81
4.50	10	x	42.80
	11	x	39.71
	12	34.76	53.21
	13	31.89	50.34
	14	x	41.93
	15	x	38.39
	16	123.36	141.81
5.00	10	51.85	72.80
	11	48.76	69.71
	12	62.26	83.21
	13	59.39	80.34
	14	50.98	71.93
	15	47.44	68.39
	16	150.86	171.81
		– 6,000 pounds per acre –	– 6,500 pounds per acre –
$4.00	12	x	41.46
	13	x	38.59
	16	114.11	130.06
4.50	10	x	63.55
	11	x	60.46
	12	55.51	73.96
	13	52.64	71.09
	14	x	62.68
	15	x	59.14
	16	144.11	162.56
5.00	10	75.10	96.05
	11	72.01	92.96
	12	85.51	106.46
	13	82.64	103.59
	14	74.23	95.18
	15	70.69	61.64
	16	174.11	195.06

[1]Yield comparisons of irrigated soil sorghum and dryland sorghum were as follows:

	Solid irrigated	Double-row irrigated	Dryland
Low yield	5,000 lbs.	5,500 lbs.	1,000 lbs.
Average yield	5,500 lbs.	6,000 lbs.	1,500 lbs.
High yield	6,000 lbs.	6,500 lbs.	2,000 lbs.

Dryland net returns were as follows:

Yield	Prices	Net Returns
1,000 lbs.	$4.00	$ .65
	4.50	4.35
	5.00	9.35
1,500 lbs.	4.00	18.35
	4.50	25.85
	5.00	33.35
2,000 lbs.	4.00	37.35
	4.50	47.35
	5.00	57.35

Notation "x" designated net returns of irrigated sorghum which not exceed dryland net returns at specified price.

[2]Systems not appearing in the table under each specified price a quantity have been omitted because the net returns of dryland sorghum exceeded the net returns of the enterprise with which that system was associated.

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