Application and Economics of Linear Irrigation for Precision Agriculture

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Summary:
The current trend for conversion to more efficient and precise irrigation is dominated by center pivots and some drip irrigation. Commonly overlooked are mechanical move linears. Historically linear irrigation tends to only be considered for large, rectangular fields or very high value crops. This paper will focus on the application and economics of linear irrigation for a variety of sizes and shapes of fields. The analysis will include a look at capital investment, operation and maintenance costs. In addition limitations of linear irrigation will be presented.

Objective:
To present information on the viability of linear irrigation for small, irregular shaped fields

Introduction:
Many people when they think of linear irrigation think primarily of large fields (320ac / 130ha or larger) being irrigated from a canal. For irrigating irregular shaped fields, traveling guns, solid set, SDI, and center pivots, either with corner arms, part circle operation or towable operation are usually the only considered options. Product changes and improvements by mechanized irrigation manufacturers have lead to a variety of cost effective linears for smaller, irregular shaped fields.

Discussion:
Too often linears are not even considered for small irregular shaped fields. Linears can in many cases bring the advantages of center pivots (application efficiency and uniformity, cost effectiveness, and low labor requirements) to these smaller, irregular fields. Linears have been introduced by manufacturers recently allowing for small, two wheel carts which may be towed forward and reverse and/or swung around. These units generally use a maximum of center pivot components and commonly do not use the more complex floating alignment or special carts required for the large field linears. In addition these small, flexible linears commonly pull fairly long hoses and have the ability to reverse without having to move the hose. This overcomes one of the primary disadvantages of linears – labor to handle and move the hose. The following examples will be used to illustrate the potential advantages of a linear. The prices and costs are in relative terms compared to the linear.

Example 1
Water source – well in center of field
Flow – 150gpm
Annual application – 8in per year
Field - 660 x 1320, rectangular shaped field, 20 acres
Power - generator

Irrigation	Traveling Gun	Center pivot Towable	Center pivot Part circle	Linear
Acres irrigated	19.1	18.2	17.9	19.3
Number of sets	3	2	1	1
Annual costs				
Energy	+$ 594	-$ 59	-$ 9	$ 0
Lease (5yr)	-$ 3,959	-$ 3,945	-$ 1,576	$ 0
Labor	+$ 1,680	+$ 840	+$ 0	$ 0
	-$ 1,685	-$ 3,164	-$ 1,585	$ 0
Crop revenue	-$ 1,614	-$ 1,110	-$ 868	$ 0
Net difference	+$ 71	+$ 2,054	+$ 717	$ 0

The energy costs are based on diesel fuel at $ 1.65 per gallon. The lease is for the irrigation equipment only and does not include the cost of the pump or pipeline. Labor is considered to be $35/hour. No cost is assigned to equipment to move the traveler or the towable pivot. Due to the higher horsepower required for the traveling gun, the pump investment would be greater. Also the traveling gun and towable pivot would require additional pipeline.

As shown in example 1 it will cost the operator $71 more per year to use the linear over the traveling gun, $ 2,054 more than for the towable pivot and $ 717 more than for the part circle center pivot. The additional advantages the linear provides which are difficult to put a value on are:

- Farm in straight rows and square blocks
  - No concern about applying too much seed or fertilizer in corners
- Lower average instantaneous application rates
- Higher uniformity of application
- Easy to apply small applications for germination, chemical activation or other reasons.

Example 2
Water source – well in center of field
Flow – 150gpm
Annual application – 12in per year
Field - 660 x 1320, rectangular shaped field, 20 acres
Power - generator

Irrigation	Traveling Gun	Center pivot Towable	Center pivot Part circle	Linear
Acres irrigated	19.1	18.2	17.9	19.3
Number of sets	3	2	1	1
Annual costs				
Energy	+$ 890	-$ 89	-$ 13	$ 0
Lease (5yr)	-$ 3,959	-$ 3,945	-$ 1,576	$ 0
Labor	+$ 2,520	+$ 1,260	+$ 0	$ 0
	-$ 549	-$ 2,596	-$ 1,589	$ 0
Crop revenue	-$ 1,614	-$ 1,110	-$ 868	$ 0
Net difference	-$ 1,065	+$ 1,486	+$ 721	$ 0

As shown in example 2 as labor changes due to more applications per year, this example shows using the linear it will save the operator $ 1,065 per year over a traveling gun and now costs the operator $ 1,486 more than for the towable pivot and $ 721 more than for the part circle center pivot. The assumptions and conditions are the same as in example 1. The additional advantages are similar to Example 1.

Example 3
Water source – well in center of field
Flow – 250gpm
Annual application – 8in per year
Field - 660 x 1980, rectangular shaped field, 30 acres
Power - generator

Irrigation	Traveling Gun	Center pivot Towable	Center pivot Part circle	Linear
Acres irrigated	25.5	27.3	17.9	29.0
Number of sets	6	3	1	1

Annual costs				
Energy	+$ 890	-$ 89	-$ 13	$ 0
Lease (5yr)	-$ 3,959	-$ 3,945	-$ 1,576	$ 0
Labor	+$ 2,520	+$ 1,260	+$ 0	$ 0
	-$ 549	-$ 2,596	-$ 1,589	$ 0
Crop revenue	-$ 4,568	-$ 1,302	-$ 8,360	$ 0
Net difference	-$ 4,019	+$ 1,294	-$ 6,771	$ 0

As shown in this example as the field shape changes and the flow the costs change dramatically. Now the linear will save the operator $ 4,019 over the traveling gun and $ 6,771 over the part circle center pivot due to the combination of labor and lost revenue due to the amount of the field the part circle pivot will miss. The towable pivot would be less expensive as long as the issue of moving it does not become a major burden. The additional advantages besides those previously stated of the linear in example 3 are:

- Minimal amount of labor compared to the traveling gun and towable pivot
- Maximum land utilization particularly when compared to the part circle center pivot

Example 4

Water source – well in center of field
Flow – 250gpm
Annual application – 12in per year
Field - 660 x 1980, rectangular shaped field, 30 acres
Power - generator

Irrigation	Traveling Gun	Center pivot Towable	Center pivot Part circle	Linear
Acres irrigated	27.3	25.5	17.9	29.0
Number of sets	6	3	1	1
Annual costs				
Energy	+$ 1,335	-$ 134	-$ 20	$ 0
Lease (5yr)	-$ 3,959	-$ 3,945	-$ 1,576	$ 0
Labor	+$ 3,780	+$ 1,890	+$ 0	$ 0
	+$ 1,156	-$ 2,189	-$ 1,596	$ 0
Crop revenue	-$ 4,568	-$ 1,302	-$ 8,360	$ 0
Net difference	-$ 5,724	+$ 887	-$ 6,764	$ 0

As shown in this final example as labor changes due to more applications per year, using the linear will save the operator $5,724 per year over a traveling gun and due to the lower revenue will save the operator $ 6,764 over using the part circle pivot. The cost to operate the linear is still more than for the towable pivot ($ 887). If the field conditions require frequent light applications the labor calculations for the towable pivot will be too low. The general conditions remain the same for this example.

Conclusion:
Linear irrigation should not be automatically ruled out without consideration to the overall design. Specific parameters which favor linear irrigation would be labor required, field utilization efficiency and crop value. In many cases when all of these factors are accounted for the linear may provide a positive annual cash flow over other types of irrigation.

Small, linear irrigation units bring a number of advantages which are difficult to apply a value to such as farming with square fields, uniform application and maximization of potential irrigated area. In addition once the unit is paid off in five years (as in the examples above) the net benefit would be significantly greater for the linear systems.

Limitations of linears are:

- Higher degree of management required
- Initial investment is usually higher
- Labor if not properly designed.

The perception that linears have little place in the irrigation of small fields may be in many cases incorrect.

References:
Personal communication with irrigation dealers and manufacturers.

Valmont Linear Design Guide