SELECTING SPRINKLER PACKAGES FOR LAND APPLICATION OF LIVESTOCK WASTEWATER

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INTRODUCTION

Livestock operations have changed dramatically in the last ten years. For example the number of hog farms has decreased from 600,000 to 157,000 in the last fifteen years. (Harkin 1998) During this same time the overall output of pork has increased. This increase of size also indicates an increased concentration of animals. Problems associated with any traditional livestock production unit are multiplied as the size increases. Management of the wastewater stream becomes a major component of the management strategy. Maintaining the environmental quality for the area of the livestock operation is critical to the overall success.

Livestock wastes may be applied by a number of methods. Tractor towed manure spreaders or slurry wagons are used to apply to the soil surface. Tractor towed slurry tanks with equipment to 'inject' the waste into the soil are used. Another choice is a plow down system where a tractor tows an injection unit attached to a long hose connected to a pump and the lagoon. On-land application units such as fixed head sprinklers, traveling guns or a center pivots are also commonly used.

Decisions on the type of waste application system are important to the economics of the livestock operation. Timing is one issue, which plays a key role in determining application methods (Hardeman 1997). Most of the methods listed above are only viable in the spring before the crop is planted or in the fall after it is harvested. Center pivots are not however limited by whether a crop is present or not as they may be used to apply over an active crop.

Center pivots, due to their characteristics, are considered to have advantages with regards to applying livestock wastes, particularly from a lagoon with large amounts of water to handle. Some of these characteristics include limited labor input required, application uniformity, ease in handling large quantities of effluent rule and the three-quarters-plus rule. These general guidelines are broadly applied to two categories of systems, those with runoff reuse and those without runoff reuse.

Systems with Runoff Reuse

When runoff is reused, apply the less-than-half rule to obtain uniform application: the average furrow advance time should be less than half of the total set time. The exception is the first irrigation of the year when advance should take closer to 60-65% of the total irrigation time. This rule will be easier to follow as the season progresses and advance times quicken, as furrows tend to smooth out. If the irrigator normally uses 12-hour sets, shorter set times should generally be used during the first irrigation, to avoid uniformly over-irrigating the whole field.

Systems without reuse of runoff

If there is no reuse system, apply the three-quarters-plus rule to estimate the advance time: water should get to the end of the field in about three fourths of the total irrigation set time. This rule applied throughout the growing season, both for early season and later irrigations. For example: if you run 12-hour irrigations, your set size should be adjusted so that water reaches the end of the field in an average of 9 hours. Although a 9-hour advance time follows the three-quarters plus rule, a 12-hour set time may still result in poor irrigation uniformity and efficiency. For the first irrigation of the season when the root zone is shallow, 12-hour sets are likely too long on 1/4 mile rows.

Blocking the lower end of the field is one method that is sometimes used to retain water that would otherwise be runoff. The practice of blocking furrow ends often results in excessive deep percolation, especially at the downstream end of the field. If blocked-end furrows are used, apply the three-quarters-plus advance time rule discussed earlier. By properly managing blocked-end furrow irrigation, deep percolation cannot be eliminated, but it can be minimized.

Summary

The goal of every irrigator should be to apply the right amount of water as uniformly as possible to meet the crop needs. With a better understanding of how irrigation system management affects water distribution and a willingness to make management changes, the uniformity and efficiency of most surface irrigation systems can be improved. This paper presented some generalized irrigation management rules-of-thumb that if properly applied will improve irrigation system performance. Application of the *cutoff ratio* concept to evaluate irrigation performance was also illustrated. More detailed *cutoff ratio* resources are available through Nebraska Cooperative Extension.

and particularly the ability to apply to actively growing crops with minimal negative impact to the crop.

Operators readily invest in major capital improvements and equipment to facilitate the production of meat or milk by providing the best possible environment for the animals. However most producers have a strong reluctance to invest in more than the minimum required to meet existing local, state and federal environmental regulations for disposal of the wastewater. If the investment does not add value to their operation - why make the expenditure?

DISCUSSION

Land application of wastewater with center pivot and linear irrigation equipment has been used for more than thirty years. Until the late 1970's the land application package was easy to select, as the choices were limited to relatively high-pressure impact sprinklers (50psi) or the Valley Slurry Shooter™ using high volume sprinklers (90psi). Since the early 1980's the equipment and techniques for irrigating with fresh water have changed dramatically to the point the pressures at the nozzle inlet may be as low as 6psi. Currently more than five major classes of sprinkler packages are being used with many options within each class – pad styles being the main option. In many cases both water for reuse and fresh water are applied with the same equipment. Midwest Plan Service's MWPS-30 (MWPS, 1999) discusses general principles in sprinkler selection relating to fresh water application but does not attempt to quantify any procedure or specifically look at effluent application. Other publications have provided general discussions without offering a specific procedure – Livestock Waste Facilities Handbook (MWPS, 1993), Liquid Manure Application Systems Design Manual (NRAES, 1998) and Agricultural Waste Management Field Handbook (USDA, 1992)

Then also in today's world one must take into account the issues and public perception of land application systems. Land application of wastes may be imposing in some locations, potentially dangerous conditions relative to environmental quality (Hegde 1997). We must insure any equipment being used for land application meets public scrutiny.

OBJECTIVE

How does one select the optimum sprinkler package for a particular waste water situation?

DISCUSSION

Currently many sprinkler packages are selected by irrigation dealers and customers based on personal experience and preference. Some of these general sprinkler categories are:

type	orifice diameters	pad	pressure
drag hose	4/64 to 24/64in	none	6 to 10psi
fixed pad	4/64 to 24/64in	fixed	6 to 20psi
rotating pad	4/64 to 24/64in	rotating	15 to 30psi
impact	9/64 to 40/64in	n/a	40 to 60psi
high volume guns	0.50 to 0.94in	N/A	45 to 90psi

A systematic approach does not exist to assistance in the decision making process. Experience has taught that "if it worked the last time, it should work again" or "that is what my neighbor's doing".

It is recommended looking at each system individually to make the selection on the best information available.

To begin the process information is required about the particular application:

- Material being applied
  - Estimated solids content
  - Organic material
  - Inorganic material
  - Particle size
- Environmental constraints
  - Ground water wells
  - Neighbors
  - Tile line
- Management issues
  - Operating costs
  - Energy costs
  - Maintenance
- CAFO permit constraints

Then look at how the wastewater stream is handled –

- Collection
- Treatment (if any)
- Storage
- Pump system
- Position of inlet of the pump

We have tried to develop a quantitative approach to the selection of a recommended sprinkler package based on the information collected. To do this we apply the information to a ranking system

First assign 1-5 points for each item based on the headings –

Value to assign	1	2	3	4	5
Item			Range		
1 - Solids content	<0.5%	1.0%	2.0%	3.0%	>4.0%
2 - Particle size	small		medium		large
3 - Pump impeller	closed		semi open		open
4 - Pump inlet	floating				bottom
5 - Labor costs	low		medium		high
6 - Energy costs	high		medium		low
7 - Environment	high		medium		low
8 - Storage	2 stage Lagoon		1 stage lagoon		pit
9 - Collection	flushing				scraper
10 – Pump style	fresh water		slurry		chopper
11 – Uniformity (CU)	85		75		65

Minimum number of possible points – 11
Maximum number of points - 55

This is the range within which to work with the lower the number tending to indicate a wastewater stream, which has limited solids content and small particles. The closer a number approaches 55 the thicker the wastewater and larger the particles.

Some of the items are relatively easy to estimate – others such as the solids content are very difficult. The following table is one way to characterize the solids in a waste stream.

First visualize a bucket with the manure in it. Then start tipping the bucket -

Angle from ground	how it flows	estimated solids
45 degrees above	smooth stream	1 to 2%
30 degrees above	in small globs	3%
15 degrees above	in quarter sized globs	4%
0 degrees, bucket parallel to ground	fist sized globs	5%

45 degrees, pouring down	thick chunks	6%

This table allows a method to roughly estimate the solids content based on how the effluent flows.

Using the point total one goes into the table to select a recommended sprinkler type.

Point Total	Type	Pad	Pressure
10 to 19	low pressure on drops	fixed	6 to 20psi
20 to 29	low pressure on drops	rotating	15 to 30psi
30 to 39	impact	n/a	40 to 60psi
40 to 50	high volume guns	n/a	45 to 90psi

A worksheet was developed to allow a person to 'fill-in-the blank' with the data and information collected. One does the best to estimate and make a selection based o experience and quantitative data if available.

Sprinkler Selection Worksheet

Item
Ranking

1) -Solids content – _____ consistancy _____% ___
2) Particle size _____ inches ___

3) Pump impellor _____ ___
4) Pump inlet _____ ___

5) Labor costs _____ $/hr ___
6) Energy costs _____ ¢/kw-hr or gallon ___

7) Environment _____ issues ___
8) Storage _____ ___

9) Collection _____ ___
10) Pump style _____ ___
11) Uniformity _____ ___

Total Points ___

Ranking	type	pad	pressure
11 to 19		fixed	6 to 20psi
20 to 29		rotating	15 to 30psi
30 to 39	impact	n/a	40 to 60psi
40 to 55	high volume guns		45 to 90psi

Sprinkler package selected – ________________

Pad type if applicable – ________________

Pressure selected - ________________

Testing of the selection process

Example 1 **-** Single stage dairy lagoon, limited labor, no neighbors within two miles, flushing system, wants to pump from bottom, is not nutrient limited. Primarily system to be used for land application and not irrigation.

Item ranking			
1) Solids content –	thick consistancy	4%	4
2) Particle size	3/16 inches (pieces of corn cob)		4
3) Pump style	slurry		4
4) Pump impellor	semi open		3
5) Pump inlet	on bottom of lagoon		5
6) Labor costs	9.25 $/hr		4
7) Energy costs	4.25 ¢/kw-hr or gallon		2
8) Environment	no issues		5
9) Collection	flushing		1
10) Storage	pit		5
11) Uniformity	low		5
		Total Points	42

Ranking	type	pad	pressure
10 to 19		fixed	6 to 20psi
20 to 29		rotating	15 to 30psi
30 to 39	impact	n/a	40 to 60psi
40 to 50	high volume guns		45 to 90psi

Sprinkler package selected
minimum of impact sprinkler, hig volume gun suggested

Pad type if applicable -
Not applicible to impact or volume guns

Pressure selected –
Minimum suggested of 45psi

Example 2 - *two* stage hog lagoon, limited labor, no neighbors within two miles, plug/pull system, wants to pump from top w/ floating pump, wants no problem with plugging and will use for irrigation

Item ranking			
1) Solids content –	thin	<.5%	1
2) Particle size	3/16 inches (trash in lagoon, in-organics		4
3) Pump style	fresh water		1
4) Pump impellor	closed		1
5) Pump inlet	on top of lagoon		1
6) Labor costs	20.00 $/hr		4
7) Energy costs	2.25 ¢/kw-hr or gallon		2
8) Environment	no issues		5
9) Collection	flushing		1
10) Storage	two stage lagoon		1
11) Uniformity	high		1
		Total Points	22

Ranking	type	pad	pressure
10 to 19		fixed	low
20 to 29		rotating	low to medium
30 to 39	impact	n/a	medium to high
40 to 50	high volume guns		high

Sprinkler package selected

From ranking – rotating pad

But customer suggestions wants no problems

A combination system may be the best choice. Utilizing the wider spacing of the sprinklers with rotating pads for the first portion of the center pivot until a larger nozzle size is reached.

SUMMARY

The model has proved to be successful in the actual situations where it has been applied as a decision tool. This is process is not perfect and one must apply reasonable judgement in selecting a sprinkler package. Also the process is only as good as the data which is collected. As with any tool care must be taken to consider all factors and apply appropriately.

In addition center pivots can successfully used to meet requirements for minimizing environmental impact of spray drift and runoff and also meet customer requirement for monitoring and reporting by the selection of equipment options.

Livestock systems continue to evolve. Rations, genetics and housing systems have changed significantly in the last five years. Feeding and manure handling systems continue to change. As production units change the irrigation industry is working on equipment to continue to meet customer's requirements.

Center pivots continued to be an accepted option for land application of wastewater generated from a CAFO particularly if a lagoon or storage reservoir is used. This type of equipment provides the control and monitoring capabilities required by many CAFOs (LaRue 1998).

In many cases the CAFO may have different constraints from traditional farm livestock units. In these cases, alternative treatment such as the Sheaffer MRRS, (Sheaffer, 1998) anaerobic digestion or other methods may need to be utilized to reduce the nutrient, odor and sludge. Once the treatment process is completed, the remaining liquid fraction may be land applied with a center pivot or other system designed to handle large volumes of low nutrient strength water.

As is always the case the operator must be aware and follow local and state regulations.

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USING LIVESTOCK WASTEWATER WITH SDI
A STATUS REPORT AFTER THREE SEASONS

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ABSTRACT

Using subsurface drip irrigation (SDI) with lagoon wastewater has many potential advantages. The challenge is to design and manage the SDI system to prevent emitter clogging. A study was initiated in 1998 to test the performance of five types of driplines (with emitter flow rates of 0.15, 0.24, 0.40, 0.60, and 0.92 gal/hr-emitter) with lagoon wastewater. A disk filter (200 mesh, with openings of 0.003 inches) was used and shock treatments of chlorine and acid were injected periodically. Over the course of three seasons (1998-2000) a total of approximately 52 inches of irrigation water has been applied through the SDI system. The flow rates of the two smallest emitter sizes, 0.15 gal/hr-emitter and 0.24 gal/hr-emitter have decreased approximately 30% during the three seasons, indicating some emitter clogging. The three largest driplines (0.40, 0.60, and 0.92 gal/hr-emitters) have had less than 5% reduction in flow rate. The disk filter and automatic backflush controller have performed adequately with the beef livestock wastewater in all three years. Based on these results, the use of SDI with beef lagoon wastewater shows promise. However, the smaller emitter sizes normally used with groundwater sources in western Kansas may be risky for use with lagoon wastewater and the long-term (> 3 growing seasons) effects are untested.

INTRODUCTION

In response to increasing nationwide concern about problems associated with livestock wastewater generated by confined animal feeding operations, K-State Research and Extension initiated a project to address odor, seepage into groundwater and runoff into surface water supplies. Subsurface drip irrigation (SDI) is a potential tool that can alleviate all three problems, while still utilizing livestock wastewater as a valuable resource for crop production. A study was begun in 1998 on a commercial beef feedlot to answer the engineering question, ***"Can SDI be successfully used to apply livestock wastewater?"***

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