University of Idaho Extension

BULLETIN 888

Costs of Liquid-Manure Application Systems

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Introduction

Concentrated animal feeding operations (CAFOs) have a requirement to spread both solid and liquid manure to crop fields in a manner that minimizes the potential for contamination of air and water. Idaho dairies deal with large volumes of liquid waste, and they need efficient, environmentally sound, economical, and nutrient-saving application methods. This publication evaluates the costs of four liquid-manure field application methods available to Idaho dairies: knife injection, disk injection, broadcast, and drag hose.

Assumptions and Information Sources

While several models and capacities of tank systems are available, this publication summarizes probable costs of operation for a 7,400-gallon tanker unit. Distance from the lagoon or pit to the field for application was assumed to be 2 miles (Mancl and Slates, 2003).

Two time and motion studies (Harrigan 1997, Harrigan 2010) were used as the basis for calculating equipment scheduling for the comparisons. Factors included loading time at the pit/lagoon, travel to and from the field, in-field maneuvering, loading of the application tanker by the nurse tanker, and application time. Times for a single tanker that returned to the pit to refill and for a single tanker refilled by two nurse tankers were compared.

Cost calculations (MACHCOST 2013) are based on 500 hours annual use for the tractor and 200 hours annual use for the injection system. Tractor operator labor is estimated at $11.70/hour; diesel is estimated at $4.00/gallon. Purchase costs of equipment are from *Costs of Owning and Operating Farm Machinery in the Pacific Northwest* (Painter 2011) and (Smith Equipment Co. 2012). Typically, nurse tankers are a used semi-tractor and used liquid tank trailer such as a used milk tank trailer. A mid-size 185 horsepower (HP) tractor and power take-off (PTO) lagoon pump are used to load the tankers at the pit. The drag hose system eliminates the need for nurse tankers and return trips to the lagoon for refilling.

Assumptions and Findings by Application Method

Note: Detailed cost tables are in the appendix. Table 1 summarizes costs of the four systems.

Knife injection

The knife injection unit used for comparison is a 12-foot-wide, five-knife injection unit that utilizes a 7,400-gallon tanker at a discharge rate of 1,125 gpm.

A 225 PTO HP tractor is needed to pull this unit at an average ground speed of 7 mph during application (Smith Equipment Co. 2012). The tank is discharged in approximately 6.7 minutes. Approximately 2.4 acres per hour can be covered with the unit based on the unit returning to the lagoon to refill. If two nurse tankers are used to fill the unit, approximately 4.5 acres per hour can be covered.

For a single tanker unit without nurse tanker support, the estimated cost is $224.56 per hour or $93.45 per acre (table A1). If two nurse tankers are employed to

Table 1. Application method cost comparison.

	Power unit & implement	
	$/hour	$/acre
Single knife injection unit, no nurse tanker support	$224.56	$93.45
Combined cost of knife injection unit with 2 nurse tankers and manure pump	$407.85	$80.50
Single disk injection unit, no nurse tanker support	$213.00	$86.80
Combined cost of disk injection unit with 2 nurse tankers and manure pump	$396.29	$81.13
Single broadcast unit, no nurse tanker support	$226.07	$65.58
Combined cost of broadcast unit with 2 nurse tankers and manure pump	$409.36	$64.99
Knife injection drag hose unit + diesel pump and lines	$369.65	$72.61

keep the application tanker filled, the estimated cost is $407.85 per hour or $80.50 per acre (table A2).

Disk injection

A 12-foot-wide, five-disk injection unit utilizes a 7,400-gallon tanker at a discharge rate of 1,125 gpm.

A 215 PTO HP tractor is needed to pull this unit at an average ground speed of 7 mph during application (Smith Equipment Co. 2012). The tank is discharged in approximately 6.7 minutes. Approximately 2.5 acres per hour can be covered with the unit based on the unit returning to the lagoon to refill. If two nurse tankers are used to fill the unit, approximately 4.2 acres per hour can be covered.

For a single tanker unit without nurse tanker support, the estimated cost is $213.00 per hour or $86.80 per acre (table A3). If two nurse tankers are employed to keep the application tanker filled, the estimated cost is $396.29 per hour or $81.13 per acre (table A4).

Broadcast

This broadcast method uses a 7,400-gallon tanker with a 1,300 gpm discharge rate and a 15-foot-wide broadcast unit.

A 185 PTO HP tractor is needed to pull this unit at an average ground speed of 8 mph during application (Smith Equipment Co. 2012). The tank is discharged in approximately 5.7 minutes. Approximately 3.4 acres per hour can be covered with the unit based on the unit returning to the lagoon to refill. If two nurse tankers are used to fill the unit, approximately 6.6 acres per hour can be covered.

For a single tanker unit without nurse tanker support, the estimated cost is $226.07 per hour or $65.58 per acre (table A5). If two nurse tankers are employed to keep the application tanker filled, the estimated cost is $409.36 per hour or $64.99 per acre (table A6). The broadcast cost per acre is lowest due to its almost continuous operation and higher ground speed.

Drag hose

The drag hose system assumes a 12-foot-wide knife injection unit. Times for returns to the pit to refill or refilling nurse tankers are eliminated.

A 250 PTO HP tractor is needed to pull this unit at an average ground speed of 3.5 mph during application (Smith Equipment Co. 2012). Approximately 5.0 acres per hour can be covered with the unit because it can operate almost continuously except for turning and hose manipulation (Newagtalk 2012).

A 270 HP stationary or trailer-mounted manure pump and mainline plus in-field drag hoses are needed to supply the unit. If the distance to the field exceeds 2 miles, a booster pump would be needed.

The estimated cost for this drag hose unit, including the manure pump and lines to reach the field, is $369.65 per hour or $72.61 per acre (table A7).

Nutrient Retention

The value of keeping the nitrogen (N) component of the liquid is not calculated in this comparison. Nitrogen is an unstable substance, and when exposed to the surface and atmosphere it can quickly volatize and the fertilizer value lost. With the three injection systems, the nitrogen is below the surface and will remain in place for a longer time. Injection of the liquid waste reduces the risks of run-off, air emissions, and pollution from application as well. Although the broadcast system costs least per acre, the material is on the surface. To retain the N value and avoid environmental concerns, the material would need to be incorporated very soon after application. That would involve another machine operation and some potential loss of N, depending on the length of the delay between application and incorporation.

Conclusion

Table 1 and figure 1 summarize the costs of the four systems. The lowest-cost system is broadcasting. As noted above, this is the one system that surface applies rather than injects the material. As a result, a cultivation operation is needed to incorporate the material and reduce volatilization of nitrogen. The drag hose system is the least expensive of the three injection systems. Which system a user would purchase will depend on the user's particular circumstances. Those would include distance to fields for application, equipment already owned that could be utilized for application, and labor availability.

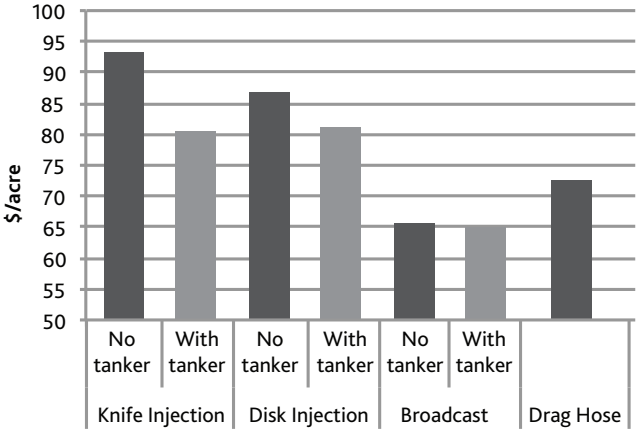

Figure 1. Comparison of application methods on a per-acre basis.

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Appendix

Table A1. Costs of single knife injection unit, no nurse tanker support.

	Power unit		Implement		Power unit & implement	
	$/hour	$/acre	$/hour	$/acre	$/hour	$/acre
Ownership costs						
Depreciation	22.57	9.39	45.2	18.81	67.77	28.2
Interest	15.62	6.50	23.56	9.80	39.18	16.30
Taxes, housing, insurance, license	2.68	1.12	2.02	0.84	4.70	1.96
Total ownership costs	40.87	17.01	70.78	29.46	111.65	46.47
Operating costs						
Repairs and maintenance	6.53	2.72	46.18	19.22	52.72	21.94
Fuel*	41.16	17.13			41.16	17.13
Lubricants*	6.17	2.57			6.17	2.57
Total operating costs	53.86	22.41	46.18	19.22	100.04	41.63
Labor	12.87	5.36			12.87	5.36
Labor + operating costs	66.73	27.77	46.18	19.22	112.91	46.99
Total cost	107.60	44.78	116.96	48.67	224.56	93.45

* Fuel and lubricant costs are always assigned to the power unit.

Table A2. Combined costs of knife injection unit with 2 nurse tankers and manure pump.

	Power unit		Implement		Power unit & implement	
	$/hour	$/acre	$/hour	$/acre	$/hour	$/acre
Ownership costs						
Depreciation	50.38	7.84	60.88	11.44	111.26	19.28
Interest	34.73	5.37	33.52	6.79	68.25	12.16
Taxes, housing, insurance, license	5.96	0.92	6.24	0.81	12.20	1.73
Total ownership costs	91.07	14.12	100.64	19.05	191.71	33.17
Operating costs						
Repairs and maintenance	11.60	1.95	55.71	11.40	67.32	13.35
Fuel*	103.56	22.63			103.56	22.63
Lubricants*	15.53	3.39			15.53	3.39
Total operating costs	130.69	27.96	55.71	11.40	186.40	39.36
Labor	29.74	7.97			29.74	7.97
Labor + operating costs	160.43	35.93	55.71	11.40	216.14	47.33
Total cost	251.50	50.05	156.35	30.45	407.85	80.50

* Fuel and lubricant costs are always assigned to the power unit.

Table A3. Costs of single disk injection unit, no nurse tanker support.

	Power unit		Implement		Power unit & implement	
	$/hour	$/acre	$/hour	$/acre	$/hour	$/acre
Ownership costs						
Depreciation	25.60	10.43	41.58	16.95	67.18	27.38
Interest	15.45	6.30	21.67	8.83	37.12	15.13
Taxes, housing, insurance, license	2.65	1.08	1.86	0.76	4.51	1.84
Total ownership costs	43.70	17.81	65.11	26.53	108.81	44.34
Operating costs						
Repairs and maintenance	5.50	2.24	42.49	17.32	47.98	19.56
Fuel*	37.68	15.36			37.68	15.36
Lubricants*	5.65	2.30			5.65	2.30
Total operating costs	48.83	19.90	42.49	17.32	91.32	37.22
Labor	12.87	5.24			12.87	5.24
Labor + operating costs	61.70	25.14	42.49	17.32	104.19	42.46
Total cost	105.40	42.95	107.60	43.85	213.00	86.80

* Fuel and lubricant costs are always assigned to the power unit.

Table A4. Combined costs of disk injection unit with 2 nurse tankers and manure pump.

	Power unit		Implement		Power unit & implement	
	$/hour	$/acre	$/hour	$/acre	$/hour	$/acre
Ownership costs						
Depreciation	53.41	8.89	57.26	11.26	110.67	20.15
Interest	34.56	5.57	31.63	6.69	66.19	12.26
Taxes, housing, insurance, license	18.73	0.95	6.08	0.80	12.01	1.75
Total ownership costs	93.90	15.41	94.97	18.77	188.87	34.18
Operating costs						
Repairs and maintenance	10.57	1.80	52.02	11.22	62.58	13.02
Fuel*	100.08	22.42			100.08	22.42
Lubricants*	15.01	3.36			15.01	3.36
Total operating costs	125.66	27.57	52.02	11.22	177.68	38.79
Labor	29.74	8.16			29.74	8.16
Labor + operating costs	155.40	35.73	52.02	11.22	207.42	46.95
Total cost	249.30	51.14	146.99	29.99	396.29	81.13

* Fuel and lubricant costs are always assigned to the power unit.

Table A5. Cost of single broadcast unit, no nurse tanker support.

	Power unit		Implement		Power unit & implement	
	$/hour	$/acre	$/hour	$/acre	$/hour	$/acre
Ownership costs						
Depreciation	19.89	5.77	36.16	10.49	56.05	16.26
Interest	13.76	3.99	18.84	5.47	32.60	9.46
Taxes, housing, insurance, license	2.36	0.68	1.62	0.47	3.98	1.15
Total ownership costs	36.01	10.45	56.62	16.42	92.63	26.87
Operating costs						
Repairs and maintenance	5.75	1.67	77.56	22.5	83.32	24.17
Fuel*	32.40	9.40			32.40	9.40
Lubricants*	4.86	1.41			4.86	1.41
Total operating costs	43.01	12.48	77.56	22.5	120.57	34.98
Labor	12.87	3.73			12.87	3.73
Labor + operating costs	55.88	16.21	77.56	22.5	133.44	38.71
Total cost	91.89	26.66	134.18	38.92	226.07	65.58

* Fuel and lubricant costs are always assigned to the power unit.

Table A6. Combined cost of broadcast unit with 2 nurse tankers and manure pump.

	Power unit		Implement		Power unit & implement	
	$/hour	$/acre	$/hour	$/acre	$/hour	$/acre
Ownership costs						
Depreciation	47.70	5.85	51.84	6.90	99.54	12.75
Interest	32.87	3.99	28.80	4.42	61.67	8.41
Taxes, housing, insurance, license	5.64	0.68	5.84	0.61	11.48	1.29
Total ownership costs	86.21	10.52	86.48	11.93	172.69	22.45
Operating costs						
Repairs and maintenance	10.82	1.38	87.09	12.94	97.92	14.32
Fuel*	94.80	18.41			94.80	18.41
Lubricants*	14.22	2.76			14.22	2.76
Total operating costs	119.84	22.53	87.09	12.94	206.93	35.47
Labor	29.74	7.07			29.74	7.07
Labor + operating costs	149.58	29.60	87.09	12.94	236.67	42.54
Total cost	235.79	40.12	173.57	24.87	409.36	64.99

* Fuel and Lubricant Costs are always assigned to the power unit.

Table A7. Costs of knife injection drag hose unit + diesel pump and lines.

	Power unit		Implement		Power unit & implement	
	$/hour	$/acre	$/hour	$/acre	$/hour	$/acre
Ownership costs						
Depreciation	41.70	8.19	64.23	12.61	105.93	20.80
Interest	28.86	5.67	33.20	6.52	62.06	12.19
Taxes, housing, insurance, license	4.95	0.97	2.85	0.56	7.80	1.53
Total ownership costs	75.51	14.83	100.28	19.70	175.79	34.53
Operating costs						
Repairs and maintenance	5.18	1.01	66.97	13.16	72.14	14.17
Fuel*	94.64	18.60			94.64	18.60
Lubricants*	14.20	2.78			14.20	2.78
Total operating costs	114.02	22.39	66.97	13.16	180.99	35.55
Labor	12.87	2.53			12.87	2.53
Labor + operating costs	126.89	24.92	66.97	13.16	193.86	38.08
Total cost	202.40	39.76	167.25	32.85	369.65	72.61

* Fuel and lubricant costs are always assigned to the power unit.

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Published March 2014