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Assessment of Windrow Turners

Aeromaster PT-120 **Agricultural Loader** **Allu SM 2-12**

Brown Bear PTO PA35-10.5 **Earthsaver CT-12-PTO**

Scat 481 **Wildcat FX700**

By
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Abstract

Alberta producers are considering composting to address odour problems, health concerns, and environmental sustainability while adding value and improving transportability of manure to offset the costs of management practices. Though the benefits of composting are obvious, many producers have legitimate questions about the equipment needed, costs, and quality of the compost produced. The machinery to turn the windrows is a key component to produce quality compost, yet the source of the largest fixed and operating costs.

The machinery efficiency varied between the seven windrow turners used. All turners produced good quality compost and sustained adequate temperatures to destroy pathogens, weed seeds, and fly larvae. No statistical difference was evidenced between windrow turners regarding volume and mass reduction.

Assessment of Windrow Turners

Introduction

Producers are expanding their manure management strategies to incorporate new environmental considerations into their plan. As a result Alberta Agriculture Food and Rural Development has been flooded with questions regarding manure management options, including composting and available windrow turning equipment.

Alberta producers want to find ways to address odour problems, health concerns and environmental sustainability while adding value and improving transportability of manure to offset the costs of management practices. Composting can address the problems and concerns surrounding intensive livestock operations and offers many benefits to producers. Composting has become a key component of manure management in many intensive livestock areas and has recently been successfully applied in Alberta's unique operations and climate by several local producers and institutions.

Though the benefits of composting are obvious many producers have legitimate questions about the equipment needed, costs and quality of the compost produced. The machinery to turn the windrows is a key component to produce quality compost, yet the source of the largest fixed and operating costs. Machinery for windrow turning includes front-end loaders, rotating drums, flail configurations, conveyors, and augers. Producers require examples of the machinery options and information on costs and quality of work before they can make a confident assessment of how composting will work in their manure management strategy.

Materials and Methods

To promote composting, five compost sites with multiple windrows were managed in southern Alberta over three years. The mechanical and biological efficiencies of seven different compost turners were tested. The machines included an agricultural loader, an Allu SM 2-12 bucket with screening drums, a Scat 481 and a Wildcat FX700 which turned half the profile at a time, an Aeromaster PT-120, a Brown Bear PTO PA35-10.5, and an Earthsaver CT-12-PTO which turned the entire profile at once.

Each of the turners tested and their respective windrows were monitored closely. The temperature of each windrow and weather conditions were recorded hourly throughout the entire composting process. The windrows were sampled weekly to study the moisture, nitrogen, phosphorus, potassium, organic matter,

and other elements. Cross-sectional profiles of the windrows were taken before and after each turning to display any shape changes, and the average size and volume reduction. The windrows were turned weekly until the active composting stage ended. A data acquisition system was used to monitor and record electronic measurements from the tractor during the turnings. Measurements on the hydraulically operated machines included hydraulic flow, hydraulic pressure and fluid temperature. For PTO driven machines the torque and speed of the PTO were measured.

Equipment Tested

Aeromaster PT-120

The AgTech Centre tested the PT-120 tow-type Aeromaster with the model WT-1000 water tank. The Aeromaster uses a rotating drum with bolt-on tines to turn the windrow as shown in Figure 1. A windrow 3 m (10 ft) wide by 1.4 m (4.5 ft) high can be turned in one pass. A 150-270 RPM drum speed and hood design ensures a natural triangular shape of the windrow. The hood and drum assembly lift up hydraulically; in the event of a breakdown the turner can be removed without destroying the windrow. Water can be supplied to the windrow, during the turning, by a pull-behind water tank and nozzles located underneath the hood.

Figure 1 – Aeromaster PT-120

Agricultural Loader

A New Holland 7312 front-end loader was used with a New Holland 8560 tractor to aerate the windrows. The bucket was simply filled with material and dumped out (Figure 2). The operator must maneuver the tractor appropriately so all the material in the windrow is turned.

Figure 2 – Agricultural Loader

Allu SM 2-12

An Allu SM 2-12 bucket was tested at the AgTech Centre. The windrow turner consists of a frame (bucket design) without a back plate, onto which two to four screening and crushing drums are mounted. Once the Allu has a bucket full of material the hydraulics that rotate the drums are turned on allowing the material to pass through the drums (Figure 3). The operator must maneuver the tractor so that all the material in the windrow is turned. The type of drums, counter blade, and rotation speed used determines the size of the processed material. The rotation of the drums can be reversed to loosen material.

Figure 3 – Allu SM 2-12

Figure 4 – Brown Bear PTO PA35-10.5

Brown Bear PTO PA35-10.5

The three-point hitch mount PTO operated Brown Bear tested at the AgTech Centre was the model PTO PA35-10.5. The Brown Bear, shown in Figure 4, uses a saw-tooth paddle auger to turn the windrows. The turning mechanism moves the entire windrow to the right, ensuring all the material is aerated. This model can turn a windrow 3.2 m (10.5 ft) wide by 1.2 m (4 ft) high.

Earthsaver CT-12-PTO

The Earthsaver CT-12-PTO (Figure 5) tested by the AgTech Centre was modified by the owners for attachment to their tractor. A hydraulic pump operated by the tractor PTO powers the turner. The Earthsaver uses a rotating drum with solid flails to turn the windrows. A windrow 3.7 m (12 ft) wide by 2 m (6.5 ft) high can be turned in one pass. The wheels are mounted on hydraulically driven telescoping support legs, which are operated independent of each other. The legs are adjusted to suite the size of the windrow.

Figure 5 – Earthsaver CT-12-PTO

Scat 481

The tow-type Scat model tested by the AgTech Centre (Figure 6) was very similar to the Scat 481 available to producers. The only difference is the model tested had a PTO powered hydraulic pump and the Scat 481 has a diesel motor powered hydraulic pump. The Scat has an elevating face with shredding teeth to process the compost. Adjustable vanes at the top of the elevating face determine the shape of the windrow. The face is driven hydraulically and is reversible. The Scat can turn a windrow 3.7 m (12 ft) wide by 1.5 m (5 ft) high with two passes. The elevating face ground clearance is adjustable from 0 to 25.4 cm (0 to 10 in).

Figure 6 – Scat 481

Wildcat FX700

The three-point hitch mount PTO operated Wildcat tested by the AgTech Centre was the model FX700. The Wildcat uses a rotating drum with solid flails to turn the windrows. A windrow 4.3 m (14 ft) wide by 1.2 m (4 ft) high can be turned in two passes as shown in Figure 7. A supporting arm extending over the windrow is equipped with a hydraulic ram to help adjust the height and stabilize the windrow turner.

Figure 7 – Wildcat FX700

Machinery Efficiency

The horsepower requirements and capacity of composting machinery is necessary to help producers interested in composting select a machine that will meet their needs when considering cost and performance. The horsepower requirements of the turners tested were measured while turning the windrows. For PTO operated machines the torque and speed of the PTO were measured. For machines operated hydraulically, the hydraulic pressure, flow, and temperature were measured.

The maximum and average horsepower requirements for the Aeromaster, Allu, Brown Bear, Earthsaver, Scat, and Wildcat tested at the AgTech Centre are shown in Figure 8. Generally, the first turning requires the most horsepower; as the active composting stage progresses and materials break down the horsepower required reduces. The turners that turn the entire width of the windrow in one pass (Aeromaster, Brown Bear, and Earthsaver) required more horsepower than those that turn half the width (Scat and Wildcat). Of the full width turners the Aeromaster required the least horsepower due to the mechanical design and low turning RPM. The Brown Bear required the most horsepower; the auguring design ensures all the material is moved but requires significant horsepower. Of the half width turners the Wildcat required more horsepower than the Scat due to extremely different mechanical designs. The Allu required the least horsepower of the turners tested. Power was required in small intervals only when the material was being processed out of the bucket.

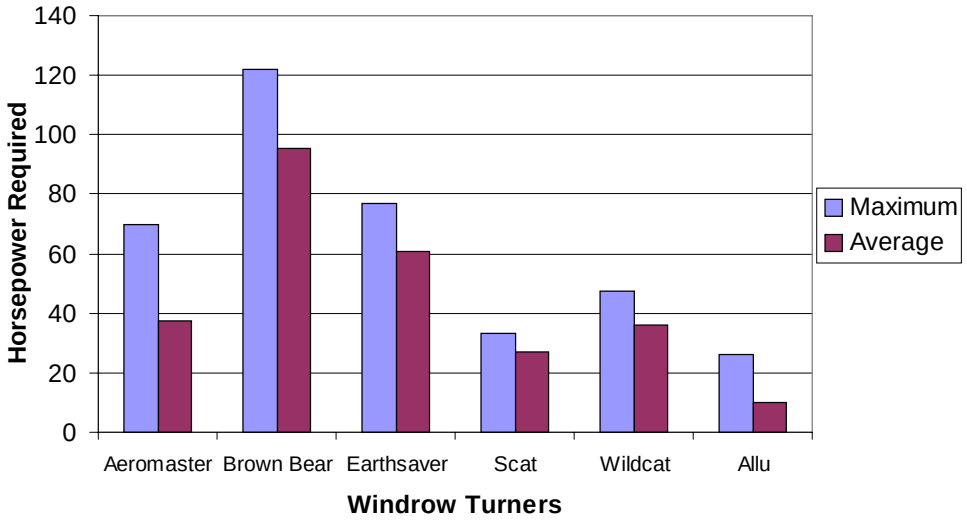

Figure 8 – Horsepower Required for Windrow Turners

The time required for each of the windrow turners tested and respective capacities are shown in Table 1. The most time was spent on the Wildcat due to the hydraulic support arm and three-point hitch design. The capacity increased throughout the series of turnings for each turner, except the loader, due to changes of the material, bulk density, volume, and particle size.

Table 1 – Capacity of Windrow Turners

Turners	Hook-up Time	Un-hook Time	Turn testing windrow		Total		Capacity	
			first turning	last turning	first turning	last turning	first turning	last turning
	(min.)	(min.)	(min.)	(min.)	(min.)	(min.)	(t/hr)	(t/hr)
Aeromaster	5	5	3.97	3.21	13.97	13.21	**387**	**475**
Ag Loader	n/a	n/a	14.36	14.36	14.36	14.36	**146**	**146**
Allu	n/a	n/a	21.77	16.55	21.77	16.55	**96**	**127**
Brown Bear	10	8	3.94	3.13	21.94	21.13	**402**	**483**
Earth Saver	12	10	10.94	4.62	32.94	26.62	**144**	**329**
Scat	8	5	6.64	5.36	19.64	18.36	**316**	**392**
Wildcat	20	30	6.32	3.97	56.32	53.97	**332**	**529**

Compost Produced

Each of the turners tested produced quality compost. Compost was coffee coloured and the texture was similar to loam or potting soil. Table 2 contains comparisons between quality, particle size and consistency, time above 40°C (104°F), and profile shape. Temperatures above 40°C (104°F) destroy pathogens, weed seeds, and fly larvae in the composting material. Studies show that after two weeks of composting nearly all weed seed viability has been destroyed. The average active composting stage for all turners was 6 weeks.

Table 2 – Compost Characteristic Comparisons

	Aeromaster	Ag Loader	Allu	Brown Bear	Earthsaver	Scat	Wildcat
Quality	High	Low	High	High	High	High	High
Particle Size	*	large	small	*	*	small	small
Variation	*	inconsistent	small	*	*	large	small
Time Above 40 degrees C	> 6 weeks	6 weeks	6 weeks	5 weeks	> 6 weeks	5 weeks	6 weeks
Profile Shape	machine dependent	machine dependent	machine dependent	machine dependent	machine dependent	machine dependent	machine dependent

***** See Figure 9 for more detailed results.

The porosity of compost is a combination of the free air space and the volume of the moisture within the material. The free air space is dictated by the structure of the material created by the particles. Generally, a good structure has a high level of porosity, therefore good air flow through the windrow.

A particle size distribution test was performed on the product produced by the Aeromaster, Brown Bear, and Earthsaver. The results are shown in Figure 9. The Aeromaster had more particles that were greater than 9.5 mm (.37 in). Most of these particles were pieces of straw which help to form a positive structure for air to flow through and are a result of a slow turning RPM of the machine.

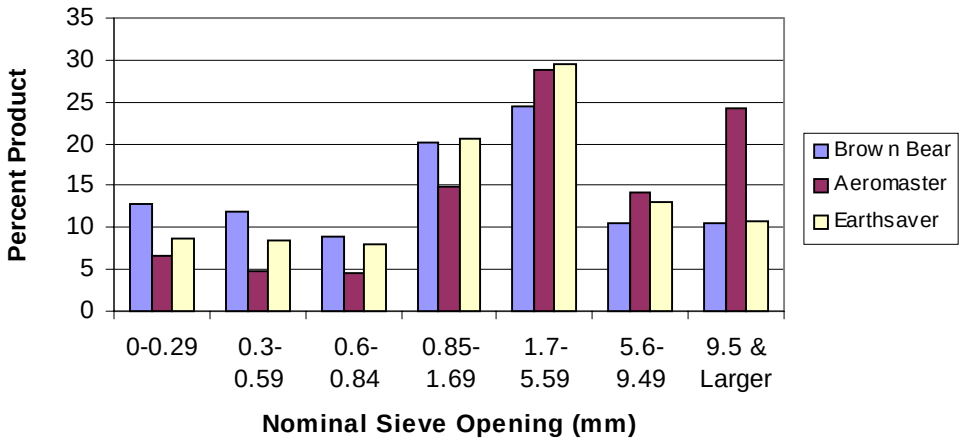

Figure 9 – Particle Size Distribution

Volume and Mass Reduction

The volume and mass reduction for the Aeromaster, Brown Bear, and Earthsaver are shown in Figure 10. There is no statistical difference between the windrow turners regarding volume and mass reduction. Volume reductions achieved were less than other published values. The measurements used to calculate the volumes were taken while the material was still in the windrows. In windrow form the material has a crumb structure with free air spaces to allow oxygen to travel through, which increases the overall volume. The appearance that the Aeromaster did not reduce the volume as much as the other turners is due to the crumb structure of the windrows.

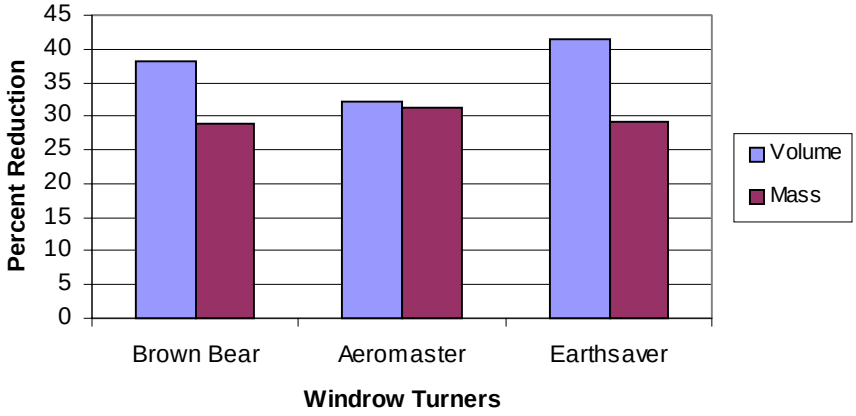

Figure 10 – Overall Mass and Volume Reductions

Nutrients

Samples were taken from each windrow prior to every turning. The organic matter (Figure 11) differed between windrow turners. The rotating drum style turners retained higher organic matter contents than the other turners.

The nutrient present in the final compost varied between sites. The levels of nitrogen, phosphorus and potassium remained constant throughtout the composting process, regardless fo the turner.

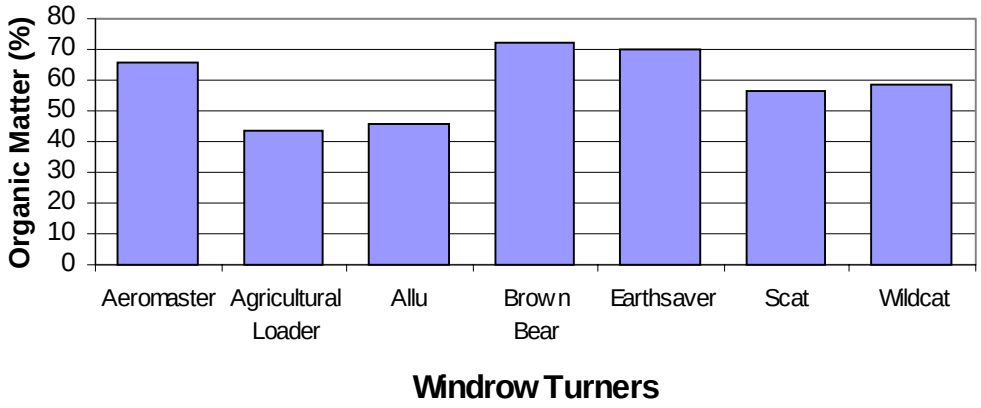

Figure 11 – Organic Matter Content

Economics

Composting of manure has costs associated with the machinery and operation. The cost analysis shown in Figure 12 is based on 100 hours of operation per year for 15 years and current economic states. The cost of a tractor and labour to operate the equipment is not incorporated into this analysis. The producer must clean pens and haul the manure regardless of composting; therefore, these costs were not considered. The differences in the operation costs are directly related to the differences in the purchase prices. The Aeromaster, Allu, and Brown Bear are all available from dealers in Alberta, therefore shipping charges are minimized. The Earthsaver, Scat, and Wildcat are manufactured and sold from the United States and shipping charges may be significant.

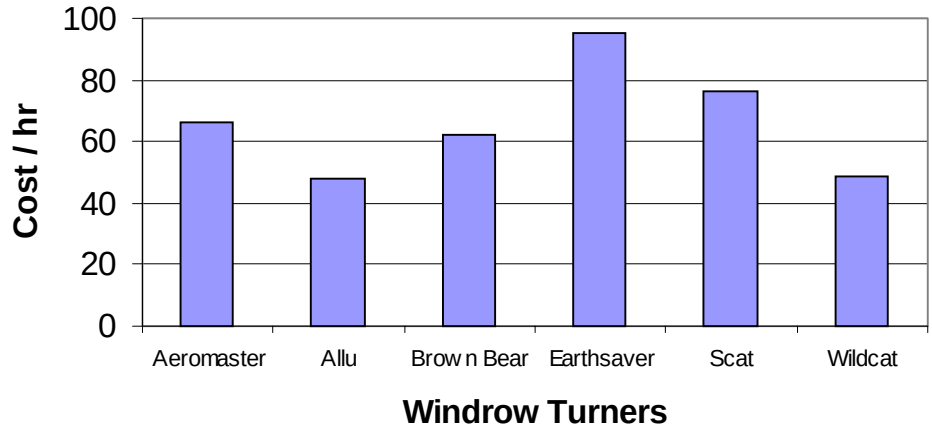

Figure 12 – Composting Costs

Results

Aeromaster PT-120

- Produced high quality compost with small consistent particles.
- The windrow temperature remained above 40^0 C (104^0 F) throughout the entire active composting stage (6 weeks).
- The shape of the windrow was controlled by the machine.
- As the turnings proceeded very little widening of the windrows occurred; therefore, minimal work was required to maintain the width of the windrow.
- Moisture was easy to control with the water wagon.

Agricultural Loader

- Created lower quality compost with a very inconsistent texture.
- Particle sizes ranged from potting soil material to lumps of 20 cm (7.9 in) in diameter.
- Temperature remained above 40^0 C (104^0 F) for the entire active composting stage (6 weeks).
- The operator controls the shape and changes the windrow undergoes.
- Increased time compared to specialized machinery.

Allu SM 2-12

- Produced high quality compost with small consistent particles.
- The temperature remained above 40^0 C (104^0 F) for the entire active composting stage (6 weeks).
- The shape and changes the windrows experienced were operator controlled.
- The operator can change or maintain the shape to suit his needs.
- The time to turn with the Allu is greater than with other machines but no front-end loader is required.

Brown Bear PTO PA35-10.5

- The compost produced by this turner was high quality with consistent particle sizes.
- The temperatures remained above 40^0 C (104^0 F) for three weeks, thus destroying the viability of weed seeds. Twice after turning the temperature dropped below 40^o C (104^0 F) for a couple of hours.
- The turner determined the shape of the windrow by auguring the windrow over to the side.
- No widening of the windrow occurred, therefore no additional equipment was required.
- The horsepower required to operate the Brown Bear was greater than the other turners due to the auguring.

Earthsaver CT-12-PTO

- High quality compost was produced containing consistent particle sizes.
- The temperature remained above 40^0 C (104^0 F) throughout the entire active composting stage (6weeks).
- The windrow turner determined the shape of the windrow.
- Throughout the turning sequence slight widening of the windrow was apparent. The use of a front-end loader was minimal to clean the edges.

Scat 481:

- Produced high quality compost.
- Particles varied in size from potting soil type material to lumps of 10 cm (3.9 in).
- Temperature was above 40^0 C (104^0 F) for 5 weeks, long enough to kill pathogens and destroy weed seed viability. Once, at 3 1/2 weeks the temperature dropped below 40^0 C (104^0 F) for 1 day.
- The machine determined the shape of the windrow and how it changed.
- The windrows slowly widened making it impossible to turn the center of the windrow.
- A front-end loader was required to maintain the width, which increased the inputs thus increasing the cost of composting.

Wildcat FX700:

- Produced high quality consistent compost.
- Particles were small and similar to potting soil with little variation.
- Temperature remained above 40^0 C (104^0 F) for 6 weeks. Once at 3 1/2 weeks the temperature dropped below 40^0 C (104^0 F) for 12 hours
- The Wildcat determined shape and changes the windrow underwent.
- As the turnings proceeded the windrows got wider and longer.
- The width made it difficult to reach the center of the windrows but not impossible.
- Using a front-end loader to maintain the width makes the turnings easier but increases the time and input costs for composting.

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