Fuel Efficiency of Golf Course Mowing Equipment

By KATHY RICE
The Toro Company

Figure 1

With today's high fuel prices, you likely consider fuel efficiency when purchasing a new vehicle, but have you ever wondered about the fuel efficiency of your mowing equipment? As part of a larger effort to increase the fuel efficiency of their products, Toro conducted a study last summer to quantify fuel consumption for a variety of turf vehicles.

Small GPS devices attached to the machines recorded position, altitude, speed and heading every second of operation. Golf course personnel tracked which machine the loggers were used on and carefully measured how much fuel was used by each machine each day. The data was then downloaded and analyzed using GIS (Geographic Information System) software to come up with a variety of fuel and time performance metrics.

During the summer of 2009, at two local Minneapolis courses, 134 sets of data were collected representing 31 days of operation for 34 separate machines. Additional data was collected at other locations for a total of 213 sets of data at 14 different locations.

A typical dataset contained about 10,000 data points. With the GIS software, each point was connected and the vehicle "tracks" were overlaid on aerial photographs. Based on vehicle location, speed and pattern of movement the connecting lines were classified as:

- Working - performing the specified task
- Transport - driving between work sites
- Trailered - being hauled between work sites
- Stopped 1 to 10 minutes - These stops could be due to dumping clippings or waiting for play.
- On break - stops longer than 10 minutes were considered break times

Mowed acres were calculated using aerial photography and vehicle tracks.

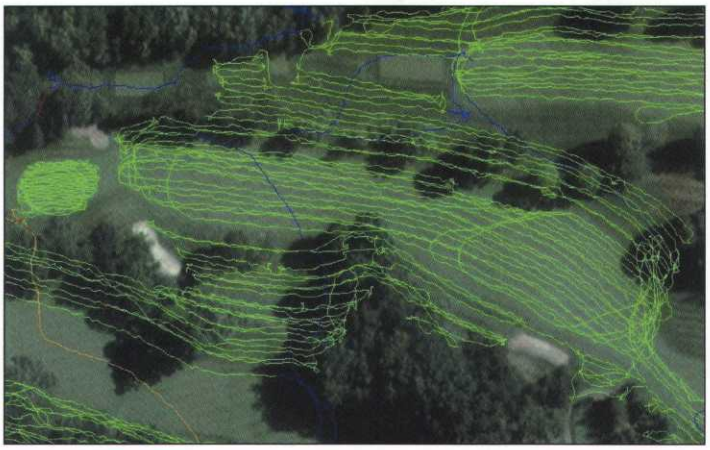

Figure 1. Typical Vehicle Tracks
Green - mowing *Blue - transport*
Orange - trailored *Red - stopped*

(Continued on Page 29)

Fuel Efficiency-

(Continued from Page 7)

Table 1

Machine Type	Avg Total Time	Avg Work Time	Avg Trans Time	Avg Total Dist	Avg Work Dist	Avg Trans Dist
Walk Greensmower	1:53:28	1:28:03	0:25:25	6.5	4.3	2.2
Large Reel (Fwy)	3:56:47	3:30:22	0:26:25	16.6	14.3	2.3
Large Reel (Short Rough)	2:24:32	1:41:42	0:42:50	9.0	6.2	2.7
Large Rotary	4:42:46	4:21:11	0:21:35	20.6	18.4	2.2
Trim Mower	3:18:28	2:41:06	0:37:22	10.7	8.0	2.6
Riding Greensmower (Greens)	2:14:29	1:29:12	0:45:17	7.1	4.1	3.0
Riding Greensmower (Tees,Aprons)	2:51:27	2:04:52	0:46:35	9.9	6.1	3.8
Utility Vehicles	1:36:57			9.8		

Since the primary task of mowing equipment is to cut grass, the performance metric selected was units per acre. Figure 2 and 3 show average performance for each machine type. Not surprisingly, smaller machines, while more fuel efficient, are less time efficient. This is best demonstrated by a look at mowing greens.

Figure 2

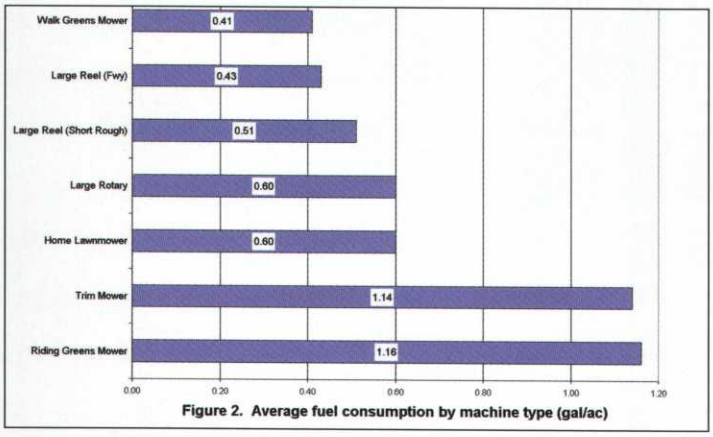

Figure 2. Average fuel consumption by machine type (gal/ac)

Figure 3

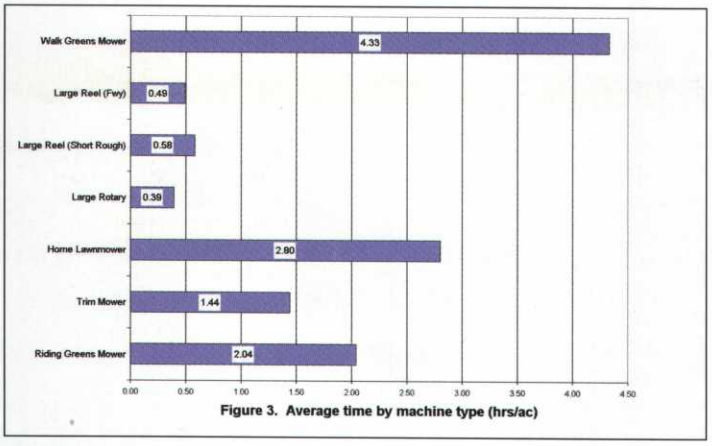

Figure 3. Average time by machine type (hrs/ac)

Figure 4 compares a walk greens mower to a triplex riding greens mower for mowing 2 fi acres of greens. The riding mower uses nearly 3 times as much fuel as the walk mower but takes less than half the time. If you calculate the cost of mowing 2 fi acres assuming the cost of fuel at $2.85/gal and labor at $10.00/hr, the total cost of mowing with a walk mower is $110.85 or $44.34/ac. Mowing the same area with a riding mower would cost $59.27 or $23.71/ac. Since walk mowers are generally towed between greens a small amount of fuel (0.20gal - 0.25gal) should be added to the walk mower calculation. This increases the cost per acre to $44.62 - still nearly twice as much as a riding mower.

When mowing fairways, both direction and speed make a measurable difference. Today's mowers are more fuel efficient at higher mowing speeds and obviously mowing faster results in time savings. Using the same fuel and labor cost as mowing greens results in a cost of $6.61/ac at 3.5mph and $4.08/ac at 5.8mph. (The average fairway mow speeds at the two courses studied were 3.5mph and 5.8mph).

Figure 4

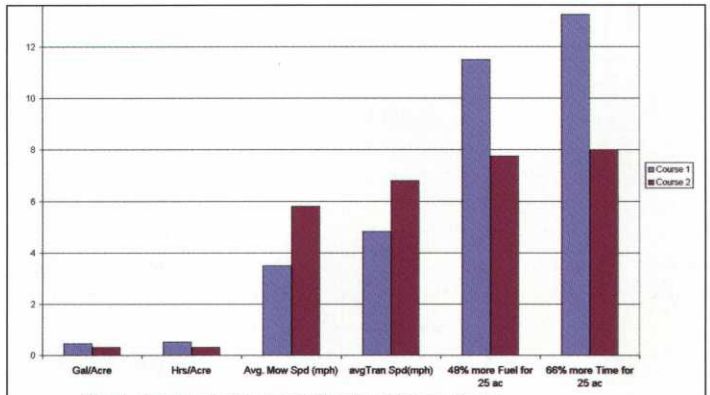

Figure 4. Comparison of walk mower vs. riding mower on 2.5 acres of greens. Walk mower transport speed is higher due to being towed between holes by a utility vehicle.

Figure 5

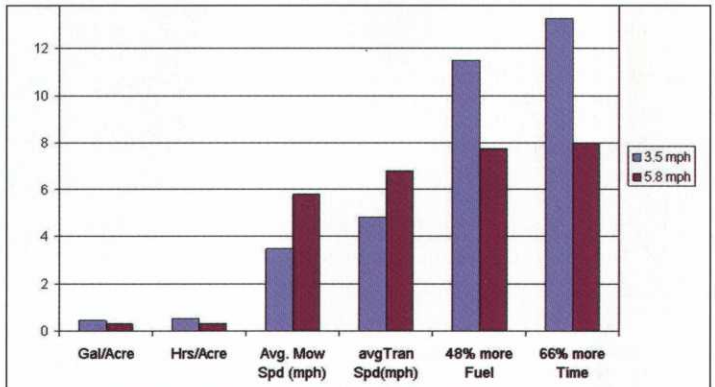

Figure 5. Effect of speed on mowing 25 acres of fairway

While not as significant as speed, direction does make a difference. Data captured at one course for fairway mowing "zamboni style" (0 degrees) and cross-cutting at an angle of about 45 degrees showed a cost per acre difference of 16%. This is primarily due to the increased distance traveled and the number of turns required to cross-cut. On a single fairway the distance traveled was 2.4 miles "zamboni style" and 2.9 miles for cross-cutting - a difference of fi mile, nearly 20% more! The cost of fuel and labor per acre is $5.73 and $6.78 for zamboni and cross-cutting respectively. These results are very similar to those of a previous study Toro performed comparing the efficiency related to mowing direction.

Figure 6. 'Zamboni-Style mowing $5.73/acre

Figure 6

(Continued on Page 30)

Fuel Efficiency-

(Continued from Page 29)

The process of aerifying greens was tracked at one of the courses. Because of a limited number of tracking devices it was not possible to track all of the equipment used in the process. Movements of ten pieces of equipment were recorded including two different aerators, a variety of utility vehicles and a skid steer used to haul sand for top-dressing. The total distance traveled by those ten vehicles was 106 miles.

One of the courses participating in the study had fuel records by machine for each month for the previous four years. These records were used to validate study results. Estimated fuel usage based on maintained acres and average fuel efficiency compared reasonably well with their actual usage records. The pie chart below showing fuel use for a single mowing cycle (mowing every area a single time) shows that the larger turf areas use the vast majority of fuel for any single cycle.

Due to more frequent mowing of greens, tees and aprons the chart changes significantly for the yearly fuel budget. One of the surprises of this study was that on a yearly basis, mowing greens can consume nearly as much fuel as mowing fairways even though on average, the area of greens is 1/10 the area of fairways. Figures 9 and 10 assume greens are cut with a riding mower.

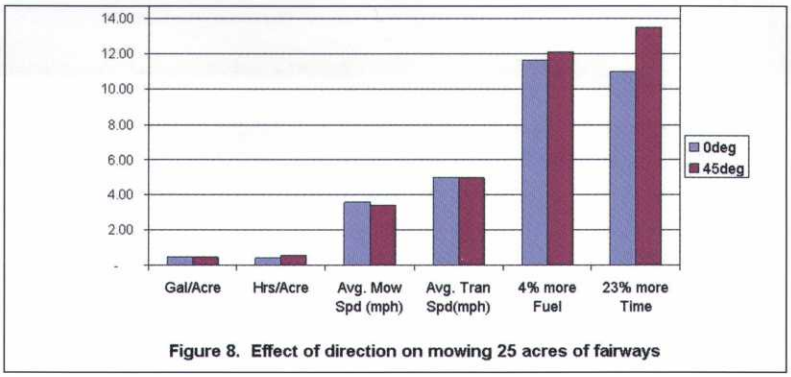

Figure 8

Figure 8. Effect of direction on mowing 25 acres of fairways

Figure 7. Cross cut mowing. $6.78/acre

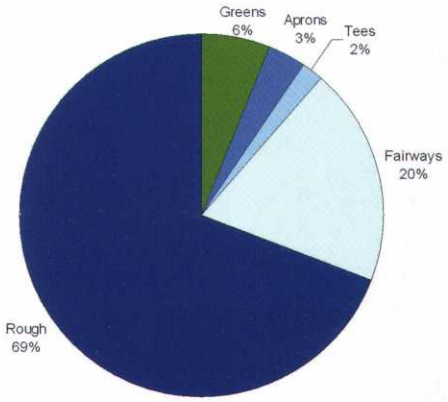

Figure 9. Single cycle fuel consumption by area

Many factors - equipment, mow speed, direction, and size of the course - will affect fuel use and total mowing time on any particular course.

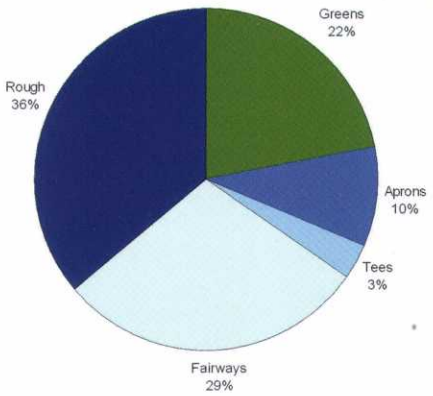

Figure 10. Yearly fuel consumption by area

Until recently, fuel efficiency has not been a primary factor in design of turf maintenance equipment. Driven by rising fuel prices and stricter emission standards, future machines will likely utilize technology to maximize fuel efficiency. Other projects are underway at Toro to quantify how much power is used by specific machine systems. This data will be used to design machines that use power more effectively than the machines available today.