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Diesel Fuel Consumption during Tractor Operations

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Abstract
Direct energy expenses (diesel, gasoline, propane, electricity) total more than $1 billion annually for Iowa's farmers. Day-to-day farm management techniques such as adjusting tractor gear and throttle settings, making use of front-wheel-drive, and other strategies can reduce diesel fuel consumption for row crop production and general tractor operations. This study is being conducted over multiple years to measure the effects of energy management techniques on tractor fuel consumption during field operations.

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Diesel Fuel Consumption during Tractor Operations

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Introduction

Direct energy expenses (diesel, gasoline, propane, electricity) total more than $1 billion annually for Iowa's farmers. Day-to-day farm management techniques such as adjusting tractor gear and throttle settings, making use of front-wheel-drive, and other strategies can reduce diesel fuel consumption for row crop production and general tractor operations. This study is being conducted over multiple years to measure the effects of energy management techniques on tractor fuel consumption during field operations.

Materials and Methods

A small auxiliary 12-gallon fuel tank was mounted on a John Deere 6420 tractor. Plumbing was added for diesel fuel to be supplied and returned from the engine via either the main or auxiliary fuel tank, depending on the setting of a single flow control valve. A load cell under the auxiliary fuel tank measured the net (supply–return) weight of fuel consumed.

Most of the field work at the farm was conducted using small plot areas for row crops and forage production. One objective was to measure fuel use in areas of 0.7 to 1 acre when possible; the auxiliary tank measures fuel consumption within 0.1 lb increments. Another objective was to obtain multiple replications of land area and timing of trials allowed. Small plots and weather frequently conflicted with these objectives, limiting the ability to measure statistical significance beyond overall trends in some trials.

Fuel consumption was measured as gallons/acre or gallons/mile for hauling. Although larger equipment consumes fuel at higher rates, field work also was completed at a faster rate (acres/hr). Gallons/acre generally remains consistent and is a common, useful measure for farmers.

Results and Discussion

Effects of shifting up one transmission gear and throttling back the engine's speed were compared during planting of both row and cover crops (Tables 1 and 2). In both cases, shifting to a higher gear and reducing engine speed reduced fuel use while maintaining the same travel speed for planting operations (fuel savings of 16 and 43%, respectively).

By not using the available front-wheel drive on the tractor, fuel use increased by 7 percent during row-crop planting, by 5 percent when seeding a cover crop with a grain drill, and by 32 percent during summer mowing of grassy areas (Tables 1–3). Disengaging the front-wheel drive while hauling bales increased fuel consumption by 12 percent (Table 4), although discretion should be used if the hauling route is on a highway or paved surface that would limit wheel slip.

Fuel consumption increased 20 percent towing a grain wagon at 20 miles/hr rather than 17 miles/hr (Table 5). Reducing engine speed is not generally recommended for PTO operations as lower speed increases torque requirements and stress on equipment. During summer 2014, however, hay mowing was conducted at a 15 percent reduction in engine speed. In this trial, the cutting and crimping quality and the width of the windrow produced were similar to the quality and width obtained at rated PTO speed. Fuel savings of 16 percent (Table 6) resulted in terms of fuel consumption/acre, although field speed also was reduced with the tractor kept in the same transmission gear.

Conclusions

Results indicate reduced diesel fuel consumption when using a 'shift-up/throttle-back' strategy with drawbar loads that are less than the available maximum tractor horsepower. Similarly, fuel savings were consistent when using available front-wheel-assist drive on the tractor. Loads operated by the power-take-off usually require operating the engine at rated PTO speed, however, effective rotary cutting speed was able to be maintained during the field conditions that were present. When conditions allow, lower transport speeds reduced fuel consumption/mile. Results are only from the first year of study. Farm staff plan to continue additional fuel consumption comparisons next year.

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Table 1. Fuel consumption during row-crop planting.

Treatment	Replications	Gal/acre
Gear/engine rpm		
B4/2150	8	0.574
C2/1900	8	0.495
LSD $_{\alpha=0.05}$ [a]		0.027
MFD[b]		
disengaged	8	0.553
engaged	8	0.515
LSD $_{\alpha=0.05}$ [a]		0.027

[a]Least significant difference between treatments at a 95 percent confidence level.
[b]Mechanical front-wheel drive engaged (yes) or disengaged (no).

Table 2. Fuel consumption with a grain drill planting rye cover crop.

Treatment	Replications	Gal/acre
Gear/engine rpm		
B4/2150	6	0.556
C2/1900	6	0.390
LSD $_{\alpha=0.05}$ [a]		0.044
MFD[b]		
disengaged	6	0.485
engaged	6	0.461
LSD $_{\alpha=0.05}$ [a]		NS[c]

[a]Least significant difference between treatments at a 95 percent confidence level.
[b]Mechanical front-wheel drive engaged (yes) or disengaged (no).
[c]No significant difference at the 95 percent confidence level.

Table 3. Fuel consumption during rotary mowing.

Operation	No. of replications	Treatment MFD[a]	Gal/acre
Rotary mowing, 4.3 mi/h	4	no	0.777
	4	yes	0.591
LSD $_{\alpha=0.05}$[b]			0.148

[a]Mechanical front-wheel drive engaged (yes) or disengaged (no).
[b]Least significant difference between treatments at a 95 percent confidence level.

Table 4. Fuel consumption hauling two large round bales.

Operation	No. of replications	Treatment MFD[a]	Gal/mile
Hauling bales, 5 mi/h	4	no	0.330
	4	yes	0.293
LSD $_{\alpha=0.05}$[b]			0.021

[a]Mechanical front-wheel drive engaged (yes) or disengaged (no).
[b]Least significant difference between treatments at a 95 percent confidence level.

Table 5. Fuel consumption hauling 265-bushel wagon full of corn (and empty return).

Operation	No. of replications	Treatment Travel speed, mi/h	Gal/mile
Hauling corn	4	17	0.171
	4	20	0.205
LSD $_{\alpha=0.05}$[b]			0.002

[a]Least significant difference between treatments at a 95 percent confidence level.

Table 6. Fuel consumption while mowing hay.

Operation	Replications	Treatment		Gal/acre
		Engine rpm	Travel speed, mi/h	
Mowing hay	4	2160	5.3	0.726
	4	1840	4.5	0.626
LSD $_{\alpha=0.05}$[a]				0.016

[a]Least significant difference between treatments at a 95 percent confidence level.