Computerized Tillage System Calculator

Jake Walker, Aaron Weinhold, Adam Duff

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Objectives:

•Determine if the ASAE fuel consumption equation is outdated or variable across a range of tractors.

•Create a program to determine fuel consumption from required horsepower for tractors '95 and newer and over 100 horsepower using the Nebraska Tractor Tests.

•Perform a sensitivity analysis to determine optimum operating speeds for specific labor and fuel prices in an operation.

•Assist the user in sizing tillage implements to a specific tractor in different soil conditions.

•Make this user-friendly program accessible and deliverable to educators, farmers, and dealers.

Procedures

•Obtain and compile Nebraska Tractor Tests for 214 tractors.

•Compare fuel consumption data to the ASAE equation.

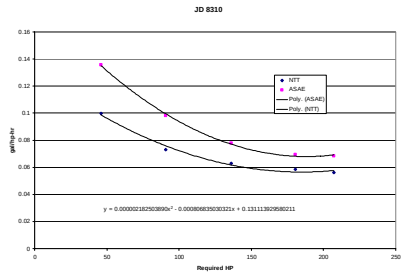
•Use Excel to create a fuel consumption regression equation for each tractor.

•Create a program to predict fuel consumption, fuel costs, and horsepower and labor requirements for various tillage operations.

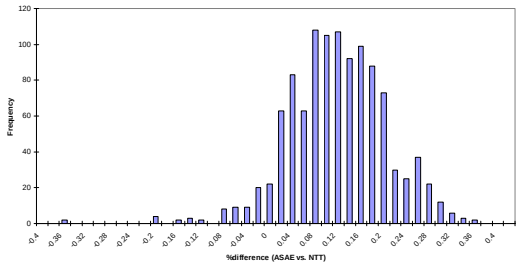
•Include a sensitivity analysis to determine the optimum operating speed for the specific operation.

ASAE vs. Nebraska Tractor Test data

	A	B	C	D	E	F	G	H	I
1	JD 7220		103.99				ASAE		
2	power	gal/hr	hp-hr/gal	max pwr	gal/hp-hr	equiv/max	gal/hp-hr	-15%	difference
3		22.25	3.09	7.19	103.99	0.139082	0.213963	0.130585	-6.5%
4		43.97	4	11	103.99	0.093909	0.422029	0.108919	0.092581	1.8%
5		65.33	4.9	13.34	103.99	0.074963	0.628233	0.087415	0.074303	-0.9%
6		86.41	5.8	14.9	103.99	0.067114	0.830945	0.080494	0.06842	1.9%
7		97.18	6.18	15.73	103.99	0.063573	0.934513	0.081097	0.068932	7.8%
8	JD 7320			117.1				ASAE		
9	power	gal/hr	hp-hr/gal	max pwr	gal/hp-hr	equiv/max	gal/hp-hr	-15%	difference
10		24.7	3.21	7.67	117.1	0.130378	0.210931	0.154557	0.13134	0.7%
11		48.7	4.1	11.69	117.1	0.094175	0.415984	0.109974	0.093478	10.0%
12		72.4	5.07	14.26	117.1	0.070126	0.618275	0.080079	0.074067	6.3%
13		95.7	6.04	15.86	117.1	0.063052	0.81725	0.080905	0.068514	8.0%
14		109.8	6.67	16.45	117.1	0.06079	0.93766	0.081153	0.06898	11.9%
15	JD 7420			127.38				ASAE		
16	power	gal/hr	hp-hr/gal	max pwr	gal/hp-hr	equiv/max	gal/hp-hr	-15%	difference
17		26.58	3.09	8.59	127.38	0.116414	0.206667	0.155185	0.131908	11.7%
18		52.77	4.08	12.93	127.38	0.07734	0.414272	0.110223	0.093689	17.5%
19		78.17	5.07	15.42	127.38	0.064051	0.613676	0.080397	0.075138	13.7%
20		102.37	6.1	16.78	127.38	0.059595	0.803058	0.080762	0.068648	13.2%
21		116.56	6.74	17.29	127.38	0.057837	0.915057	0.080799	0.068678	15.8%



ASAE Fuel Consumption Equation vs. Nebraska Tractor Test Data



Histogram showing the difference between the ASAE fuel consumption equation and the regression equations created from the Nebraska Tractor Test data.

Calculations

The following information from the ASAE standards is used to make the calculations within the program:

- Draft equation
- Machine and soil parameters
- Power relations/conversions
- Field capacity equation
- Typical field efficiencies

Running the program

Macros run within Excel make it easy for the user to input their information.

The user is asked for information such as the tractor and implement they are using, tillage depth, field conditions, operating speeds, soil textures, and their fuel and labor costs.

The program then uses the ASAE standards and the fuel use regression equations to calculate the outputs.

The generated outputs are then shown to the user in a printable format.

Sample Input Boxes

Example Summary Table

Scenario Name	JD 8400	JD 8400 optimized	Fendt 920	Fendt 920 optimized
Tractor Brand	John Deere	John Deere	Fendt	Fendt
Tractor	JD 8400	JD 8400	Fendt 920	Fendt 920
Drive Type	MFWD	MFWD	MFWD	MFWD
Implement	chisel plow, 7.5 cm	chisel plow, 7.5 cm	chisel plow 10 cm	chisel plow 10 cm
Field Efficiency				
Tool Spacing	1.25	1.25	1.25	1.25
Impl width/# of tools	11	11	11	11
Tillage Depth	8	8	8	8
Fuel Price	$ 1.50	$ 1.50	$ 1.50	$ 1.50
Labor Price	$ 10.00	$ 10.00	$ 10.00	$ 10.00
Tractor Conditions	Firm	Firm	Firm	Firm
Soil 1				
Speed	5	6.75	5	5.5
Soil Texture	fine	fine	fine	fine
Field size	100	100	100	100
Soil 2				
Speed	5	7.5	5	6
Soil Texture	medium	medium	medium	medium
Field size	100	100	100	100
Soil 3				
Speed	5	9	5	7.25
Soil Texture	coarse	coarse	coarse	coarse
Field size	100	100	100	100
Fine Soil				
Field capacity (ac/hr)	7.08	9.56	7.08	7.79
Total time in field (hr)	14.12	10.46	14.12	12.83
PTO HP required	137	206	158	179
Max PTO HP	252	252	195	195
fuel use rate (gal/hr)	8.42	11.37	8.68	9.94
Total fuel use (gal)	119	119	121	128
Fuel cost per acre	$ 1.78	$ 1.78	$ 1.82	$ 1.91
Total fuel cost	$ 179.30	$ 178.37	$ 181.69	$ 191.30
Labor cost per acre	$ 1.41	$ 1.05	$ 1.41	$ 1.26
Total labor cost	$ 141.18	$ 104.58	$ 141.18	$ 126.34
Labor & Fuel costs/ac	$ 3.19	$ 2.83	$ 3.23	$ 3.20
Total L & F cost	$ 319.47	$ 282.94	$ 322.86	$ 319.64
Optimum Speed	6.75	6.75	5.5	5.5
Labor & Fuel savings	$ 36.53	$ -	$ 3.22	$ -
Savings per acre	$ 0.37	$ -	$ 0.03	$ -
Medium Soil				
Field capacity (ac/hr)	7.08	10.63	7.08	8.50
Total time in field (hr)	14.12	9.41	14.12	11.76
PTO HP required	117	203	134	171
Max PTO HP	252	252	195	195
fuel use rate (gal/hr)	7.73	11.19	7.55	9.36
Total fuel use (gal)	109	105	107	110
Fuel cost per acre	$ 1.64	$ 1.58	$ 1.60	$ 1.66

Advantages of using the program

- Instant results
- Operation specific
- No calculations performed by the user
- Easy comparisons of different operations
- Ability to refine inputs and get immediate results
- "What if?" scenarios
- Sizing tractors to specific implements
- User can determine time requirements for an operation
- Sensitivity analysis to determine optimum operating speed

Results

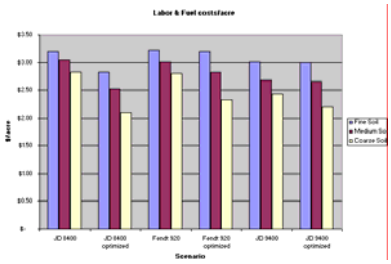
Once the user accepts their inputs, the program does the calculations and shows the outputs in a summary table.

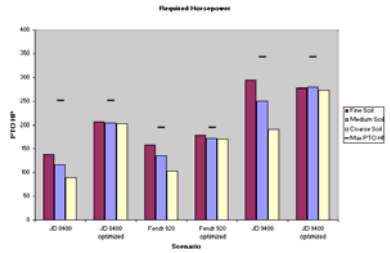
Six scenarios can be evaluated side by side.

Minor changes can be made or a complete new operation can be entered.

An optimum speed is calculated by minimizing total fuel and labor costs in each soil.

Four charts are prepared by the program showing the user fuel and labor costs, horsepower requirements, and the effects of different soil textures on an operation.





Conclusions

The ASAE fuel consumption equation was determined to be inaccurate over a range of today's tractors.

A program was created to quickly predict fuel and labor requirements that until now took tedious calculations that gave inaccurate results.

This program should be helpful to educators, farmers, and dealers.

Tillage System Calculator can be accessed at:
www.angelfire.com/mech/tillagecalculator

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