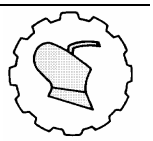
POLJOPRIVREDNA TEHNIKA
✧
Godina XXXVII
Broj 1, jul 2012.
Strane: 1 - 9

Poljoprivredni
fakultet
Institut za
poljoprivrednu
tehniku



UDK: 631.331

Originalni naučni rad
Original scientific paper

USING TRACTOR TEST DATA FOR SELECTING FARM TRACTORS

Robert D. Grisso[1], David H. Vaughan[1], John V. Perumpral[1], Gary T. Roberson[2], Robert Pitman[3], Roger M. Hoy[4*]

[1]Virginia Tech University, College of Agriculture and Life Sciences, Department of Biological Systems Engineering, Blacksburg, VA, USA
[2] North Carolina State University, College of Agriculture & Life Sciences, Department of Biological and Agricultural Engineering, Raleigh, NC, USA
[3]Virginia Tech University, Est. Virginia Agr. Research & Extension Center, Virginia Tech, Warsaw, VA, USA
[4]University of Nebraska, Nebraska Tractor Test Laboratory, Lincoln, NE, USA

Abstract: The Nebraska Tractor Test Laboratory (NTTL) at the University of Nebraska is the official tractor testing station for the Organization for Economic Cooperation and Development (OECD) in the United States. This laboratory is responsible for testing a representative tractor of each model sold in the state of Nebraska. It also tests tractors manufactured in the USA and sold in international markets. The Laboratory publishes the results of all tests conducted. The test reports published by NTTL can be extremely useful in the selection of tractors or for comparing the performance of different makes and models of tractors. The proper selection and sizing of a tractor is important to the economic viability and sustainability of farms. This paper shows the use Nebraska Tractor Tests and test reports for that selection. A step-by-step procedure for selecting a farm tractor using published tractor test reports has been developed and demonstrated.

Key words*: tractor selection, tractor test reports, performance comparisons*

INTRODUCTION

The test reports published by Nebraska Tractor Test Laboratory (NTTL) can be extremely useful in the selection of tractors or for comparing the performance of

[*] Corresponding author. E-mail: tractortestlab@unl.edu
University of Nebraska, Tractor Test Laboratory, 35 & East Campus Loop
P.O. Box 830832, Lincoln, NE 68583-0832, phone: (402) 472-2442, fax: (402) 472-8367
http://tractortestlab.unl.edu/

different makes and models of tractors. For example, when a farmer is in the market for a tractor, the performance data in the test reports can be used to select a tractor that will meet his/her needs. Similarly, these reports can also serve as an effective tool for making tractor sales. Dealership personnel can use the performance data to compare their products to those of competitors.

For either application, familiarity with the content of the test reports and the know how to use the information effectively are essential. Therefore, this factsheet is developed with the following two specific objectives:

1. To inform users of the data within tractor testing and Nebraska Test Reports.
2. To demonstrate the use of tractor test information for the selection and performance comparison of farm tractors.

MATERIALS AND METHODS

NTTL, the official tractor testing laboratory in the US, is a member of the OECD with 27 other countries. The OECD recommends all tractors manufactured in member countries to be tested in the country where they are manufactured, following the OECD guidelines. Based on an established agreement between member countries, test reports approved by OECD are accepted by all participating countries.

*Tractor Test***.** The purpose of the tests is to collect data that can be used to assess the performance of tractors of different makes and models. For this reason, all tests are conducted under same or similar test conditions and procedures. Tractor tests are generally conducted to assess the PTO (power take-off) performance, drawbar performance, hydraulic lift capacity, and hydraulic system pressure and flow. In addition, sound level measurements are also taken at operator and bystander locations.

PTO performance tests are conducted with a dynamometer attached to the tractor PTO (Fig. 1). The purpose of the dynamometer is to apply varying loads through the PTO and to measure the power generated by the tractor. These tests are conducted within restricted range of ambient temperature and a barometer pressure. During tests, when the tractor performance has stabilized, the data is recorded at predetermined intervals.

The load applied by the dynamometer follows the operating curve of the engine at full throttle. Data collected include torque, rpm, power, and fuel consumption. A series of PTO tests are conducted at rated engine speed, at standard PTO speed (either 1000 or 540 rpm), at the engine speed where maximum power is produced, at varying load, and at maximum torque.

Drawbar performance tests (Fig. 2 and 3) are conducted in all gears between one gear below the one which provided maximum drawbar force (without exceeding a wheel slip of 15%) and a maximum speed of 16 km/$^{-1}$. In each gear, at full throttle, the load is increased until maximum drawbar power is achieved. Engine speed, wheel slip and fuel consumption data are recorded when test conditions are stabilized.

Drawbar tests are also conducted with partial loads at 75% and 50% of the maximum drawbar load (at rated engine speed). These partial load tests are also conducted at reduced engine speeds (selected by the manufacturer).

Figure 1. The tractor being tested on the PTO dynamometer
The test apparatus in the foreground is measuring fuel flow.

Figure 2. The lead tractor is being tested on the track during drawbar performance tests
The two vehicles in tow are load units.

Figure 3. Tractor running on the test course
Drawbar performance test being performed.

Hydraulic lift capacity and flow tests are conducted to determine the maximum lift capacity of hydraulic system through the full lift range. The lift capacity in the report is 90% of the maximum load carried through the full lift range.

Additional tests are also conducted to determine the pressure-flow relationship of the hydraulic system for supplying power to external actuators (such as motors or cylinders). Reports include data on delivery rate, pressure and available power.

Sound level measurements during performance tests are taken at the operator and bystander locations. At bystander location, the readings are taken by locating the microphone 7.6 m from the center line of the tractor. Sound levels are recorded using "A" scale in the sound level meter and is expressed in terms of dB (A). The "A" scale is a filter that responds like a human ear.

Nebraska Test Reports

A full OECD report is generally 30 pages long. NTTL summarizes and publishes the test results in two formats (to order, see contact information at the end). The first format is a booklet published annually with limited performance data on all tractors available for sale that year in the state of Nebraska. The summary booklet generally includes approximately 400 tractor models from different manufacturers. The second format is a more detailed report (typically 2-6 pages) covering individual tractor test results. These reports are discussed in the following paragraphs.

The summary booklet have a cover page that provides the year in which the tractors were summarized and the name and address of the person responsible for the tests. A typical page in the summary booklet provides the summary of test results of two or three tractors from a manufacturer. Included in the summary is information on tractor model, limited engine and chassis specifications, PTO and drawbar performance data, sound level, three-point lift capacity and hydraulic system parameters. The summary booklets are particularly useful for an initial review of the performance of tractors of different sizes produced by different manufacturers.

When the initial review generates interest in a particular tractor model, the user can obtain a summary report specific to that model tractor. The first page of the summary report provides information on test number, make and model of tractor tested, and transmission. It also includes results of PTO and drawbar performance tests in addition to tractor specifications in a column located on the right-hand side of the page. Fuel consumption is reported in three different ways: $l \cdot h^{-1}$, $kg \cdot kW^{-1} \cdot h^{-1}$, and $kW \cdot h \cdot l^{-1}$. Fuel consumption expressed in terms of $kW \cdot h \cdot l^{-1}$ is useful for comparing fuel consumption of tractors of different sizes [1-2]. PTO tests at varying power levels simulate a wide range of field operations using the tractor.

The drawbar performance data includes drawbar power and pull, forward speed, wheel slip, engine speed, fuel consumption, temperature and relative humidity conditions at maximum, 75% and 50% pull at maximum power. The tests at reduced engine speed also include similar data at various travel speeds.

Power measured at 75% of pull at maximum power may represent a typical operation with heavy load such as primary tillage. At 75% pull, the tractor may still have some reserve power to overcome unexpected overload situations. The average fuel consumption at 75% and 50% pull may represent tillage and seeding operations respectively on small grain farms. Similarly, the average fuel consumption at the 50%

pull tests can serve as a good estimate of fuel consumption when tractors are used in row-crop farming. This distinction between small grain and row-crop production is made because more efficient tractor-implement matching is possible for small grain production. For small grain applications, selection of implements to utilize the available tractor power can be accomplished more easily. However, the same conclusion may not be true in the case of row-crop implements.

Tractor tests are conducted on concrete or asphalt tracks. Therefore, the performance data recorded during these tests can be significantly better than what can be expected under normal field conditions. Tests are conducted on hard surface (concrete and asphalt) for consistency between tests.

At the end of the summary reports are sound levels, tire and weight information. Tractor sound level at the operator's ear location is critical because governmental agencies have strict sound level and exposure time regulations. For example, in the US, the safety regulations permits an eight hour exposure period if the sound level in the work area is 90 dB(A). Due to the fact that a 3 dB(A) increase in sound level corresponds to doubling of sound pressure level, for every 5 dB(A) rise in sound level, the permissible exposure time is cut in half. In other words, at 95 dB(A), the allowable exposure time is only four (4) hours. It is not uncommon to have tractor sound level reaching 95 dB(A).

If the tractor tested has front wheel assist, additional drawbar tests with the front wheel assist disengaged may follow. The last page of the summary report is devoted to three-point hitch performance data, hydraulic system parameters and hitch dimensions.

Published tractor test results can also be used for estimating annual fuel consumption by knowing how the tractors are used during the year. This information is particularly useful for budgeting and management purposes.

Fuel savings are possible with practices such as "Gear-Up & Throttle-Down." The "DRAWBAR PERFORMANCE" data documents the fuel savings possible with the practice of "Gear-Up and Throttle-Down" for light load conditions. The lines ending with the words "at Reduced Engine Speed" can be compared with the tests conducted at full throttle at the same load level. The specific fuel consumption (kW-hr/l) for the "at Reduced Engine Speed" tests will always be more efficient than the values for the full throttle with the difference being expected fuel savings.

Depending on the engine design and other controlling factors, the "Gear-Up & Throttle-Down" technique can provide fuel savings in the range of 15-30% [3]. The annual fuel savings from the use of this technique can be estimated by multiplying the total number of hours the tractor is used annually for "light load operations," by the fuel consumption difference.

RESULTS AND DISCUSSION

Using the Test Reports for Tractor Selection. Many factors are taken into consideration in the selection and purchase of a new tractor. These may include factors such as: types of jobs to be performed, price, proximity and reputation of the dealership, desired power output at the drawbar and PTO, hydraulic system capacity, and fuel efficiency. The tractor test reports can play an important role in the decision-making process. Both summary booklets and summary reports on

individual tractors are useful in selecting tractor models or for evaluating and comparing performance of different tractor models. The first step in the tractor selection process is to evaluate the need that exists. Depending upon the needs identified, the purchaser should estimate the power requirements at the PTO and drawbar. Knowing the power requirements, the next step is to identify tractor models that are capable of providing the required output power. This list may include tractors from different manufacturers if more than one dealership is available in the proximity.

Once the tractor models that meet the power requirements are identified, the next step in the selection process is to compare their performance data. This comparison can be accomplished by preparing a table. The first column of this table may include the performance variables listed in NTTL booklet plus any other variables that are pertinent to the selection process. The number of additional columns will depend on the number of tractor models identified during initial screening. The data for each column can be extracted from the test reports. This table allows easy comparison among several tractor models. The tractor information available in the summary reports may be used for the final selection. Factors such as stability, tire size, tractor configuration (2WD, FWA, 4WD), repair frequency, proximity and reputation of dealership, and price may be considered in the final selection.

To illustrate the step-by-step procedure for selecting a tractor using the Nebraska Tractor Test data, let us consider the following hypothetical example [4]. Assume farmer JS is interested in selecting a new tractor for his orchard/vegetable operation. To select the tractor for this operation, let us follow the step-by-step procedure established earlier.

Step 1. Evaluate the need and estimate the power requirement. JS considered all the different operations that need to be carried out using the new tractor during the year. He estimated that the new tractor should have a minimum rated PTO power of 52 kW.

Step 2. Identify all tractor models meeting the power requirement. A review of "Nebraska and OECD Tractor Test Data" summary booklet (MP-37) showed that 17 different tractor models will meet the power requirement.

Step 3. Prepare a table to compare the performance data of tractors identified. Table 1 summarizes the performance data of the 17 tractor models identified from the summary booklet.

Final selection of a tractor model depends on many other factors such as cost, personal preference, dealership location, safety features, fuel consumption, sound level readings, and hydraulic system capacity. For example, two service centers/dealerships (Case- IH and John Deere) are located within 32 km of JS's farm [5]. If proximity of dealership is important to JS, the list is reduced to six models from Case-IH and John Deere. With the list narrowed to six tractor models, the final selection may be made taking the factors listed earlier into consideration. Summary Reports for tractors tested since 1999 can be found at: http://tractortestlab.unl.edu/testreports.htm (at no charge) and in this example all Summary Reports are available at this website in Adobe format.

Table 1. Summary of tractors from the "Nebraska and OECD Tractor Test Data" summary booklet (MP-37)

Manufacturer	Model	Test #	2WD FWA[1]	Trans[2]	E N G[3]	Rated Power (hp)	Fuel Use[4]	Draw Test[5]	Sound Test (dBA)[6]		H[7]
AGCO	GT75A	1850	FWA	16-M	T	76.31	15.67	NA	77.3	NA	11.7
	LT75A	1883	FWA	16-PS	T	78.41	15.48	NA	74.9	81.0	25.1
CASE-IH	JX1085	571	2WD FWA	16-M	A	71.7	15.08	PART	77.9	82.1	12.7
	JX1080	529	2WD FWA	12-M	A	71.6	14.71	PART	79.3 79.1	86.0 85.5	16.4
	JX85	462	2WD FWA	12-M	T	78.4	17.11	FULL	88.2* 88.4*	NA NA	15.6
CHALLENGER	MT445B	515	2WD FWA	16-PS	T	70.7	14.16	FULL	77.3 77.3	88.2 NA	15.6
	MT455B	516	2WD FWA	16-PS	T	80.2	15.37	FULL	75.2 75.3	88.3 NA	15.6
JOHN DEERE	5652	1869	FWA	9-M	T	76.01	14.13	NA	85.8	83.3	18.6
	6215	481	FWA	16-M	TI	74.5	14.73	FULL	70.5	NA	17.8
	6220	385	FWA	24-PQ	T	75.8	15.63	FULL	71.0	NA	31.1
MASSEY FERGUSON	583	1865	2WD	8-M	A	73.61	15.06	NA	94.4*	NA	11.0
	593	1851	FWA	12-M	T	78.81	15.92	NA	94.7*	87.6	10.0
	5445	511	2WD FWA	16-PS	T	70.7	14.16	FULL	77.3 77.3	88.2 NA	15.6
	5455	512	2WD FWA	16-PS	T	80.2	15.37	FULL	75.2 75.2	88.3 NA	15.6
McCORMICK	CX85	327	FWA	16-PS	T	71.3	15.18	FULL	78.0	NA	16.5
	CX95	328	FWA	16-PS	T	79.7	16.04	FULL	77.0	NA	17.0
NEW HOLLAND	TL80A	524	2WD FWA	12-M	A	71.4	14.65	PART	79.0 79.0	85.5 85.5	16.5

1 Chassis Type: 2WD=two wheel drive, FWA=front wheel assist
2 Transmission: number of gears, M=manual, PS=power shift, PQ=power quad
3 Engine accessories, A= naturally aspirated, T=turbocharged, I=intercooled
4 Specific fuel consumption, kw-h·l^{-1}
5 Drawbar test complete? NA-no data, PART=some data not complete, FULL= all data
6 Sound test, first column sound at operator's ear, second column at bystander @ 7.6 m
7 Hydraulic flow in l/min, may be max flow from a single outlet others may be from all ports
* Without a cab otherwise the tractor is equipped with a cab

CONCLUSIONS

The proper selection and sizing of a tractor is important to the economic viability and sustainability of farms. This paper introduces users to Nebraska Tractor Tests and test reports. A step-by-step procedure for selecting a farm tractor using published tractor test reports has been developed and demonstrated. In the case example, a farmer had 17 tractors to select from and the selection process was narrow to 6 tractor models.

BIBLIOGRAPHY

[1] Grisso, R.D., Vaughan, D., Roberson, G. 2008. Fuel prediction for specific tractor models. *Applied Engineering in Agriculture* 24(4):423-428.

[2] Grisso, R., Perumpral, J., Vaughan, D., Roberson, G., Pitman, R. 2010. Predicting tractor fuel diesel fuel consumption. *Virginia Cooperative Extension Publication Number*: *442-073*, posted October 2001, Virginia Tech, Blacksburg, VA http://www.ext.vt.edu/pubs/bse/442-073 (Accessed June 21, 2012).

[3] Grisso, R., Pitman, R., Perumpral, J., Vaughan, D., Roberson, G., Hoy R. 2011. "Gear up and throttle down" to save fuel. *Virginia Cooperative Extension Publication Number: 442-450*, posted May 2011, Virginia Tech, Blacksburg, VA http://pubs.ext.vt.edu/442/442-450 (Accessed June 21, 2012).

[4] Grisso, R., Vaughan, D., Perumpral, J., Roberson, G., Pitman, R. Hoy R. 2009. Using tractor test data for selecting farm tractors. *Virginia Cooperative Extension Publication Number: 442-072*, posted May 2009, Virginia Tech, Blacksburg, VA http://www.ext.vt.edu/pubs/bse/442-072 (Accessed June 21, 2012).

[5] Grisso, R., Pitman, R. 2002. Five strategies for extending machinery life. *Virginia Cooperative Extension Publication Number: 442-451*, posted January 2002, Virginia Tech, Blacksburg, VA http://www.ext.vt.edu/pubs/bse/442-451 (Accessed June 21, 2012).

UPOTREBA REZULTATA TESTIRANJA ZA IZBOR TRAKTORA NA FARMI

Robert D. Grisso[1], David H. Vaughan[1], John V. Perumpral[1], Gary T. Roberson[2], Robert Pitman[3], Roger M. Hoy[4]

[1] Tehnički Univerzitet Virdžinije, Fakultet za poljoprivredu i prirodne nauke, Institut za inženjering bioloških sistema, Blacksburg, VA, SAD
[2] Državni Univerzitet Severne Karoline, Fakultet za poljoprivredu i prirodne nauke, Institut za biološki i poljoprivredni inženjering, Raleigh, NC, SAD
[3] Tehnički Univerzitet Virdžinije, Centar za istraživanja i unapređenje poljoprivrede Istočne Virdžinije, Warsaw, VA, SAD
[4]Univerzitet Nebraske, Laboratorija za ispitivanje traktora Nebraska, Lincoln, NE, SAD

Sažetak: Laboratorija za testiranje traktora u Nebraski (NTTL), pri Univerzitetu Nebraska, je zvanična stanica za testiranje traktora, ovlašćena od Organizacije za ekonomsku saradnju i razvoj (OECD) u SAD. Ova Laboratorija je odgovorna za testiranje traktora svih modela koji se prodaju u državi Nebraska. U ovoj Laboratoriji se testiraju i traktori koji se proizvode u SAD, a prodaju na stranim tržištima. Laboratorija objavljuje rezultate svih sprovedenih testova. Izveštaji ovih testiranja, koje NTTL objavljuje, mogu biti izuzetno korisni pri izboru traktora ili poređenju performansi traktora različitih proizvođača i različitih modela. Pravilan izbor i dimenzionisanje traktora je važno za ekonomsku održivost i pouzdanost proizvodnje na farmi. U ovom radu je predstavljena upotreba rezultata objavljenih u NTTL izveštajima pri izboru traktora. Razvijena je i prikazana postupna procedura izbora traktora za farmu na osnovu objavljenih rezultata testiranja traktora.

Ključne reči*: izbor traktora, izveštaji testiranja traktora, poređenje performansi*

Datum prijema rukopisa:
Paper submitted: 21.06.2012.
Datum prijema rukopisa sa ispravkama:
Paper revised: 25.06.2012.
Datum prihvatanja rada:
Paper accepted: 01.07.2012.