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Calculating Farm Machinery Field Capacities

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Calculating field capacities is just part of the overall concept of farm machinery management. Successful farm machinery management does not guarantee a profit, but machinery costs are a major expense and they must be monitored and managed. Therefore, the efficient use of farm machinery starts with determining working capacity in conjunction with the amount of work to be accomplished in a timely manner.

The term capacity means the amount of work that can be performed. The measures of capacity for agricultural machines are theoretical field capacity, effective field capacity and material capacity. Field capacity is measured in acres per hour.

The effective field capacities should be used to size your machinery, given the amount of time or good field days available to accomplish the specific task. For example, some farmers who are both livestock and crop producers may have to maintain larger equipment than do similarly sized crop producers, simply because of the time required for the livestock.

Theoretical Field Capacity

Theoretical field capacity (TFC) is a simple calculation involving speed and width with efficiency set at 100%. It can be calculated from the following equation:

$$\text{TFC}\left(\frac{\text{Acres}}{\text{Hour}}\right) = \frac{\text{width (ft)} \times \text{speed (mph)}}{8.25}$$

Width is the effective working width in feet of the machine. Speed must be given in miles per hour. A simple and accurate measure for speed is to divide 60 by the time in seconds it takes to travel 88 feet on the machine. Time-speed relations are given in Table 1. The 8.25 is a constant used to convert the multiplication of feet and miles to the area in acres.

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Theoretical Field Capacity Example

Suppose a tractor with a 20 foot grain drill travels 5.0 mph. What is the theoretical field capacity (TFC)?

$$TFC = \frac{\text{width (ft)} \times \text{speed (mph)}}{8.25}$$

$$TFC = \frac{20 \times 5}{8.25}$$

TFC = 12.12 acres per hour

It is impossible to maintain the theoretical field capacity of a machine over long periods of time. Interruptions such as turning, filling seed hoppers and breakdowns cause severe reductions in theoretical field capacity. The theoretical field capacity can be used as a benchmark for evaluating the performance of a machine or operator because it is the maximum capacity attainable at a given speed.

Effective Field Capacity

The effective field capacity (EFC) is a more usable measure because it brings in the factor of efficiency. The EFC can be calculated by dividing the hours actually worked into acres covered.

Effective Field Capacity Example

If a 20 ft. grain drill plants 70 acres while operating for 10 hours with no breakdowns, its effective field capacity would be 70 acres divided by 10 hours, or 7.0 acres per hour. This one-day calculation of the effective field capacity does not indicate what the effective field capacity would be for an entire year or growing season. The most accurate field capacity data should be collected for a two-week period of operation. The following is a good example.

Total calendar days = 14	**Total hours in field = 88**
Total working days = 11	**Total acres covered = 704**

$$\text{Effective Field Capacity} = \frac{\text{total acres}}{\text{total hours}} = \frac{704}{88}$$

EFC = 8 acres per hour

Field Efficiency

The ratio of effective field capacity (EFC) to theoretical field capacity (TFC) is called the machine's field efficiency (FE).

Field efficiency accounts for failure to utilize the full operating width of the machine and many other interruptions such as breakdowns, waiting, turning, filling hoppers, etc.

$$FE\ (\%) = \frac{EFC}{TFC} \times 100$$

Below is a comparison of the field efficiency (FE) for a one day and a two-week period.

$$\text{One day (FE)} = \frac{\text{Effective Field Capacity}}{\text{Theoretical Capacity}} \times 100$$

$$\frac{7.0}{12.12} \times 100 = 57.75\ \%$$

$$\text{Two weeks (FE)} = \frac{8.0}{12.12} \times 100 = 66.0\%$$

Thus, the two week field efficiency was greater than the one day check.

Material Capacity

Material capacity and effective field capacity are the two most common methods of measuring machine capacity. The material capacity is the measurement of volume throughput per hour and is expressed as bushels per hour or tons per hour. The formula for material capacity is total volume throughput divided by hours used to harvest the volume.

If a forage chopper harvested 140 tons of haylage in a ten hour period with no breakdowns, the tons of haylage harvested per hour would be 14.

Material Capacity Example

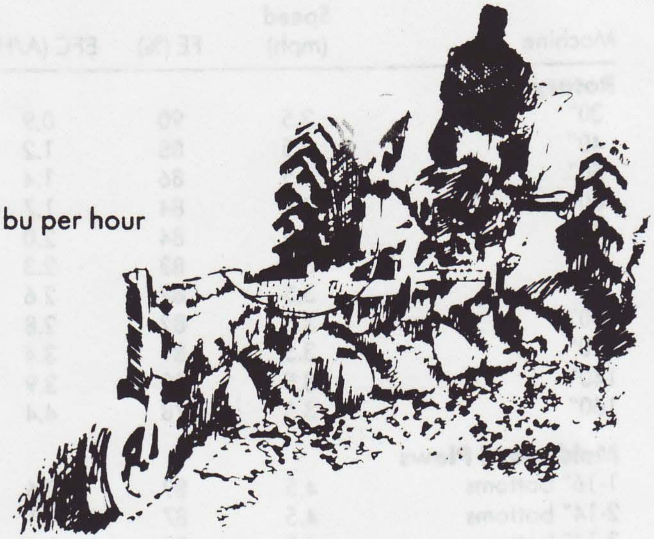
If a self propelled combine was shelling corn that yielded 150 bushels per acre, its effective field capacity could be expressed in bushels per acre. If 39 acres of the corn is combined in ten hours with no breakdowns or other delays, its effective material capacity would be:

$$\frac{150 \text{ bu} \times 39 \text{ acres}}{10 \text{ hours}} = 585 \text{ bushels per hour}$$

Again, the harvesting data should be collected over a two-week period instead of one day. If the same combine is used for two weeks, different figures will be collected:

Total calendar days= 14
Total working days = 10
Total hours in field = 100
Total bushels harvested = 45,000

$$\text{Effective Field Capacity} = \frac{\text{Total Bushels}}{\text{Total Hours}} = \frac{45{,}000}{100} = 450 \text{ bu per hour}$$



Theoretical capacity was calculated at 645 bushels per hour.

$$\text{One Day Field Efficiency } \frac{585}{645} \times 100 = 90.69\ \%$$

$$\text{Two Week Field Efficiency } \frac{450}{645} \times 100 = 69.76\ \%$$

The effective field capacity and material capacity of equipment should be calculated on a regular basis. One day's experience may not be a true picture of the effective field capacity or material capacity and cause farm operators to make mistakes in planning and scheduling. Always use realistic field capacities when scheduling operations or sizing machinery for the future.

The effective field capacity (EFC) can now be calculated using the theoretical field capacity (TFC) and field efficiency (FE).

$$\text{EFC}\left(\frac{\text{acres}}{\text{hour}}\right) = \text{TFC} \times \frac{\text{FE}}{100} = \frac{\text{width (ft)} \times \text{speed (mph)} \times \text{FE (\%)}}{8.25}$$

Table 2 contains the speed, field efficiency (FE) and effective field capacity (EFC) for typical farm machinery in Kentucky. In normal situations these numbers would be sufficient, but on-farm data should be collected and used in the effective field capacity formula.

TABLE 1
Time-Speed Relations

Time to Travel 88 feet, Seconds	Speed, mph
2.5	24
3.0	20.0
3.5	17.1
4.0	15.0
4.5	13.3
5.0	12.0
5.5	10.9
6.0	10.0
6.5	9.2
7.0	8.6
8.0	7.5
9.0	6.7
10.0	6.0
11.0	5.5
12.0	5.0
13.0	4.6
14.0	4.3
15.0	4.0
16.0	3.8
17.0	3.5
18.0	3.3
19.0	3.2
20.0	3.0
40.0	1.5

TABLE 2
Field Speeds (mph), Field Efficiencies (FE) and Effective Field Capacities (EFC) for Kentucky Farm Machines

Machine	Speed (mph)	FE (%)	EFC (A/H)
Rotary Tiller			
30″	3.5	90	0.9
40″	3.5	88	1.2
50″	3.5	86	1.4
60″	3.5	84	1.7
70″	3.5	84	2.0
80″	3.5	83	2.3
90″	3.5	83	2.6
100″	3.5	82	2.8
120″	3.5	81	3.4
140″	3.5	80	3.9
160″	3.5	78	4.4
Moldboard Plows			
1-16″ bottoms	4.5	89	0.6
2-14″ bottoms	4.5	87	1.1
3-14″ bottoms	4.5	86	1.6
3-16″ bottoms	4.5	85	1.8
4-16″ bottoms	4.5	85	2.5
5-16″ bottoms	4.5	83	3.0
6-18″ bottoms	4.5	81	3.9
7-18″ bottoms	4.5	79	4.5
8-18″ bottoms	4.5	78	5.1
Chisel Plow			
7′0″	4.0	87	2.9
9′0″	4.0	85	3.7
12′0″	4.0	83	4.8
15′0″	4.0	81	5.8
20′0″	4.0	79	7.6
30′0″	4.0	74	10.7
40′0″	4.0	72	13.9
Subsoil Chisel (V-Ripper)			
3′0″	4.0	90	1.3
6′0″	4.0	85	2.4
8′3″	4.0	85	3.4
10′3″	4.0	83	4.1
12′3″	4.0	81	4.8
15′4″	4.0	78	5.7
21′8″	4.0	70	7.3
Conser-Till Chisel			
6′3″	4.0	85	2.5
8′9″	4.0	84	3.5
11′3″	4.0	83	4.5
13′9″	4.0	83	5.5
16′3″	4.0	81	6.3
18′9″	4.0	81	7.3
21′3″	4.0	80	8.2
Field Cultivator			
8′6″	5.0	86	4.4
10′6″	5.0	85	5.4
21′6″	5.0	83	10.8
22′11″	5.0	83	11.5
24′4″	5.0	83	12.2
25′6″	5.0	82	12.6
30′8″	5.0	80	14.8
31′10″	5.0	80	15.4
44′7″	5.0	78	21.0
51′11″	5.0	70	22.0
Roller Harrow			
10′1″	6.0	85	6.2
15′3″	6.0	83	9.2
20′10″	6.0	81	12.2
28′0″	6.0	80	16.2
30′0″	6.0	80	17.4
Seedbed Finisher			
12′6″	5.0	84	6.3
14′0″	5.0	83	7.0
19′3″	5.0	80	9.3
21′0″	5.0	80	10.1
25′10″	5.0	78	12.2
Peg Tooth			
6′0″	4.5	87	2.8
12′0″	4.5	85	5.5
18′0″	4.5	82	8.0
24′0″	4.5	80	10.4
Tandem Disk			
5′6″	4.5	87	2.6
7′11″	4.5	87	3.7
9′1″	4.5	85	4.2
11′6″	4.5	85	5.3
13′10″	4.5	83	6.2
16′3″	4.5	81	7.1
21′0″	4.5	81	9.2
23′4″	4.5	79	10.0
30′10″	4.5	77	12.9
45′3″	4.5	72	17.7
Rotary Hoe			
15′	8.0	88	12.8
30′	8.0	84	24.4
41′	8.0	80	31.8
Sweep Cultivator			
1-42″	2.0	85	0.7
2-42″	2.0	85	1.4
4-38″	4.5	83	5.7
4-30″	4.5	83	4.5
6-30″	4.5	80	6.5
8-30″	4.5	78	8.5
12-30″	4.5	76	12.4
Rolling Cultivator			
4-38″	4.0	83	5.0
6-30″	4.0	80	5.8
8-30″	4.0	78	7.5
12-30″	4.0	76	11.0

Machine	Speed (mph)	FE (%)	EFC (A/H)
Sickle-Bar Mower			
7'0"	5.0	80	3.4
9'0"	5.0	80	4.3
Grain Drill			
8'	5.0	72	3.4
12'	5.0	72	5.2
16'	5.0	70	6.7
20'	5.0	70	8.4
24'	5.0	68	9.8
34'	5.0	68	14.0
39'	5.0	66	15.6
Planter			
2-38"	5.0	78	2.9
4-38"	5.0	76	5.8
4-30"	5.0	76	4.6
6-30"	5.0	74	6.7
8-30"	5.0	72	8.7
12-30"	5.0	68	12.3
16-30"	5.0	66	16.0
24-30"	5.0	64	23.2
Combine Soybeans and Small Grain			
10'	2.8	76	2.5
13'	2.8	74	3.2
15'	2.8	73	3.7
20'	2.6	71	4.4
22'5"	2.6	70	4.9
25'	2.4	69	5.0
30'	2.2	68	5.4
Combine Corn			
2-38"	2.6	75	1.4
3-38"	2.6	73	2.1
4-38"	2.6	71	2.8
6-38"	2.6	67	4.0
3-30"	2.6	73	1.7
4-30"	2.6	71	2.2
6-30"	2.6	67	3.1
8-30"	2.5	65	3.9
12-30"	2.3	61	5.1
Machine Disc Mowers			
5'6"	6.0	85	3.4
6'8"	6.0	83	4.0
7'10"	6.0	81	4.6
Rakes			
8'6"	5.0	88	4.5
9'6"	5.0	88	5.0
15'0"	5.0	86	6.7
18'0"	5.0	83	9.0
23'0"	5.0	80	11.1
Tedders			
10'2"	5.0	88	5.4
13'0"	5.0	86	6.7
17'0"	5.0	83	8.5

Machine	Speed (mph)	FE (%)	EFC (A/H)
Self Propelled Windrower			
12'	5.0	84	6.1
14'	5.0	83	7.0
16'	5.0	82	7.9
Pull Type Mower/Conditioner			
7'	5.0	85	3.6
9'	5.0	83	4.5
12'	5.0	81	5.8
14'	5.0	79	6.7
16'	5.0	77	7.4
Rotary Mower/Conditioner			
8'	5.0	84	4.0
9'	5.0	83	4.5
Sprayer			
4-row	5.0	65	5.5
6-row	5.0	65	8.2
8-row	5.0	65	9.4
12-row	5.0	65	11.8
18-row	5.0	65	17.7
Transplanter			
1-42"	2.0	55	0.4
2-42"	2.0	60	1.0
4-42"	2.0	65	2.2
Broadcast Seeder			
20'	5.0	75	9.1

Machine	Tons/Hr
Baler, medium-duty-ejector or wagon chute	6.8
Baler, medium-duty-bales on ground	6.4
Baler, medium duty	8.0
Baler, round-600-lb. bale	3.4
Baler, round-1200 lb. bale	7.5
Baler, round-2000 lb. bale	8.5

65% Moisture Content Silage	Tons/Hr
Harvester, direct-cut; small, PTO	12.0
Harvester, direct-cut; medium, PTO	20.0
Harvester, direct-cut; large, PTO	24.0
Harvester, direct-cut; SP	40.0
Harvester, pick-up; medium, PTO	15.0
Tractor; packing horizontal silo	40.0
Blower	25.0

50% Moisture Content	Tons/hr
Blower	20.0
Harvester, pickup: Medium, PTO	10.0
Harvester, pickup: SP	20.0

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