FARMING KNOW-HOW
Guidelines to Better Family Farming

Determining Capacities Of Farm Machines*

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How many acres per hour can one expect to cover with a moldboard plow? A combine? A disk harrow? Or any other farm machine? These questions are frequently asked by both full-time and part-time farm operators, and their answers play an important role in determining the size of machine needed. The answers are affected, at least in part, by the experience of the operator, his familiarity with the machine and by variations in crop, soil, field topography, and weather conditions. Three factors play a dominant role:

1. the operating width or "effective width" of the machine,
2. the operating speed, and
3. the field efficiency, or relative productivity, of the machine under a specific set of field and operating conditions.

Operating width, under most circumstances, is a "design factor," and cannot be readily changed once the machine has been purchased. (There are a few exceptions, such as certain models of moldboard plows whose width of cut per plow bottom can be varied from roughly 12 to 20 or more inches hydraulically while the plow is in operation.)

Operating speed for most farm machines can, at least theoretically, be varied over a wide range, from very slow to very fast. Practical limitations, however, such as operator ability, tractor power and speed ranges, topography, crop or soil conditions, safety considerations, and machine capacity or performance characteristics, tend to set both lower and upper limits. Reasonable ranges of operating speeds for a selected list of farm machines are shown in Table I, while "typical" operating speeds are shown in both Tables I and II. These suggested "typical" speeds, however, must be tailored to meet specific field and operating conditions.

Field efficiency is undoubtedly the most elusive factor in estimating the field capacity of a farm machine. Field efficiency may be defined as the ratio of the theoretical productivity of a machine to its actual productivity. It takes into consideration "lost productivity" resulting from failure to consistently utilize the full operating width or capacity of the machine, along with time losses resulting from operator inefficiency, operating practices, and field, crop or weather limitations. The following items account for the majority of time losses in field operations:

1. turning at row ends or cornering;
2. maneuvering around field obstructions;
3. idle travel;
4. materials handling, which includes
   a. filling hoppers with seed, fertilizer, chemicals, etc.,
   b. unloading harvested crop, changing wagons, etc.;
5. cleaning or clearing clogged equipment;
6. making adjustments and minor repairs;
7. lubricating and refueling (beyond daily service);
8. adding twine, wire or other operating supplies;
9. waiting for other machines; and
10. miscellaneous time interruptions, such as rest stops, visiting with neighbors, etc.

Many factors affecting field efficiency are beyond the operator's control. Many others, however, are "management" factors, and can be directly influenced by the operator. In many instances, improving the field efficiency of an operation will be more economical and more effective than buying a larger machine.

Table I is a guide in determining typical field efficiency factors and ground speeds for many of the more common farming operations. Keep in mind, however, that these are "typical" figures, and apply to normal, or average, operating conditions. Specific circumstances

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* *In Acres Per Hour and Hectares Per Hour. (Only U.S. units of measurement are used in the text.) Tables and equations, however, show both U.S. and metric units.*

TABLE I. FIELD EFFICIENCY FACTORS AND OPERATING SPEEDS FOR SELECTED FARMING OPERATIONS.

MACHINE	FIELD EFFICIENCY		OPERATING SPEEDS U.S. Units		Metric Units	
	Range %	Typical %	Range mi/hr	Typical mi/hr	Range km/hr	Typical km/hr
TILLAGE						
Moldboard Plow	70-90	80	3.0-6.0	4.5	4.8-9.7	7.2
Heavy-Duty Disk	70-90	85	3.5-6.0	4.5	5.6-9.7	7.2
Tandem Disk Harrow:						
Loose soil	70-90	80	3.0-6.0	4.0	4.8-9.7	6.4
Firm soil	70-90	85	3.0-6.0	4.5	4.8-9.7	7.2
Chisel Plow	70-90	85	4.0-6.5	4.5	6.4-10.5	7.2
Field Cultivator	70-90	85	3.0-8.0	5.5	4.8-12.9	8.9
Spring Tooth Harrow	70-90	85	3.0-6.0	5.0	4.8-9.7	8.0
Roller-Packer	70-90	85	4.5-7.5	6.0	7.2-12.1	9.7
Mulcher-Packer	70-90	80	4.0-6.0	5.0	6.4-9.7	8.0
Rotary Hoe	70-85	80	5.0-10.0	7.0	8.0-16.1	11.3
Row Crop Cultivator	70-90	80	2.5-5.0	3.5	4.0-8.0	5.6
PLANTING						
Row Crop Planter						
No-till tillage:						
4 row or less	50-75	60	2.0-4.0	3.0	3.2-6.4	4.8
over 4 row	50-75	55	2.0-4.0	3.0	3.2-6.4	4.8
Conventional tillage:						
4 row or less, 40-in.	50-75	60	3.0-6.0	3.5	4.8-9.7	5.6
4 row or less, 30-in.	50-75	60	3.0-6.0	4.5	4.8-9.7	7.2
6 to 8 row, 30-in.	50-75	55	3.0-6.0	4.5	4.8-9.7	7.2
over 8 row, 30-in.	50-75	50	3.0-6.0	4.0	4.8-9.7	6.4
Grain Drill	65-85	70	2.5-6.0	4.0	4.0-9.7	6.4
MISCELLANEOUS						
Fertilizer Spreader	60-75	70	3.0-5.0	4.5	4.8-8.0	7.2
Boom-Type Sprayer	50-80	65	3.0-7.0	6.5	4.8-11.3	10.5
Air-Carrier Sprayer	55-70	60	2.0-5.0	3.0	3.2-8.0	4.8
Bean Puller and Windrower	70-90	80	2.0-5.0	3.5	3.2-8.0	5.6
Sugar Beet Topper	60-80	70	2.0-3.0	2.5	3.2-4.8	4.0

MACHINE	FIELD EFFICIENCY		OPERATING SPEEDS U.S. Units		Metric Units	
	Range %	Typical %	Range mi/hr	Typical mi/hr	Range km/hr	Typical km/hr
HARVESTING						
Corn Picker:						
1 row	60-80	70	2.0-4.0	3.0	3.2-6.4	4.8
2 row and over	60-75	65	2.0-4.0	2.5	3.2-6.4	4.0
Picker-Sheller	55-70	60	2.0-4.0	2.5	3.2-6.4	4.0
Combine (Small Grain):						
Pull-type	60-75	65	2.0-4.0	3.0	3.2-6.4	4.8
Self-propelled	65-80	70	2.0-4.0	3.0	3.2-6.4	4.8
Combine, S.P. (Row Crop):						
3 row or less	65-80	70	2.0-4.0	2.5	3.2-6.4	4.0
4 to 6 row	65-80	65	2.0-4.0	2.5	3.2-6.4	4.0
Over 6 row	65-80	65	2.0-4.0	2.0	3.2-6.4	3.2
Mower:						
Cutterbar type	75-85	80	4.0-7.0	5.0	6.4-11.3	8.0
Flail type	75-85	80	4.0-6.0	4.5	6.4-9.7	7.2
Mower With Conditioner	60-80	75	3.5-6.0	4.5	5.6-9.7	7.2
Mower-Conditioner	55-80	75	3.0-6.0	4.5	4.8-9.7	7.2
Side Delivery Rake	70-85	80	4.0-5.0	4.5	6.4-8.1	7.2
Baler:						
Bales dropped	65-85	75	2.5-5.0	3.5	4.0-8.1	5.6
Bale thrower	55-75	65	2.5-5.0	3.5	4.0-8.1	5.6
Big Bale Baler	55-75	65	3.0-5.0	4.0	4.8-8.1	6.4
Long Hay Stacker	55-75	60	2.5-4.5	3.5	4.0-7.2	5.6
Forage Harvester:						
Haylage	50-75	65	1.5-3.5	2.0	2.4-5.6	3.2
Corn silage						
1 row	55-75	65	1.5-4.0	3.0	2.4-4.6	4.8
2 and 3 row	55-75	60	1.5-4.0	2.5	2.4-4.6	4.0
over 3 row	55-75	55	1.5-4.0	2.5	2.4-4.6	4.0
Straw	55-75	65	2.0-4.0	3.0	3.2-4.6	4.8
Sugar Beet Harvester:						
1 row	60-80	70	2.5-5.0	3.5	4.0-8.1	5.6
2 row	60-80	70	2.5-5.0	3.0	4.0-8.1	4.8
3 row and larger	60-80	65	2.5-5.0	3.0	4.0-8.1	4.8
Potato Harvester:						
2 row	55-70	60	1.5-4.0	2.5	2.4-6.4	4.0
4 row (incl. windrow)	55-70	60	1.5-4.0	2.0	2.4-6.4	3.2
6 row (incl. windrow)	55-70	55	1.5-4.0	2.0	2.4-6.4	3.2

may dictate use of a field efficiency factor or ground speed somewhat higher or lower than those shown. Extreme caution should be exercised in selecting field efficiency factors or ground speeds either higher or lower than the limits of the ranges shown.

Theoretical Machine Capacity

The *theoretical* number of acres per hour that can be covered by any farm machine can be calculated from the following simplified equation:

$$\frac{W \times S}{100} = \text{theoretical acres per hour,}$$

where: W = operating width in inches,
S = operating speed in miles per hour, and
100 = a constant (To be mathematically correct, this constant should be 99, but to simplify computations, 100 is commonly used.)

This equation, however, completely ignores the question of field efficiency, and will always give an answer that is unrealistically high. Therefore, a field efficiency factor must be inserted to obtain an answer that is representative of typical field situations.

Calculating Actual Machine Capacity

The *actual* number of *acres per hour* that can be covered by a machine can be calculated from the following equation:

$$\frac{W \times S \times E}{100} = \textit{actual}\text{ acres per hour,}$$

where: W = operating width in inches,
S = operating speed in miles per hour,
E = field efficiency factor (expressed as a decimal), and
100 = a constant.

To determine *actual* machine capacity in *hectares per hour*, the equation becomes:

$$\frac{W \times S \times E}{1{,}000} = \textit{actual}\text{ hectares per hour,}$$

where: W = operating width in centimeters,
S = operating speed in kilometers per hour,
E = field efficiency factor (expressed as a decimal), and
1,000 = a constant.

EXAMPLE 1

How many acres per hour can one expect to cover with a 3-bottom, 16-inch moldboard plow, operating at a speed of 4.5 miles per hour, with a field efficiency of 80 percent?

$$\frac{3 \times 16(W) \times 4.5(S) \times .80(E)}{100} = \_\_\_\_\_\text{ acres per hour.}$$

$$\frac{48 \times 4.5 \times .80}{100} = 1.73\text{ acres per hour.}$$

EXAMPLE 2

How many hectares per hour can one expect to cover with a 305-centimeter (10-foot) self-propelled combine harvesting small grain, operating at 4.8 kilometers (3.0 miles) per hour, with a field efficiency of 70 percent?

$$\frac{305(W) \times 4.8(S) \times .70(E)}{1{,}000} = \_\_\_\_\_\text{ hectares per hour.}$$

$$\frac{305 \times 4.8 \times .70}{1{,}000} = 1.02\text{ hectares per hour.}$$

Use of the Nomograph

Machine capacities in acres per hour (but *not* in *hectares* per hour) can also be determined from Figure 1, MACHINE CAPACITY NOMOGRAPH. Refer again to Example 1, in which we have a 3-bottom, 16-inch (48-inch operating width) moldboard plow, operating at a speed of 4.5 miles per hour, with a field efficiency factor of 80 percent. To use the nomograph, follow these steps:

1. With a sharp pencil, place a dot at the specified operating speed (4.5 miles per hour) on the first vertical scale.
2. Next, place a dot at the specified operating width (48 inches) on the second vertical scale.
3. Using a straightedge, extend a line through these two points to the third vertical scale, labeled "Theoretical Field Capacity, Acres per Hour," and place a dot at the point of intersection. This point is 2.16 theoretical acres per hour.
4. Put a dot on the fourth vertical scale at the desired field efficiency factor (80 percent, or 80 on the scale).
5. Again using a straightedge, extend a line from the point of intersection in the third vertical scale through the field efficiency point in the fourth vertical scale to a point of intersection with the fifth vertical scale, "Effective Field Capacity, Acres per Hour."
6. The resulting answer is 1.73 *actual* acres per hour.

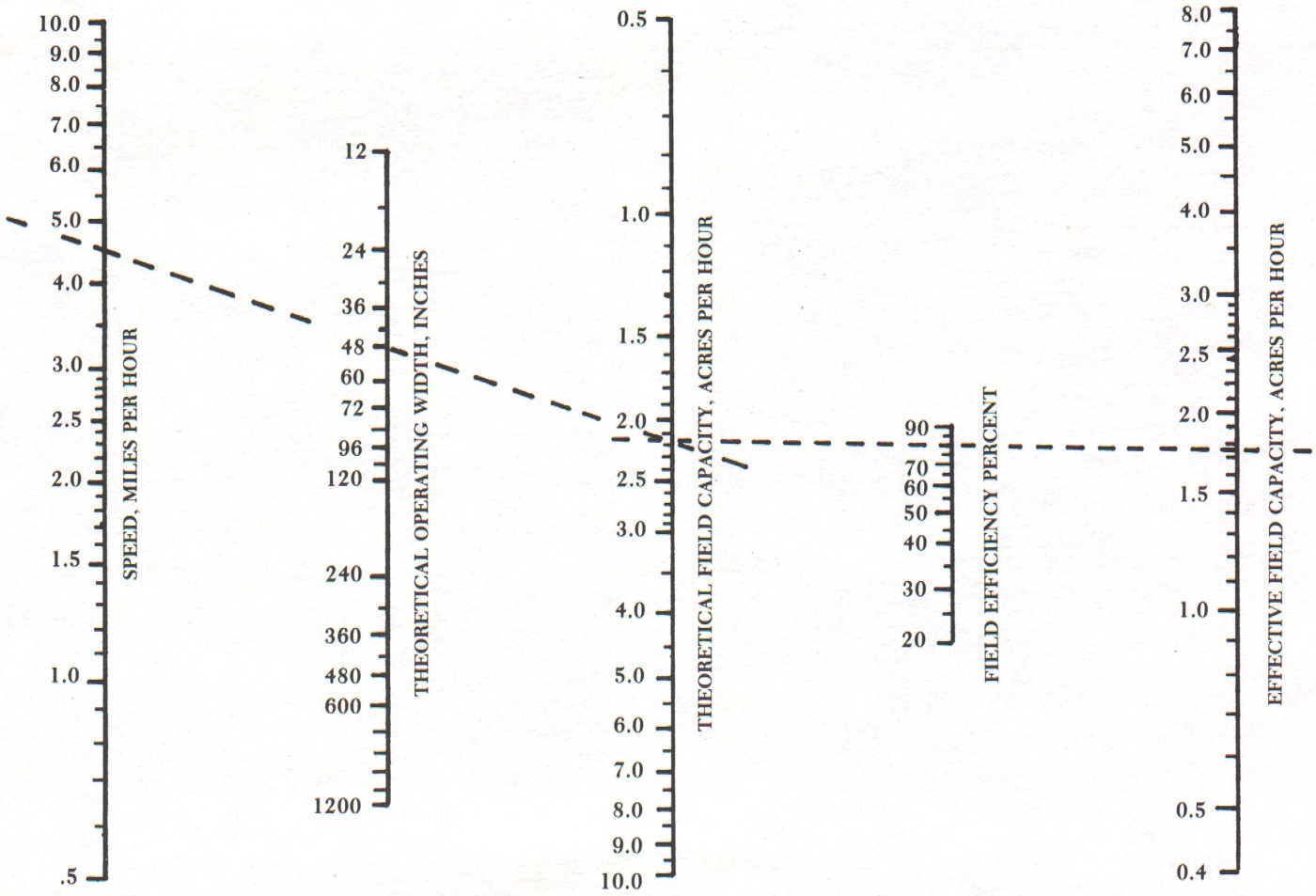
Results obtained from nomographs are approximations only, and may not be as accurate as calculated results. As operating speed and/or machine width increases, the accuracy of nomographs tends to decrease.

Machine capacities in both *acres* per hour and *hectares* per hour are shown in Table II through a typical range of sizes for a selected group of farm machines.

Tips for Improving Field Efficiency

1. Remove stumps, stones and other obstructions from fields.
2. Remove fences or change field boundaries to permit longer operating rows, thus eliminating excessive turning at field ends.
3. Wherever possible, work parallel to the long dimension of the field to reduce the number of turns.
4. Make plans to unload grain tanks (combines) on the go, to reduce or eliminate unloading time.
5. Mechanize the handling of seed, fertilizer, etc., so as to fill hoppers more rapidly.
6. Consider installing a "bank lubrication" or "multilubrication" system, where applicable, to reduce "down time" for lubrication purposes.
7. Plan ahead. Be sure all equipment is serviced, in good repair and in proper working condition before taking it to the field.
8. Tile and/or drain wet spots in the field that frequently have to be worked around.
9. Organize the operation so that all phases move smoothly in unison, without bottlenecks.
10. Train the entire crew so that each man operates as a part of a team.
11. Wait until field and crop conditions are ready, then be ready to go.
12. Work SAFELY at all times.

*FIGURE 1. MACHINE CAPACITY NOMOGRAPH**



* *This nomograph has been adapted from Agricultural Machinery Management Data, ASAE D230.2, 1977 Agricultural Engineering Yearbook, page 333, with permission from American Society of Agricultural Engineers, 2950 Niles Road, St. Joseph, Michigan 49085. Permission also granted to change the second vertical scale from "Theoretical Operating Width, Feet" to "Theoretical Operating Width, Inches."*

Appendix

Conversion Factors Applicable to This Publication

U.S. to Metric	*Metric to U.S.*
1 inch = 2.540 centimeters	1 centimeter = 0.3937 inches
1 foot = 30.480 centimeters	1 meter = 39.370 inches
1 foot = 0.3048 meters	1 meter = 3.2808 feet
1 yard = 0.9144 meters	1 meter = 1.0936 yards
1 acre = 0.4047 hectares	1 hectare = 2.471 acres
1 mile per hour = 1.6094 kilometers per hour	1 kilometer per hour = 0.6214 miles per hour

TABLE II. MACHINE CAPACITIES, ACRES/HR. AND HECTARES/HR. FOR SELECTED FARMING OPERATIONS.

MACHINE	FIELD EFF. %	U.S. UNITS Width in.	Speed mi/hr	Acres per hr	METRIC UNITS Width cm	Speed km/hr	Hectares per hr
TILLAGE							
Moldboard Plow:							
2-bottom, 14-in.	80	28	4.5	1.01	71	7.2	.41
3-bottom, 14-in.	80	42	4.5	1.51	107	7.2	.62
5-bottom, 16-in.	80	80	4.5	2.88	203	7.2	1.17
7-bottom, 16-in.	80	112	4.5	4.03	284	7.2	1.64
Heavy-Duty Disk:							
8-ft.	85	96	4.5	3.67	244	7.2	1.49
12-ft.	85	144	4.5	5.51	366	7.2	2.24
Tandem Disk Harrow:							
6-ft., loose soil	80	72	4.0	2.30	183	6.4	.94
6-ft., firm soil	85	72	4.5	2.75	183	7.2	1.12
8-ft., firm soil	85	96	4.5	3.67	244	7.2	1.49
10-ft., firm soil	85	120	4.5	4.59	305	7.2	1.87
Chisel Plow:							
6-ft.	85	72	4.5	2.75	183	7.2	1.12
9-ft.	85	108	4.5	4.13	274	7.2	1.68
Field Cultivator:							
8-ft.	85	96	5.5	4.49	244	8.9	1.85
12-ft.	85	144	5.5	6.73	366	8.9	2.77
16-ft.	85	192	5.5	8.98	488	8.9	3.69
Spring Tooth Harrow:							
12-ft.	85	144	5.0	6.12	366	8.0	2.49
18-ft.	85	216	5.0	9.18	549	8.0	3.73
Roller-Packer:							
8-ft.	85	96	6.0	4.90	244	9.7	2.01
12-ft.	85	144	6.0	7.34	366	9.7	3.02
Mulcher-Packer:							
8-ft.	80	96	5.0	3.84	244	8.0	1.56
10-ft.	80	120	5.0	4.80	305	8.0	1.95
Rotary Hoe:							
10-ft.	80	120	7.0	6.72	305	11.3	2.76
18-ft.	80	216	7.0	12.10	549	11.3	4.96
Row Crop Cultivator:							
4-row, 40-in.	80	160	3.5	4.48	406	5.6	1.82
8-row, 30-in.	80	240	3.5	6.72	610	5.6	2.73
PLANTING							
Row Crop Planter							
No-till tillage:							
4-row, 30-in.	60	120	3.0	2.16	305	4.8	.88
4-row, 40-in.	60	160	3.0	2.88	406	4.8	1.17
Conventional tillage:							
2-row, 40-in.	60	80	3.5	1.68	203	5.6	.68
4-row, 40-in.	60	160	3.5	3.36	406	5.6	1.36
6-row, 30-in.	55	180	4.5	4.46	457	7.2	1.81
8-row, 30-in.	55	240	4.5	5.94	610	7.2	2.42
12-row, 30-in.	50	360	4.0	7.20	914	6.4	2.92
Grain Drill:							
17-hole, 7-in.	70	119	4.0	3.33	302	6.4	1.35
23-hole, 8-in.	70	184	4.0	5.15	467	6.4	2.09

MACHINE	FIELD EFF. %	U.S. UNITS Width in.	Speed mi/hr	Acres per hr	METRIC UNITS Width cm	Speed km/hr	Hectares per hr
HARVESTING							
Corn Picker:							
1-row, 30-in.	70	30	3.0	.63	76	4.8	.26
1-row, 40-in.	70	40	3.0	.84	102	4.8	.34
2-row, 40-in.	65	80	2.5	1.30	203	4.0	.53
3-row, 30-in.	65	90	2.5	1.46	229	4.0	.60
Combine (Small Grain):							
Pull-type, 7-ft.	65	84	3.0	1.64	213	4.8	.66
Self-propelled, 10-ft.	70	120	3.0	2.52	305	4.8	1.02
Self-propelled, 16-ft.	70	192	3.0	4.03	488	4.8	1.64
Combine, S.P.,							
Row Crop:							
2-row, 40-in.	70	80	2.5	1.40	203	4.0	.57
3-row, 30-in.	70	90	2.5	1.58	229	4.0	.64
4-row, 30-in.	65	120	2.5	1.95	305	4.0	.79
4-row, 40-in.	65	160	2.5	2.60	406	4.0	1.06
6-row, 30-in.	65	180	2.5	2.93	457	4.0	1.19
8-row, 20-in.	65	160	2.0	2.08	406	3.8	1.00
8-row, 30-in.	65	240	2.0	3.12	610	3.8	1.27
Mower:							
7-ft., cutterbar type	80	84	5.0	3.36	213	8.0	1.36
8-ft., flail type	80	96	4.5	3.46	244	7.2	1.41
Mower with Conditioner,	75	84	4.5	2.84	213	7.2	1.15
Mower-Conditioner:							
9-ft., pull type	75	108	4.5	3.65	274	7.2	1.48
12-ft., self-propelled	75	144	4.5	4.86	366	7.2	1.98
Side Delivery Rake:							
7-ft.	80	84	4.5	3.02	213	7.2	1.23
18-ft.	80	216	4.5	7.78	549	7.2	3.16
Baler, Bales Dropped:							
7-ft. windrow	75	84	3.5	2.21	213	5.6	.89
9-ft. windrow	75	108	3.5	2.84	274	5.6	1.15
Baler, Bale Thrower:							
7-ft. windrow	65	84	3.5	1.91	213	5.6	.78
9-ft. windrow	65	108	3.5	2.46	274	5.6	1.00
Big Bale Baler:							
9-ft. windrow	65	108	4.0	2.81	274	6.4	1.14
12-ft. windrow	65	144	4.0	3.74	366	6.4	1.52
Long Hay Stacker:							
9-ft. windrow	60	108	3.5	2.27	274	5.6	.92
12-ft. windrow	60	144	3.5	3.02	366	5.6	1.23
Forage Harvester							
Haylage:							
7-ft. windrow	65	84	2.0	1.09	213	3.2	.44
9-ft. windrow	65	108	2.0	1.40	274	3.2	.57
12-ft. windrow	60	144	2.0	1.73	366	3.2	.70
Corn silage:							
1-row, 30-in.	65	30	3.0	.59	76	4.8	.24
1-row, 40-in.	65	40	3.0	.78	102	4.8	.32
2-row, 30-in.	60	60	2.5	.90	152	4.0	.36
2-row, 40-in.	60	80	2.5	1.20	203	4.0	.49
3-row, 30-in.	60	90	2.5	1.35	229	4.0	.55
4-row, 30-in.	55	120	2.5	1.65	305	4.0	.67

(Continued on next page)

TABLE II. (Continued from page 5)

MACHINE	FIELD EFF. %	U.S. UNITS Width in.	Speed mi/hr	Acres per hr	METRIC UNITS Width cm	Speed km/hr	Hectares per hr
Straw							
12-ft. windrow	65	144	3.0	2.81	366	4.8	1.14
Sugar Beet Harvester:							
1-row, 28-in.	70	28	3.5	.69	71	5.6	.28
2-row, 28-in.	70	56	3.0	1.18	142	4.8	.48
4-row, 28-in.	65	112	3.0	2.18	284	4.8	.89
Potato Harvester:							
2-row, 28-in.	60	56	2.5	.84	142	4.0	.34
4-row, 28-in.	60	112	2.0	1.34	284	3.2	.55
6-row, 28-in.	55	168	2.0	1.85	427	3.2	.75
MISCELLANEOUS							
Fertilizer Spreader:							
14-ft., spreader type	70	168	4.5	5.29	427	7.2	2.15
36-ft., spinner type	70	432	4.5	13.61	1097	7.2	5.53
Boom-Type Sprayer:							
21-ft.	65	252	6.5	10.65	640	10.5	4.37
35-ft.	65	420	6.5	17.75	1067	10.5	7.28
Air-Carrier Sprayer:							
40-ft.	60	480	3.0	8.64	1219	4.8	3.51
90-ft.	60	1080	3.0	19.44	2743	4.8	7.90
Bean Puller and Windrower:							
4-row, 28-in.	80	112	3.5	3.14	284	5.6	1.27
6-row, 28-in.	80	168	3.5	4.70	427	5.6	1.91
Sugar Beet Topper:							
4-row, 28-in.	70	112	2.5	1.96	284	4.0	.80
8-row, 28-in.	70	224	2.5	3.92	569	4.0	1.59