

Units of Measurement Commonly Used in Agriculture

We are talking with the representative from a dairy farmers' association, who tells us that presently, the price of a hundredweight of milk is lower than it was in 2004. What does a "hundredweight" of milk mean? Or a Midwestern farmer who grows corn and soybeans reports his yields in "bushels per acre." What is our understanding of a "bushel"? (The question turns out to be more complicated than we might have realized – for example, a bushel of soybeans weighs more than a bushel of corn grain.) Or we are reading about grain production in Europe, and don't find the term "bushels per acre" at all, but rather "quintals per hectare." What is a "quintal"? When studying agriculture, a grasp of the different units of measurements is essential.

There are two systems of units in use in the United States. One, commonly used in science but less commonly used in day-to-day life, is called the "SI" system (from its French name, *Système International d'Unités*). It is also known as the "International System," and informally (but not quite accurately) as the "metric" system. SI emerged in 1960 in response to a perceived need for a system that would be uniformly accepted worldwide. It is a standardized version of the metric system, which goes back to the Napoleonic era.

Although the SI/metric system is not widely used in ordinary life in the United States, it is the prevalent system in most of the world. (Actually, even in countries that use SI, the strict SI system is used primarily in the scientific literature, whereas in commercial and popular contexts, some older metric units are still used that are not official SI units, e.g., the cal, which was dropped in SI in favor of the joule as the sole unit of energy.)

- **Table 1** lists important SI units and their more familiar US counterparts.
- **Table 2** complements this with combinations of these units that are often encountered in the agricultural literature.
- **Table 3** gives the prefixes used to create units that are various powers of ten times the base SI units.

In the United States, SI is used in medical, scientific, and much other specialized, technical work. However, for commercial and day-to-day life we usually use the system called "US Customary." This is a version of the Imperial System, which was developed in Britain but which in large part has been replaced by SI even there. The main American departure from the Imperial System is in the units of volume or capacity: some units of liquid measure, such as the pint and the gallon, are smaller in the US. An additional complication is that even in work that primarily uses the Imperial/US Customary system, it is common to mix in certain SI units, especially the joule for energy and the watt for power. Finally, there is the problem mentioned at the very start: the sometimes confusing units used in the US for agricultural outputs, examples of which are given in **Table 4**.

More details about the different systems may be found in the references provided below.

Table 1. Common SI units, and their corresponding US Customary counterparts.

	SI/Metric	Comparable Imperial/US Customary Units
Length	meter (m)	foot (ft)= 0.3048 m yard (yd) = 0.9144 m
	centimeter (cm) = 10^{-2} m	inch (in) = 2.54 cm
	kilometer (km) = 10^3 m	mile (mi) = 1.609 km
Area	square meter (m ²)	square foot (ft ²) = 0.0929 m ² square yard (yd ²) = 0.8361 m ²
	square centimeter (cm ²) = 10^{-4} m ²	square inch (in ²) = 6.452 cm ²
	hectare (ha) = 10^4 m ²	acre (A or ac) = 43,560 ft ² = 0.4047 ha.
	square kilometer (km ²) = 10^6 m ² = 100 ha	square mile (mi ²) = 640 A = 2.590 km ²
Volume	liter (l or L)	gallon (gal) = 3.785 l cubic foot (ft ³) = 7.476 gal = 28.32 l
	cubic centimeter (cm ³) = 1 milliliter (ml)	cubic inch (in ³) = 16.39 cm ³
	cubic meter (m ³) = 10^3 l	cubic yard (yd ³) = 0.7645 m ³
Temperature ^a	degrees Celsius (°C)	degrees Fahrenheit (°F) = 9/5 (°C) + 32
Mass ^b	kilogram (kg)	pound (lb) = 0.4536 kg
	gram (g) = 10^{-3} kg	ounce (oz) = 1/16 lb = 28.35 g
	metric tonne or metric ton (t) = 10^3 kg	short ton (commonly called “ton”) = 2000 lb = 0.9071 t long ton = 2240 lb = 1.016 t
	quintal (q) = 10^2 kg	hundredweight (cwt) = 100 lb = 0.4536 q
Force/weight ^b	newton (N)	pound (lb) = 4.448 N
Pressure	pascal (Pa) = 1 N/m ²	
	kilopascal (kPa) = 10^3 Pa	pounds per square inch (psi) = 6.893 Pa
	torricelli (torr) = 1 mm of mercury (mm Hg) = 0.1333 kPa	inches of mercury (in Hg) = 25.4 mm Hg = 0.491 psi
	1 bar = 10^5 kPa	atmosphere (atm) = 1.013 bar
Energy ^c	joule (J)	foot-pound (ft-lb) = 1.356 J
	calorie (cal) = 4.187 J	
	kilocalorie (kcal or Cal) = 10^3 cal	British thermal unit (Btu) = 1055 J = 0.252 kcal
Power	watt (W) = joules per second (J/s)	
	kilowatt (kW) = 10^3 W	horsepower (hp) = 0.7457 kW

^aThe official way to express temperature in SI is in Kelvin (K). However, in agriculture, temperature is expressed as either Celsius or Fahrenheit.

^bIn a scientific context, the pound (lb) is a unit of weight or force, but in commercial usage it is commonly taken as unit of mass, with the indicated equivalence to the kg (a true unit of mass).

^cSeveral SI/metric units of energy and power are commonly used with the Imperial/Customary US system, e.g. W, kWh, J, and kcal (for food energy).

Table 2. Additional units customarily used in agricultural research or practice

Quantity	SI	Imperial/US Customary
Wavelength	angstrom (Å) = 10^{-10} m nanometer (nm) = 10^{-9} m	
Irradiance	watts per square meter (W/m^2)	
Volume of irrigation water	hectare-meter (ha-m)	acre-foot (ac-ft) = 0.1233 ha-m
Fertilizer and pesticide application rates	kilograms per hectare (kg/ha)	pounds per acre (lb/A or lb/ac) = 0.892 kg/ha
Electrical energy	kilowatt-hour (kWh) = 3.6×10^6 J	See note c to Table 1.
Electrical conductivity	siemen (S) = mhos per centimeter (mho/cm) decisiemens per meter (dS/m) millimhos per centimeter (mmho/cm) = 1 millisiemen (mS)	
Suspended sediment concentration	kilograms per cubic meter (kg/m^3)	
Dissolved salts	milligrams per cubic meter (mg/m^3)	
Cation exchange capacity	milliequivalents per 100 grams of soil (meq/100 g)	
Soil reaction	pH	
Particle size	Micron (or micrometer) (μ) = 10^{-6} m	

Table 3. Multiples of SI base units

Several prefixes are used with the base units in the SI system to derive other units that are greater or less than the base units by various powers of 10. The following table illustrates their usage with the meter, the base unit of length in the SI system.

Multiple	Name	Symbol	Multiple	Name	Symbol
10^0	meter	m			
10^1	decameter	dam	10^{-1}	decimeter	Dm
10^2	hectometer	hm	10^{-2}	centimeter	Cm
10^3	kilometer	km	10^{-3}	millimeter	Mm

10^6	megameter	Mm		10^{-6}	micrometer	μm
10^9	gigameter	Gm		10^{-9}	nanometer	Nm
10^{12}	terameter	Tm		10^{-12}	picometer	Pm
10^{15}	petameter	Pm		10^{-15}	femtometer	Fm

Table 4. US units of agricultural output

Unit	Value
Bushel ^a	56 lb
corn, sorghum, rye	
soybean, wheat	60 lb
Barley	48 lb
Oats	32 lb
Bale of cotton	500 lb
Hundredweight (cwt) of milk	100 lb or 11.63 gal

A more complete list of these units can be found at
<http://muextension.missouri.edu/xplor/agguides/crops/g04020.htm>

^aThe bushel was originally a unit of volume. However, for grains it has long been defined in terms of weight; the definition varies among different grains because of their differing densities.

Web-based aids for conversion of units:

Diver, S (2003). *Measurements, conversion units and calculations useful to farmers and Agricultural Specialists*. ATTRA- National Sustainable Agriculture Information Service,
<http://www.attra.org/attra-rl/measurements.html#Quick>

<http://www.wikipedia.org>

A Dictionary of Measures, Units and Conversions
 Centre for Innovation in Mathematics Teaching, University of Exeter
<http://www.ex.ac.uk/cimt/dictunit/dictunit.htm>

Tables for weights and measurements: Crops.
 Extension Department of the University of Missouri.
<http://muextension.missouri.edu/xplor/agguides/crops/g04020.htm>

US Cotton Bale Dimensions.
 National Cotton Council of America.
<http://www.cotton.org/tech/bale/bale-description.cfm>