Water for Dairy Cattle

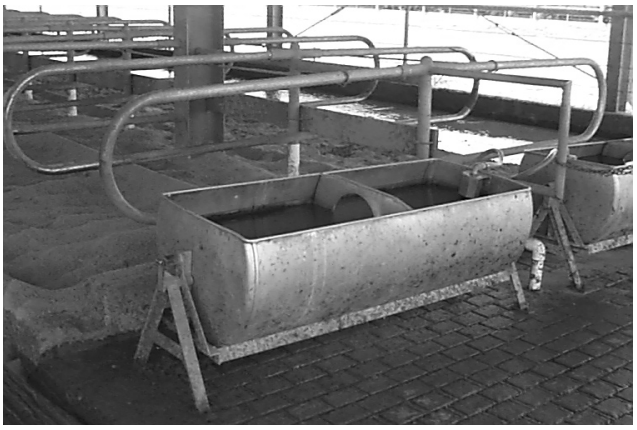
Dan N. Waldner
Extension Dairy Specialist
Oklahoma State University

Michael L Looper
Extension Dairy Specialist
New Mexico State University

Oklahoma Cooperative Extension Fact Sheets are also available on our website at:
http://osufacts.okstate.edu

Introduction

Water constitutes 60 to 70 percent of the body of livestock. Water is necessary for maintaining body fluids and proper ion balance; for digesting, absorbing, and metabolizing nutrients; for eliminating waste material and excess heat from the body; for providing a fluid environment for the fetus; and for transporting nutrients to and from body tissues. The water that dairy cattle need is supplied by drinking, by the feed that they consume, and by metabolic water produced by the oxidation of organic nutrients. Water loss occurs via saliva, urine, feces, and milk; through sweating; and by evaporation from body surfaces and the respiratory tract. The amount of water lost from the body of cattle is influenced by the activity of the animal, air temperature, humidity, respiratory rate, water intake, feed consumption, milk production and other factors.



Water Intake and Requirements

Lactating cows: Drinking or free water intake satisfies 80 to 90 percent of the dairy cows' total water needs. The amount of water a cow will drink depends on her size and milk yield, quantity of dry matter consumed, temperature and relative humidity of the environment, temperature of the water, quality and availability of the water, and amount of moisture in her feed. Water is an especially important nutrient during periods of heat stress. The physical properties of water are important for the transfer of heat from the body to the environment. During periods of cold stress, the high heat capacity of body water acts as insulation – conserving body heat. Water intake for lactating cows can be predicted from the following equation:

Water intake, lbs/day = 35.25 +1.58 x dry matter intake (lbs/day)
+ 0.90 x milk yield (lbs/day)
+ 0.11 x sodium intake (grams/day)
+ 2.65 x weekly mean minimum temperature (°F/1.8 – 17.778)

The equation predicts water consumption will change 1.58 pounds for each 1 pound change in dry matter consumed, 0.90 pounds for each 1 pound of milk produced, 0.11 pounds for each gram of sodium consumed, and 1.47 pounds for each degree Fahrenheit change in weekly mean minimum temperature. Weekly mean minimum temperature is typically 10 to 15 degrees Fahrenheit lower than mean daytime temperature. Table 1 lists the estimated daily water intake for lactating cows using the above equation.

Dry cows: The major factors affecting free water intake of dry cows are concentration of dry matter in the diet, dry matter intake and amount of protein in the diet. Water intake of dry cows can be estimated by the following equation:

Water intake, lbs/day = -22.80 + 0.5062 x diet dry matter (%)
+ 2.212 x dry matter intake (lb/day)
+ 0.0869 x diet crude protein $(\%)^2$

For example, a 1,500-pound non-lactating cow consuming 28 pounds of dry matter containing 12 percent moisture and 12 percent crude protein would consume 96 pounds (11.6 gallons) of water per day at air temperatures between 50°F and 80°F. Water intake may be 1.2 to 2-fold greater during periods of heat stress.

Calves and heifers: During the liquid feeding stage, calves receive most of their water as milk or milk replacer. However, studies show that calves offered water in addition to a liquid diet gain faster and consume dry feed earlier than calves provided water only in their liquid diet. Therefore, it

Table 1. Estimated daily water consumption for a 1,500-pound lactating cow producing 40 to 100 pounds of milk daily[a].

Milk Production (lbs/day)	*Estimated DM Intake (lbs/day)*	*Weekly Mean Minimum Temperature[b]*				
		40°F	*50°F*	*60°F*	*70°F*	*80°F*
		gallons per day[c]				
40	42	18.4	20.2	22.0	23.7	25.5
60	48	21.8	23.5	25.3	27.1	28.9
80	54	25.1	26.9	28.7	30.4	32.2
100	60	28.5	30.3	32.1	33.8	35.6

[a] Sodium intake = 0.18% of DM intake.
[b] Mean minimum temperature is typically 10 to 15∞F lower than the mean daytime temperature
[c] 1 gallon of water weighs 8.32 pounds.

is recommended to provide water to calves receiving liquid diets to enhance growth and dry matter intake.

Weaned dairy heifers consume approximately 1 to 1.5 gallons of water per 100 pounds of body weight (Table 2). As with all livestock, water should be fresh, clean and always available and care should be taken to ensure adequate water supplies during periods of heat stress.

Table 2. Estimated water intake for dairy heifers.

Weight (lbs)	*Air Temperature*		
	40°F	*60°F*	*80°F*
	gallons per day		
200	2.0	2.4	3.3
400	3.8	4.6	6.1
600	5.4	6.5	8.7
800	6.8	8.2	11.0
1000	8.0	9.6	12.7
1200	9.0	10.8	14.5

Drinking Behavior

Providing the opportunity for livestock to consume a relatively large amount of clean, fresh water is essential. Water is consumed several times per day and is generally associated with feeding or milking. Cows may consume 30 to 50 percent of their daily water intake within 1 hour after milking. Reported rates of water intake vary from 1 to 4 gallons per minute. On the basis of farm studies, the length of water troughs should be 2 inches per cow with an optimal height of 24 to 32 inches. Reducing the height 2 to 3 inches may be logical for Jerseys. Water depth should be a minimum of 3 inches to allow the animal to submerge its muzzle 1 to 2 inches. Provide at least one watering device for every 15 to 20 cows, or a minimum of two foot of tank space per 20 cows. At least two water locations are needed in the loafing area for each group of cows. For confinement operations, waterers should be located at the milking parlor exit and within 50 feet of the feed bunk or at every crossover in freestall barns. For grazing operations, water also should be located at the milking parlor exit and in each paddock so that animals are always within 600 feet of a clean, fresh water source. Heifers should be provided at least one watering space per 20 animals with a minimum of two waterers per group.

The temperature of drinking water has only a slight effect on drinking behavior and animal performance. Responses to chilling of water under most circumstances would not warrant the additional cost of cooling water. Given a choice of water temperature, cows prefer to drink water with moderate temperatures (63-82°F) rather than very cold or hot water.

Water Quality

Water quality is an important issue in the production and health of dairy cattle. The five properties most often considered in assessing water quality for both human and livestock use are organoleptic properties (odor and taste), physiochemical properties (pH, total dissolved solids, total dissolved oxygen and hardness), presence of toxic compounds (heavy metals, toxic minerals, organophosphates and hydrocarbons), presence of excess minerals or compounds (nitrates, sodium sulfates and iron), and presence of bacteria. Research on water contaminants and their effects on cattle performance are sparse. The following attempts to define some common water quality problems in relation to cattle performance.

Salinity, total dissolved solids (TDS) and total soluble salts (TSS) are measures of constituents soluble in water. Sodium chloride is the first consideration in this category. Other components associated with salinity, TDS, or TSS are bicarbonate, sulfate, calcium, magnesium and silica. A secondary group of constituents, found in lower concentrations than the major constituents, consists of iron, nitrate, strontium, potassium, carbonate, phosphorus, boron, and fluoride. Guidelines for TDS in water for dairy cattle are presented in Table 3.

Research has shown feedlot cattle drinking saline water (TDS = 6,000 parts per million, ppm) had lower weight gains than cattle drinking normal water (TDS = 1,300 ppm) when energy content of the ration was low and during heat stress. High-energy rations and cold environmental temperatures negated the detrimental effects of high-saline water consumption. Likewise, milk production of dairy cows drinking saline water (TDS = 4,400 ppm) was not different from that of cows drinking normal water during periods of low environmental temperature but was significantly lower during summer months. Cows offered salty water drank more water per day (36 vs. 32 gallons per cow) over a 12-month period than cows drinking normal water.

Hardness is generally expressed as the sum of calcium and magnesium reported in equivalent amounts of calcium carbonate. Other cations in water – such as zinc, iron, strontium,

Table 3. Guidelines for use of saline water for dairy cattle.

Total Dissolved Solids (ppm)	*Comments*
Less than 1,000	Presents no serious burden to livestock
1,000 to 2,999	Should not affect health or performance, but may cause temporary mild diarrhea
3,000 to 4,999	Generally satisfactory, but may cause diarrhea especially upon initial consumption
5,000 to 6,999	Can be used with reasonable safety for adult ruminants; should be avoided for pregnant animals and baby calves
7,000 to 10,000	Should be avoided if possible; pregnant, lactating, stressed or young animals can be affected negatively
over 10,000	Unsafe, should not be used under any conditions

ppm = parts per million

aluminum and manganese – can contribute to hardness but are usually in very low concentration compared with calcium and magnesium. Hardness categories are listed in Table 4. The hardness of water has no effect on animal performance or water intake.

Nitrate can be used in the rumen as a source of nitrogen for synthesis of bacterial protein, but reduction to nitrite also occurs. When absorbed into the body, nitrite reduces the oxygen carrying capacity of blood which can lead to asphyxiation in severe cases. Symptoms of nitrate or nitrite poisoning are labored breathing, rapid pulse rate, frothing at the mouth, convulsion, blue muzzle and bluish tint around eyes, and chocolate-brown blood. More moderate levels of nitrate poisoning have been incriminated in poor growth, infertility problems, abortions, vitamin A deficiencies, reduced milk production, and general unhealthiness.

The general safe concentration of nitrate in water is less than 44 ppm and less than 10 ppm of nitrate-nitrogen (Table 5). In evaluating potential nitrate problems, feed also should be analyzed for nitrate since the effects of feed and water are additive.

Sulfate guidelines for water are not well defined, but general recommendations are less than 500 ppm for calves and

Table 4. Water hardness guidelines.

Category	*Hardness, milligrams/liter*[a]
Soft	0-60
Moderately hard	61-120
Hard	121-180
Very hard	> 180

[a]1 grain/gal = 17.1 milligrams per liter

Table 5. Concentration of nitrates (NO_3) and nitrate nitrogen (NO_3-N) in drinking water and expected response.

NO_3 (ppm)	*NO_3-N (ppm)*	*Comment*
0-44	10	No harmful effects
45-132	11-20	Safe, if diet is low in nitrates and nutritionally balanced
133-220	21-40	Could be harmful if consumed over a long period of time
221-660	41-100	Dairy cattle at risk; possible death losses
661-800	101-200	High probability of death losses; unsafe
Over 800	Over 200	Do not use; unsafe

ppm = parts per million

less than 1,000 ppm for adult cattle. When sulfate exceeds 500 ppm, the specific salt form of sulfate or sulfur should be identified, since the form of sulfur is an important determinant of toxicity. Hydrogen sulfide is the most toxic form and concentrations as low as 0.1 milligrams per liter can reduce water intake. Common forms of sulfate in water are calcium, iron, magnesium, and sodium salts. All are a laxative, but sodium sulfate is the most potent. Cattle consuming water high in sulfates (2,000 – 2,500 ppm) initially show diarrhea, but appear to become resistant to the laxative effect. Iron sulfate has been reported to be the most potent depressor of water intake compared with other forms of sulfate. Water and feed with high sulfate contents have been linked to the development of polioencephalomalacia (PEM) in beef calves and can induce copper deficiency with or without the assistance of molybdenum.

pH is a measure of acidity or alkalinity. A pH of 7 is neutral, under 7 is acidic and over 7 is alkaline. Little is known about the specific effect of pH on water intake, animal health and production, or the microbial environment in the rumen. The preferred pH of drinking water for dairy animals is 6.0 to 8.0. Waters with a pH outside of the preferred range may cause non-specific effects related to digestive upset, diarrhea, poor feed conversion, and reduced water and feed intake.

Microbiological analysis of water for coliform bacteria and other microorganisms is necessary to determine sanitary quality. Since some coliform bacteria are soil-borne or non-fecal, a fecal coliform test may be used to determine if the source of total coliform is at least in part from feces. A fecal streptococci test may be run on fresh samples to determine if the contamination is from animal or human sources. If fecal coliforms exceed fecal streptococci, human sources of pollution may be suspect. If fecal streptococci exceed fecal coliform, animal sources of pollution are indicated. For animal consumption, especially young calves, total and fecal coliform counts should be less than 1 per 100 milliliters. For adult 0animals total and fecal coliform counts should be under 15 and 10 per 100 milliliters, respectively. It is recommended that fecal streptococci counts not exceed 3 or 30 per 100 milliliters for calves and adult cattle, respectively.

Total bacteria count measures virtually all pathogenic as well as non-infectious bacteria that use organic nutrients for

growth. Total bacteria counts in excess of 500 per 100 milliliters may indicate water quality problems. Water sources with total bacteria counts in excess of 1 million per 100 milliliters should be avoided for all classes of livestock. Most water supplies will continuously have counts below 200 per 100 milliliters.

Blue-green algae have been reported to cause illness when cattle are allowed to consume water containing this organism. Although the causative agent has not been identified specifically, cattle should be prevented from drinking water with heavy algae growth. Symptoms in blue-green algae poisoning include ataxia or incoordination of voluntary muscle movement, bloody diarrhea, convulsions and sudden death. This is an occasional problem in freestanding water such as farm ponds. Shading of water troughs and frequent sanitation will minimize algae growth.

Other potentially toxic compounds and organisms are sometimes found in water and can pose a health hazard to cattle. For safe consumption, water contaminants should not exceed the guidelines in Table 6. However, many dietary, physiologic and environmental factors affect these guidelines and make it impossible to determine precisely the concentrations at which problems may occur.

Water sampling and testing

Typically, 1 or 2 quarts of water from the source in question should be adequate to complete any needed tests. Samples may be sent to any accredited commercial or state operated laboratory for analyses. Producers should consult with their herd veterinarian or cooperative extension personnel for assistance in selecting a laboratory as well as for assistance in selecting appropriate tests and interpreting test result.

Summary

Water availability and quality are important to animal health and productivity. Limiting water availability to cattle will lower production rapidly and severely.

The most common water quality problems affecting livestock production include high concentrations of minerals (excess salinity), high nitrogen content (nitrates and nitrites), bacterial contamination, heavy growth of blue-green algae, and accidental contamination by petroleum, pesticides or fertilizer products. Monitoring of water quality during periods of reduced production or nonspecific diseases should be one aspect of an investigative procedure into herd health and production problems.

Table 6. Generally considered safe concentrations of some potentially toxic nutrients and contaminants in water for cattle.

Item	*Upper-limit guideline (ppm)*
Aluminum	0.50
Arsenic	0.05
Barium	10.0
Boron	5.0
Cadmium	0.005
Chromium	0.10
Cobalt	1.0
Copper	1.0
Fluoride	2.0
Iron	2.0
Lead	0.015
Manganese	0.05
Mercury	0.01
Nickel	0.25
Selenium	0.05
Vanadium	0.10
Zinc	5.0

ppm = parts per million

References

Beede, D.K. 1992. Water for Dairy Cattle. In: Large Dairy Herd Management. Ed. H.H. Van horn and C.J. Wilcox. Amer. Dairy Sci. Assoc. Champaign, IL.

Dairy Practices Council. 1990. Guidelines for Potable Water on Dairy Farms 3rd rev. ed. Barre, VT.

McFarland, D.F. 2000. Feed Area and Water Space Design. In: Dairy Housing and Equipment Systems. NRAES-129. Ithaca, NY.

Murphy, M.R., C.L. Davis and G.C. McCoy. 1983. Factors affecting water consumption by Holstein cows in early lactation. J. Dairy Sci. 66:35.

National Research Council. 2001. Nutrient Requirements of Dairy Cattle 7th rev. ed. Washington, D.C.: National Academy Press.

Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Robert E. Whitson, Director of Cooperative Extension Service, Oklahoma State University, Stillwater, Oklahoma. This publication is printed and issued by Oklahoma State University as authorized by the Vice President, Dean, and Director of the Division of Agricultural Sciences and Natural Resources and has been prepared and distributed at a cost of 20 cents per copy. 0607