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Pasture for Dairy Cattle: Challenges and Opportunities

Donna M. Amaral-Phillips, Roger W. Hemken, Jimmy C. Henning, and Larry W. Turner

Pastures have always been and will continue to be a source of forages and nutrients for dairy cattle, including heifers, dry cows, and the milking herd. During the 1950s and early 1960s, pasture was replaced by confinement feeding of stored forages as the preferred means of feeding and managing the milking herd. These changes allowed the amount and quality of forages and concentrates fed to dairy cows to be controlled so milk production could be maximized. With the advances in fencing and watering systems, improvements in forage species, and increasing cost of equipment, reincorporating pasture into the feeding and management program for the milking herd has gained interest. Properly managed pastures can provide cows with high-quality forage harvested at a very nutritious stage of maturity.

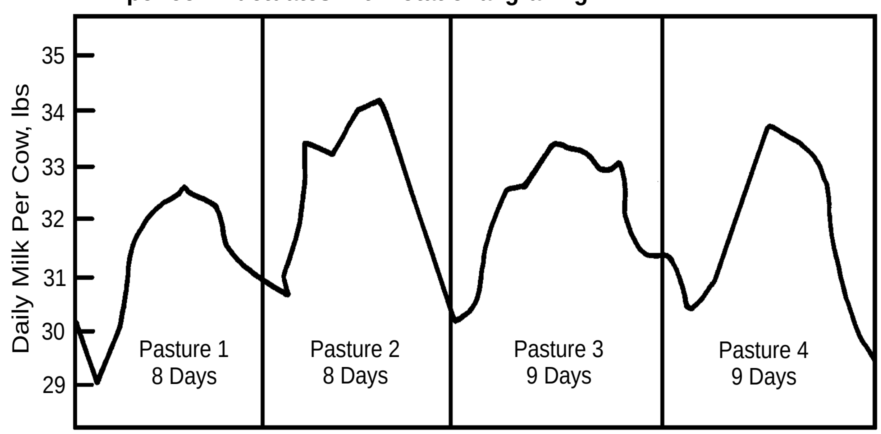
Rotational Grazing

Intensive rotational or controlled grazing systems involve intensely grazing a portion of a pasture followed by a rest period to allow the forage to regrow. Cows remain on a given paddock for as little as 12 hours for up to three days and then are rotated to a "rested" paddock. The timing of these rotations is based on the growth of forage in the paddocks, not a rigid time schedule. This rotational scheme ideally uses a minimum of eight different paddocks. The greatest reasons for an intensive rotational schedule are to allow for adequate intakes of vegetative, highly nutritious plants and to minimize the wide fluctuations in milk production due to varying nutrient intake and digestibility.

Figure 1 shows the data from a study by Blaser which illustrates the fluctuations in milk production as forage digestibility and availability decrease during an eight- or nine-day rotation. The two- to three-day lag in milk production after shifting to fresh pasture is attributed to a carryover of the less digestible pasture forage consumed previously. These fluctuations in milk production also have been observed in beef cows rotated to fresh pasture every seven days (Martz 1995).

Pastures which are intensively grazed result in greater forage utilization, higher nutrient quality, and greater stand persistency as compared to continuously grazed pastures. Continuously grazed

Milk per cow fluctuates with rotational grazing.



After available pasture declined from heights of 8 to 10 inches to 2.5 inches, cows were rotated to a fresh pasture.

***Figure 1.** Variation in milk production when pastures are rotated every eight to nine days. (Blaser 1986)*

Definition of Intensive Rotational Grazing
Cows remain on pasture for 12 hours for up to three days and then are rotated to a "rested" paddock. A minimum of eight different paddocks is used.

pastures contain some areas where forage regrowth is being grazed too closely and other areas that are overgrown with over-mature, low-quality forage that is not being consumed. Studies in Florida with Callie bermudagrass (Mathews et al. 1994) show that leaves made up 46 percent to 49 percent of the stand when rotational grazed compared to 31 percent to 36 percent when the stand was continuously grazed by dairy heifers. With more leaves in the stand, a more nutritious forage was available for grazing. In addition, the rotational-grazed stand had 84 percent Callie bermudagrass remaining after two years versus 62 percent under continuous grazing by dairy heifers.

Grazing Schemes

Grazing Systems for Dairy Cows
(April through November)

- All forage provided by pastures
- Supplemental grazing where 25 percent to 75 percent of forage needs are supplied through grazing depending on forage availability.

Grazing can supply 25 percent to 100 percent of the forage needs of a high-producing dairy cow between April and November in Kentucky. Traditionally, pasture systems provided all of the forage consumed with or without a limited amount of hay being fed. Grain, then, is supplied either through the parlor, outside in feed troughs, or on the ground as a large range pellet.

Supplemental grazing systems, where grazed forages represent only 25 percent to 75 percent of the forage dry matter intake, also can be an economical and viable option for using pasture. Supplemental pasture is used in combination with harvested silages and/or hay as a means of improving forage quality, decreasing harvesting costs, and/or increasing the utilization of land close to the barn which is not well-suited for harvesting forages due to its excessive slope. When pasture is plentiful during the spring, it can supply a larger proportion of the forages fed, and when pasture availability decreases in midsummer, the amount of stored forages can be increased to ensure that cows maintain their feed (dry matter) intakes. A supplemental grazing system is an excellent way to learn how to manage the interrelationships between forages and cattle before relying on pasture as the sole forage source during the grazing season.

A leader-follower scheme within a rotational grazing system can be an effective means of meeting the greater nutrient needs of early lactation and higher-producing cows (Figure 2). In this scheme, cows or heifers with the highest nutrient requirements are allowed to graze first and allowed to eat the tops and the most nutritious part of the plants. A second group of cows or heifers with lower nutrient requirements then is allowed to graze the paddock and remove the remaining forage to the desired height before being moved. This scheme allows the allocation of the forages with the highest nutrients to cows or heifers with the highest demand for nutrients without sacrificing growth or milk production.

Grazing Behavior of Cows

Cows graze by wrapping their tongues around the forage and snipping it off with their lower teeth and upper dental pad. (Cattle do not have upper teeth.) They are very selective in their grazing habits, first choosing tender young plants which are easily eaten and most palatable. In addition, cows eat the top of the plant first, consuming leaves before stems. Figure 3 illustrates the effect of the number of grazing days on crude protein content of

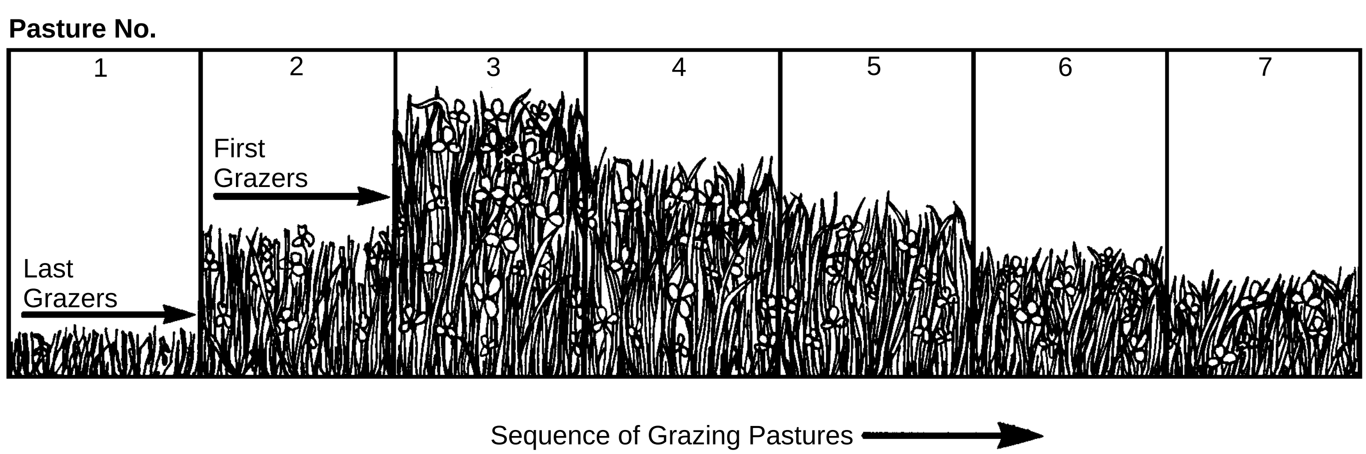


Figure 2. *Diagram of available pasture when feeding first and last grazers in rotational grazing. (Blaser 1986)*

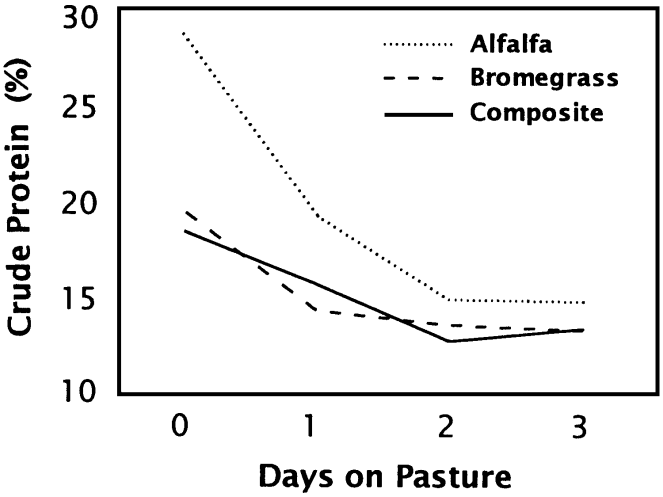


Figure 3. *Crude protein content of alfalfa/grass pastures when placed in a 12-paddock rotation. (Morrow 1995)*

remaining alfalfa/grass plants. The crude protein content of alfalfa decreases dramatically within the first day of the 12-paddock, three-day rotation as the leaves at the top of the alfalfa plant are consumed first.

Table 1. Distribution of leaf, stem, and total dry matter in a summer alfalfa canopy. Nutrient content of leaf and stem areas is listed on a dry matter basis.

	% of Total Yield	CP (%)	ADF (%)	RFV	NDF Digestibility (%)
Upper 6 inches of plant	37.3				
Leaf	30.8	24.0	18.5	250	63.2
Stem	6.5	13.0	38.6	104	44.0
Lower 12 inches of plant	62.7				
Leaf	12.9	22.0	16.6	273	65.7
Stem	49.8	9.6	52.9	65	31.1

CP=crude protein content, ADF=acid detergent fiber, RFV=relative feed value, NDF=neutral detergent fiber
(Adapted from Henning 1996)

The distribution of leaf and stem area differs between well-managed grass pastures and those containing legumes. In well-managed grass pastures kept in the vegetative state, the plant is primarily leaf area evenly distributed throughout the height of the plant with a similar nutrient content found throughout the canopy. However, with alfalfa and red clover pastures, the top part of the plant contains a higher percentage of leaf area. As shown in Table 1, more than 80 percent of the top 6 inches of the alfalfa plant is leaf, whereas 80 percent of the stem is found in the bottom 12 inches. In addition, the lower stem is lower in crude protein and relative feed value than the stem found in the upper 6 inches of the alfalfa plant. These changes in nutrient content need to be considered when planning a nutrition program around an intensive rotational grazing program. The "new grazing" varieties of alfalfa are being bred to have more leaves on the stem and to grow closer to the ground. In the future these varieties may help decrease this selective grazing.

Pasture intake is related to the amount of time spent grazing, the number of bites per minute, and the size of each bite (Phillips et al. 1988). Dairy cattle generally graze for six to nine hours per day. Because of a cow's need to ruminate and rest, she seldom grazes over nine hours per day. The number of bites taken per minute does not vary appreciably, ranging from 55 to 65 bites per minute. Thus, dry matter intake from pasture is controlled by the size of the bite of forage. This is directly related to the height and density of the forage stand being grazed.

In Scotland, Phillip and Leaver (1989) measured forage intake of cows grazing ryegrass pasture in the spring when grass was very lush and again in the fall when pasture growth was lower. In the spring, when forage growth was at its maximum, cows averaged 60 bites per minute over an eight-hour grazing period and were able to consume 31.7 pounds of dry matter daily (0.50 grams of dry matter per bite). In the fall, cows averaged 65 bites per minute and grazed for nine hours a day but were able to consume only 19.6 pounds of dry matter daily (0.25 grams of dry matter per bite). These data illustrate the importance of forage density and height when trying to maximize intake of dairy cows grazing pasture.

Cows generally prefer to graze during the early and late daylight hours. During the hottest months, cows will not graze during the late morning and afternoon hours and may compensate slightly by increasing the time spent grazing during the night. Changes in milking times and management may be beneficial in allowing cows to graze during the early morning hours and later in the evening after the sun has gone down.

Pasture Intake and Quality Govern Milk Production

The availability and quality of pasture forage consumed directly influence milk production. When forage availability decreases, the bite size of pasture forage decreases. Consequently, milk production decreases. Forage availability in pasture needs to be maintained to allow cows to milk to their genetic potential. Table 2 shows the estimated carrying capacity of pastures when pasture supplies all of the forage needs of Holstein dairy cows. Figure 4 shows a sample calculation for determining the number of cows which can graze an acre of forage daily.

Lactating dairy cows will have dry matter intakes of pasture between 1.5 percent and 3.0 percent of body weight depending on the availability of pasture, amount of supplemental concentrates provided, and milk production and stage of lactation of the cows. Holden and others (1994) reported that mature, midlactation Holstein cows averaging 68 pounds of milk consumed approximately 32 pounds of dry matter per day as pasture in the spring, or approximately 2.5 percent of their body weight. The authors noted that average daily pasture dry matter intake was the highest in late spring and fall and lowest during the summer.

Keys to Profitable Milk Production Using Pasture

1. Amount of forage available
2. Intake of pasture
3. Nutritional quality of pasture
4. Supplemental concentrates fed
5. Supplemental forages fed when pasture intake limiting

Intakes of pasture may exceed those observed with harvested forages due to greater turnover rates in the rumen.

Pasture forages generally are more nutritious than stored forages because cows harvest them at a more immature stage of growth. Table 3 shows the nutritive content of rotationally grazed pastures versus hay and silages raised in the Northeast and Midwest. Table 4 shows the average nutrient composition of pastures composed of grass, grass/legume, or legume/grass.

Well-managed pastures provide enough energy and protein for Holsteins producing 35 pounds to 45 pounds of milk with little or no additional supplementation. Early lactation and higher-producing cows need additional grain to meet their energy needs for production and reproduction. Bernard (1994) calculated the effect of decreasing pasture

Table 2. Estimated carrying capacity of pastures where pasture supplies all of forage needs for Holstein dairy cows. Actual carrying capacity will vary based on varying forage yields and utilization rates.

	Month							
	Mar	Apr	May	June	July	Aug	Sept	Oct
Wheat—Grazed in Spring (Annual yield—2 tons DM/acre with a 60% utilization rate. Assumes 30% yield from November to February, which has not been included here.)								
Monthly distribution of yield (%)	10	25	35					
Monthly yield (ton DM/acre)	0.2	0.5	0.7					
Number cows support/acre/day	6	15	21					
Number acres for 100 cows/day	16.7	6.7	4.8					
Cool Season Grass/Clover (Annual yield—4 tons DM/acre with 60% utilization rate.)								
Monthly distribution of yield (%)		15	20	20	10	5	10	10
Monthly yield (ton DM/acre)		0.6	0.8	0.8	0.4	0.2	0.4	0.4
Number cows support/acre/day		18	25	25	12	6	12	12
Number acres for 100 cows/day		5.6	4.0	4.0	8.3	16.7	8.3	8.3
Alfalfa/Grass (Annual yield—5 tons DM/acre with 65% utilization rate.)								
Monthly distribution of yield (%)		25	20	15	15	10	10	
Monthly yield (ton DM/acre)		1.25	1.00	0.75	0.75	0.50	0.50	
Number cows support/acre/day		42	33	25	25	17	17	
Number acres for 100 cows/day		2.4	3.0	4.0	4.0	5.9	5.9	
Sorghum/Sudan Grass (Annual yield—6 tons DM/acre with 65% utilization rate.)								
Monthly distribution of yield (%)			5	20	30	20	15	5
Monthly yield (ton DM/acre)			0.3	1.2	1.8	1.2	0.9	0.3
Number cows support/acre/day			10	40	60	40	30	10
Number acres for 100 cows/day			10.0	2.5	1.7	2.5	3.3	10.0

Assumptions: Holstein cows consume pasture as the sole forage source at 3% body weight, cows are rotated to new pasture daily, and cows do not regraze the pasture for 30 days. Monthly distribution of pasture yields based on numbers found in *KY Beef*. For Jersey cows, increase daily carrying capacity by 40% more cows per acre.

To calculate the number of cows an acre of pasture can support:

Step 1: Calculate amount of pasture needed daily by each cow.

Example: Holsteins averaging 1,300 lb body weight.
These cows consume forage dry matter at 3% of their body weight with 60% utilization of forage stand.
(1,300 lb BW) x (0.03) = 39 lb dry matter/cow ÷ 60% utilization of forage stand = need 65 lb dry matter/cow/day

Step 2: Calculate amount of forage supplied monthly by an acre of pasture, assuming cows graze this acre only once each month that forage is available.

Example: Wheat grazed in the month of April.
Monthly forage tonnage figures supplied in Table 2.
For wheat grazed in April, 25% of 2 tons dry matter/acre total yield
(0.25) (2 tons dry matter/acre) **=** 0.5 tons dry matter/acre = 1,000 lb dry matter/acre

Step 3: Calculate number of cows an acre of pasture can support.

$$\frac{\text{Results from Step 2}}{\text{Results from Step 1}} = \text{number of cows per acre}$$

Example: $\frac{\text{1,000 lb dry matter}}{\text{65 lb dry matter/cow}} = \text{15 cows/acre}$

Figure 4. *Calculations for the number of cows an acre of pasture can support.*

Table 3. Nutrition content of rotational-grazed pastures compared to hay and silages.

	Crude Protein (%)	NE_L (Mcal/lb)	NSC** (%)	ADF (%)	NDF (%)
	---------------------Dry Matter Basis---------------------				
Mixed, mostly grass					
Pasture	22*	0.69	16	27	48
Hay	12	0.54	18	38	60
Silage	14	0.51	13	41	58
Corn silage	9	0.73	34	26	45
Recommended total diet requirements for a herd averaging 60 lb milk	16	0.76	35	19	28

*Averaged 24% CP soluble and 72% CP rumen degradabilty (DIP)
**NSC=Nonstructural carbohydrates
(Rayburn and Fox 1991)

Table 4. Average nutrient composition of typical high-quality pastures in Northeast and Midwest.

	Grass pasture[a]			Grass/legume pasture[b]			Legume/grass pasture[c]		
	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall
CP (% of DM)	20-22	18-20	20-22	21	21	23	23	23	25
Sol. P. (% of CP)[d]	35-40	30-35	40	35-40	35-40	40	40	35	45
DIP (% of CP)[e]	75-80	65-70	70-75	80	65-70	70-75	80	70	75
UIP (% of CP)[f]	20-25	30-35	25-30	20	30-35	25-30	20	30	25
ADF (% of DM)	28	33	28	26	31	26	25	30	25
NDF (% of DM)	45	55	45	42	52	42	38	48	38
NSC (% of DM)	15-20	15-20	15-20	15-20	15-20	15-20	20	25	20
NEL (Mcal/lb.)	.73-.77	.65-.68	.70-.74	.74-.78	.66-.70	.71-.75	.74-.78	.68-.72	.72-.76
Ca (% of DM)	.50	.50	.50	.75	.75	.75	1.2	1.2	1.2
P (% of DM)	.30	.30	.30	.30	.30	.30	.30	.30	.30
Mg (% of DM)	.14	.17	.20	.15	.19	.21	.16	.20	.22
K (% of DM)	3.2	2.4	2.8	3.3	2.5	3.0	3.4	2.6	3.2
Fat (% of DM)	3.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0

[a] Grass-based pasture. [b] Mixed, mostly grass pasture. [c] Mixed, mostly legume pasture. [d] Soluble protein.
[e] Degradable intake protein. [f] Undegradable intake protein.
(Muller 1994)

Table 5. Pasture intakes necessary to balance energy requirements at different qualities and availabilities of pasture.

Milk (lb/d)	Grain to milk	Needed pasture intake, lb/d[a]				Number of grazing periods[b]			
		Excellent	Good	Fair	Poor	Excellent	Good	Fair	Poor
80	1:3	155	163	171	180	1.7[c]	2.3	3.8	6.0
	1:5	232	244	257	271	2.6	3.5	5.7	9.0
	1:7	266	279	294	310	3.0	4.0	6.5	10.3
70	1:3	149	157	165	174	1.7	2.2	3.7	5.8
	1:5	217	229	241	253	2.4	3.3	5.4	8.4
	1:7	246	259	273	287	2.7	3.7	6.1	9.6
60	1:3	144	151	160	168	1.6	2.2	3.5	5.6
	1:5	202	213	224	236	2.2	3.0	5.0	7.9
	1:7	227	239	252	265	2.5	3.4	5.6	8.8
50	1:3	139	146	154	162	1.5	2.1	3.4	5.4
	1:5	187	197	208	218	2.1	2.8	4.6	7.3
	1:7	208	219	231	242	2.3	3.1	5.1	8.1
40	1:3	133	140	148	155	1.5	2.0	3.3	5.2
	1:5	172	181	191	201	1.9	2.6	4.2	6.7
	1:7	189	199	209	220	2.1	2.8	4.7	7.3

[a] Pounds of pasture based on 15% DM and NE_L concentrations of 0.70 (Excellent), 0.67 (Good), 0.63 (Fair), and 0.60 Mcal/lb (Poor).
[b] Number of two- to three-hour grazing periods based on cows consuming 90 (Excellent), 70 (Good), 45 (Fair), and 30 lb (Poor) of pasture (15% DM) during each grazing period.
[c] Shaded values are considered realistic pasture intakes.
(Bernard 1994)

availability on the number of two- to three-hour grazing periods necessary to balance energy requirements at different amounts of milk production and grain-to-milk ratios (Table 5). Bernard assumed that three grazing periods were the maximum number allowable in order for cows to actually consume the needed forage to meet their energy needs. At 80 pounds of milk, excellent quality and quantity pasture was necessary to achieve adequate pasture intakes. Only with a 1:3 grain-to-milk ratio did good quality pasture provide adequate pasture intake at 80 pounds of milk. From research conducted by Holden and others at Penn State, Holsteins producing more than 60 pounds of milk with good quality pasture should be supplemented with 1 pound of grain per 4 pounds of milk, with the amount of concentrate varied with milk production and body condition. Generally, 12 pounds to 20 pounds of concentrate are fed to cows when pasture is their sole forage source.

When pastures are fed as the major forage source, energy may not be optimum for efficient microbial growth, which in turn can limit milk production. Grass and grass/legume pastures are low in nonstructural carbohydrates (15 percent to 20 percent NSC) compared to the requirements of high-producing dairy cows (35 percent to 40 percent NSC). Thus, feeding grains can increase the amount of non-structural carbohydrates when added to the diet.

Grazing cows also have a 10 percent to 20 percent higher maintenance requirement because of the greater activity level associated with grazing. Ideally, cows should not be pastured farther than 0.5 mile from the milking facility. However, little data exist to show that farther distances will be detrimental to milk production. Cows which graze often are thinner in body condition in comparison to cows fed in confinement. Thus, body condition in addition to milk production needs to be considered when determining the amount of supplemental concentrate needed.

With proper grazing management, pasture is very high in total crude protein, averaging 20 percent or more. Samples of consumed pasture (from esophageal-cannulated steers) suggest cows may consume even higher concentrations of protein and energy, which reflects their selective grazing (Table 6). However, 65 percent to 80 percent of the protein in high-quality pasture is degraded in the rumen (DIP). This concentration of DIP is higher than that recommended by the NRC (60 percent to 65 percent) and may suggest that additional UIP (bypass protein) sources would be beneficial. Studies where a UIP source has been added to the grain mixes of midlactation cows have failed to show a production response. However, one study using early lactation cows has shown a positive response to the addition of a high UIP protein source. Generally, concentrate mixes for pasture-based rations contain 12 percent to 14 percent crude protein with added dried distillers' grains, roasted soybeans, animal by-products, or other high UIP protein sources. In order to effectively utilize the large amount of soluble and degradable protein in high-quality pastures, sufficient energy, supplied by grains such as corn, must be present to optimize rumen fermentation. Work in Europe has suggested that the addition of high-fiber by-products, such as soy hulls, may enhance rumen fermentation, milk production, and butterfat test on pasture-based diets.

Table 6. Nutrient content (DM basis) of pasture consumed by cattle with esophageal cannulas to collect samples actually consumed.

Pasture or Feed	CP (%)	NDF (%)	ADF (%)	NSC (%)	UIP (%, CP)	NE_L (Mcal/lb)
Alfalfa, 10% Blm	34.7	43.5	16.7	11.8	30	0.83
Alfalfa, prebud	32.7	27.5	22.6	31.8	30	0.75
Fescue (Veg)-Clover (bloom)	25.0	57.0	29.4	10.0	25	0.66

(Martz and Garrett 1993)

Adapt Cows to Pasture Slowly

As with all feed changes, dairy cows, especially high-producing cows, need to be adjusted to pasture slowly. Any sudden changes will result in cows going off feed with an associated rapid decrease in milk production. Ideally, this transition should take place over at least a week, with cows allowed on pasture for longer periods of time each successive day. For example, on day one cows are fed stored forages (for example, 5 pounds of hay) before being turned out on pasture and are allowed access to pasture for one hour. Each day, cows are allowed access to the pasture for longer periods of time. Hungry cows should not be allowed access to pasture.

Bloat can occur when grazing legumes such as clover and alfalfa. Generally, bloat occurs within an hour of being placed on pasture and is more prevalent the second or third day of grazing. Five pounds of dry hay prior to grazing can help reduce the problem. Poloxalene (Bloat Guard), a commercial surfactant, can be added to the grain, mineral premix, or water. It is very effective in preventing bloat in cows.

Off flavors in milk can be a problem when grazing annual rye, some alfalfas, and weeds such as wild onions or ragweed. Removing cows from the pasture two to four hours prior to milking will help prevent off flavors in the milk.

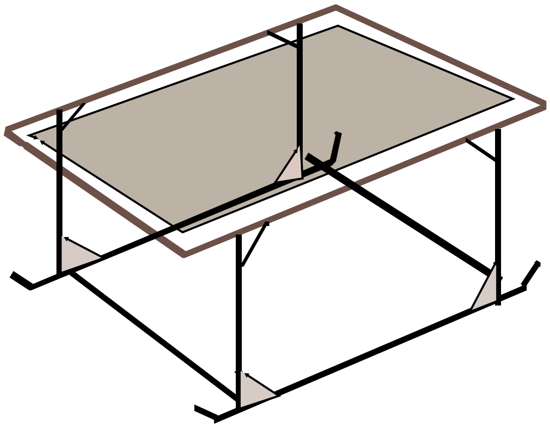


Figure 5. *Schematic of a portable shade. Plan # KY.II.772-16 provides detailed instructions for building a portable shade. Contact the Department of Agricultural Engineering at the University of Kentucky to obtain a copy.*

Shade and Water

In each paddock, shade and water should be provided unless cows are supplementally grazing for less than one hour in the summer and two hours in the spring. Portable shades can be moved as pastures are rotated, decreasing the chances of environmental mastitis. (A schematic of a portable shade is shown in Figure 5.) Grazing in the early morning and late evening will decrease the need for shades.

Lactating dairy cows consume an enormous amount of water. Table 7 shows the estimated water intake at various temperatures. Water should be located within 600 feet of the available pasture for better manure distribution and better pasture consumption.

Table 7. Estimated water needs for lactating and dry dairy cows at various temperatures.

	--------------Temperature--------------		
Milk	**10-40°F**	**70°F**	**90°F**
Production	------------------gal/day------------------		
Dry Cow	6.0	8.7	8.7
40 lb milk	16.0	21.5	26.5
80 lb milk	26.0	34.3	44.9

Mineral Supplementing of Cows on Pasture

Minerals and vitamins for milking cows on pasture should be force-fed through inclusion in the concentrate mixture. Usually, calcium, phosphorus, magnesium, trace minerals, and vitamins are added to the grain mixture. Lush-growing pastures are high in potassium and low in magnesium, which can result in a magnesium deficiency (grass tetany). Rations using pasture should contain 0.25 percent to 0.30 percent magnesium. The addition of magnesium oxide as a buffer at the rate of 0.05 to 0.10 pounds per cow per day will provide adequate supplemental magnesium.

Bottom Line

Well-managed pastures can provide high-quality and economical forages to lactating dairy cows. The key to making a grazing system work is providing the cow with a readily available pasture which does not limit forage intake and to maintain the pasture in a vegetative state to provide a highly nutritious forage. Concentrates should be fed to optimize milk production on pastures and complement the nutrients supplied by these forages.

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