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COMPOSITION AND COST OF DAIRY COW RATIONS WITH VARYING HAY CROP QUALITY

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INTRODUCTION

Researchers and extension personnel interested in dairy systems recognize the importance of high quality hay. It is generally assumed that feeding a higher quality hay should result in increased quantities of hay in the least cost balanced ration and thereby reduce total ration cost (Chase). The objective of this article is to quantify the direction and magnitude of changes in dairy cow ration composition and cost with increased hay crop quality.

The analysis procedure is to formulate least cost balanced rations for an average and a high quality hay crop silage in selected combinations with corn silage. Least cost balanced rations are formulated using corn grain, soybean meal and minerals for each forage combination at 10,000, 12,000, 14,000, 16,000 and 18,000 pounds of 3.5 percent butterfat milk per cow per year.

FEED INGREDIENTS AND FORAGE COMBINATIONS

Two roughages—hay crop silage and corn silage; two concentrates—corn grain and soybean meal; and three minerals—salt, dicalcium phosphate and limestone were the ration components. Hay crops considered were an alfalfa/brome hay crop silage with an assumed 12.6 percent crude protein and .48 Mcal NE_L per pound on a dry matter basis and an alfalfa hay crop silage with 17.0 percent crude protein and .52 Mcal NE_L.

Since the most profitable forage composition for a given farm depends upon the soil resource and fixed investments in harvesting machinery and storage structures, the impact of hay crop quality is compared for three forage compositions. The alternative forage compositions, which represent forage systems commonly found on dairy farms in the Northeast, were: (1) all forage from the hay crop, (2) half the forage dry matter from hay crop silage and half from corn silage and (3) 15.8 pounds of hay crop silage per cow per day with corn silage the remaining forage. Previous research (Knoblauch, Milligan, Fox and Woodell) has shown the composition with equal parts from each forage to be most profitable in many resource situations.

STUDY PROCEDURE

Least cost balanced rations were formulated for each of the three roughage combinations for both hay types and for each milk yield. Annual feed requirements were calculated by formulating a ration for each of ten months of lactation (30.5 days each) using the milk yield from the appropriate point on the lactation curve¹ and for a two month dry period for a 1,400 pound cow producing 3.5 percent butterfat milk.

All least cost balanced rations were formulated using NEWPLAN Program 31, Form 2 (Harsh, Hillman and Schoonaert; Knoblauch, Milligan and Chase). This linear

programming computer program has been used extensively by nutritionists, extension personnel and farmers in the Lakes States and the Northeast. Daily nutrient requirements and nutrient contents of feed ingredients in the program are based on National Research Council data (Tables 1 and 2). The nutrient contents of the forages are modified to reflect the forage quality in the Northeast (Table 1). Other linear programming restrictions included the calcium-phosphorus ratio (1.4:1.0 to 3.5:1.0 acceptable range), dry matter intake, minimum fiber level and maximum proportions of some feeds.² Prices were typical of the 1977-79 time period with the forages and corn grain priced at the farm manager's opportunity cost of home grown feeds and other feeds at purchase price. The hay crop silage prices are based upon the price of hay with the alfalfa hay priced 10 percent above the alfalfa-brome hay; a differential that is typical of reported and observed price differentials (New York State Crop Reporting Service).

Eleven least cost rations were multiplied by the appropriate number of days in each period and the totals summed to obtain annual feed requirements. This procedure was followed for each hay quality, forage composition and production level. The annual requirements for the hay crop, corn silage, corn grain and soybean meal and the total ration costs are compared in the following sections.

RATION COMPOSITION

Hay quality has the greatest impact on rations in which hay crop silage is the only forage. As milk yield increased, the quantity of alfalfa hay crop silage in the ration increased gradually and then maintained a level of 8.4 to 8.6 tons (Figure 1). With alfalfa-brome hay crop silage, however, a very small increase occurred initially followed by a gradual decline in quantity of hay as milk yield increased. Alfalfa hay crop silage content of the ration was below that for alfalfa-brome at all milk yields. Since shelled corn is a far better source of energy than hay crop silage, hay crop silage is included primarily to meet the protein and fiber requirements. With the increased nutrient content in alfalfa, less hay crop silage was needed to meet the protein and fiber requirements and increased quantities of shelled corn were used to meet the energy requirement. The composition and quantity of concentrates was also affected by the quality of hay crop silage. At all milk yields the concentrate mix contained less protein with the alfalfa hay (Table 3). More concentrate was included in the alfalfa hay ration at lower milk yields (10,000, 12,000 and 14,000); however, for 16,000 and 18,000 pound milk yields, feeding alfalfa hay resulted in a least cost ration containing less concentrate.

Two major differences appear in the ration with equal proportion of hay crop silage and corn silage as compared to the all hay ration. The first is that the hay crop silage content of the ration decreases continuously as milk yield increases for both hay

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¹Nott, *et al.* Percent of total milk yield in each month of lactation is:

1. 13.3%	3. 12.2	5. 10.3	7. 8.6	9. 6.8
2. 13.9	4. 11.5	6. 9.7%	8. 8.2	10. 5.5

²In lactation months 2 and 3 with high production, all restrictions could not be met. In those months the minimum fiber allowed in the ration was lowered to 13 percent and/or negative energy balancing was allowed with an equivalent positive energy balance in lactation months 8-10.

Table 1.
Cost and Nutrient Content for Feed Ingredients

Feed Ingredient	Cost	Moisture	Net Energy (Lact.)	Crude Protein	Crude Fiber	Calcium	Phosphorus	Magnesium	Salt
		<i>percent</i>	<i>Mcal/lb</i>	<i>—percentage on a dry matter basis—</i>					
Alfalfa hay crop silage (high quality)	\$28.00/ton	60	.52	17.0	30.6	1.33	.22	.26	0
Alfalfa/brome hay crop silage (average quality)	\$25.40/ton	60	.48	12.6	30.6	.81	.26	.22	0
Corn silage	\$18.00/ton	70	.68	8.0	25.9	.28	.22	.16	0
Shelled corn	\$2.00/bu.	15	.95	10.2	2.4	.02	.26	.12	0
Soybean meal	\$200/ton	10	.87	50.8	6.0	.29	.64	.28	0
Salt	\$5/cwt.	0	0	0	0	0	0	0	99.99
Dicalcium phosphate	\$20/cwt.	0	0	0	0	26.5	20	0	0
Limestone	\$2/cwt.	0	0	0	0	38.3	0	0	0

Source: National Academy of Sciences, National Research Council and New York Dairy Herd Improvement Corporation.

Table 2.
Nutrient Requirements for 45, 60, and 75 Pounds
Daily Milk Yield.^a

Nutrient	Daily Milk Yield		
	45 Pounds	60 Pounds	75 Pounds
Net energy (Mcal)	24.7	29.4	34.0
Total crude protein (pounds)	5.0	6.1	7.2
Calcium (grams)	80	98	116
Phosphorus (grams)	57	70	83
Magnesium (grams)	29	32	25
Salt (grams)	59	64	69

^a1,400 pound cow producing 3.5 percent butterfat milk.

Source: vanLieshout *et al.*

qualities. Second, at higher milk yields, there was more total forage in ration with alfalfa hay; however, at lower milk yields the increased protein content of the alfalfa hay in the 50-50 ration again resulted in less total forage in the ration. Except at the 10,000 pound milk yield, the 50-50 ration with alfalfa hay contained slightly less concentrate per day than the 50-50 ration with alfalfa-brome hay (Table 3). The percentage protein of the concentrate was almost constant across milk yields with alfalfa-brome hay; with alfalfa hay the percentage protein was less but increased as the milk yield increased.

The quantity of hay crop silage in the corn silage based forage combination was fixed at 15.8 pounds (6.3 pounds dry matter); however, minor adjustments in other feeds resulted from the change in hay quality. Because the alfalfa hay resulted in more protein per unit of dry matter, slightly more corn silage was consumed while maintaining minimum protein requirements and at higher milk yields without exceeding maximum intake constraints. Less concentrate per cow per day was required at all milk yields with alfalfa hay crop silage as compared with the alfalfa-brome.

For all three forage compositions at all milk yields, less soybean oil meal was required and the protein content of the concentrate was less with alfalfa hay. Other measures of the ration composition including quantities of hay crop silage, corn silage and corn grain and the proportion of roughage depend upon forage composition and milk yield.

ANNUAL COST OF THE RATIONS

The total feed cost incurred in feeding balanced dairy cattle rations is a crucial determination in making management decisions. Costs include the imputed value of hay, corn silage and corn grain³ and the soybean meal and minerals that must be purchased. The quantity harvested or purchased must be sufficient to satisfy the required consumption (Table 3) after storage and/or feeding losses are deducted.

The prices for the farm-grown feeds—hay crop silage, corn silage and corn grain—were based on the opportunity cost of feeding them to the dairy cows or the price at which they could be sold if not fed (Table 1). The better quality alfalfa hay crop silage was given a higher price of \$27.97 per ton compared to \$25.40 for the average quality hay. These prices were based on \$66 and \$60 per ton respectively for dry hay. The conversion to a hay crop silage price is based on moisture differences and differences in storage and feeding losses. Soybean meal and mineral prices were anticipated purchase prices.

The alfalfa hay resulted in a lower total ration cost for all roughage compositions at each milk yield (Table 4). As expected, the higher the proportion of hay in the roughage dry matter the greater the difference in cost between the rations. The impact of milk yield on this difference depends upon the hay nutrient composition. For the all hay ration the difference was similar for 14,000 and 18,000 pound milk yields but greater than for the 10,000 pound yield. For the 50-50 ration the difference increased with milk yield while for the corn silage based ration the cost difference was nearly constant.

Measuring the sensitivity to price changes is complicated by the inclusion of a linear programming solution for each of the ten months of lactation. Sensitivity is indicated by the break-even prices of the concentrates closest to the actual price over the ten months of lactation (Table 5). For all roughage compositions and hay qualities, the rations are stable over a wide range of soybean meal prices. The corn grain break-even prices are closer to actual prices for average quality hay and the sensitivity to a price change increases as the proportion of corn silage increases. The break-even price increase for the 50-50 average quality hay and corn silage is

³The analysis used a corn grain price consistent with on-farm production. If corn grain were purchased, the higher price would alter the conclusions very little since quantities of corn grain were not greatly different between hay qualities.

Table 3.
Annual Feed Requirements, Feeding Average and High Quality Hay Crop Silage for
10,000, 14,000 and 18,000 pounds of Milk

Forage Composition and Feed Ingredients	Annual Production					
	10,000		14,000		18,000	
	Ave. Quality	High Quality	Ave. Quality	High Quality	Ave. Quality	High Quality
ALL HAY						
Hay crop silage, tons ^a	9.6	7.1	9.5	8.4	8.9	8.6
Corn silage, tons ^b	0	0	0	0	0	0
Shelled corn, bushels ^c	76	94	96	108	120	127
Soybean oil meal, cwt. ^d	1	0	6	1	11	5
% roughage in ration	67.4	55.9	59.8	56.2	51.6	51.4
% protein in concentrate	11.6	10.2	14.4	11.1	16.3	13.1
50-50						
Hay crop silage, tons ^a	5.8	5.5	5.4	5.4	4.9	5.0
Corn silage, tons ^b	7.8	7.4	7.2	7.2	6.5	6.7
Shelled corn, bushels ^c	31	39	58	61	87	88
Soybean oil meal, cwt. ^d	6	2	11	7	16	12
% roughage in ration	82.2	81.3	69.7	71.0	58.4	60.4
% protein in concentrate	20.9	13.9	20.8	17.2	20.8	18.6
CORN SILAGE BASED						
Hay crop silage, tons ^a	2.9	2.9	2.9	2.9	2.9	2.9
Corn silage, tons ^b	12.4	12.5	11.8	12.0	10.7	10.9
Shelled corn, bushels ^c	7	7	28	31	61	61
Soybean oil meal, cwt. ^d	10	8	14	12	19	17
% roughage in ration	88.8	90.3	78.4	78.8	65.4	66.6
% protein in concentrate	40.1	38.1	30.2	27.6	25.2	24.2

^a40 percent dry matter.^b30 percent dry matter^c85 percent dry matter.^d90 percent dry matter.

Table 4.
Ration Cost Feeding Average and High Quality Hay Crop Silage for 10,000, 14,000,
and 18,000 pounds Production^a

Forage Composition and Cost	10,000		14,000		18,000	
	Ave.	High	Ave.	High	Ave.	High
ALL HAY						
Hay crop silage ^b	\$304.59	\$249.59	\$302.05	\$292.79	\$282.53	\$299.71
Corn silage ^c	—	—	—	—	—	—
Shelled corn ^d	176.87	218.74	223.19	250.07	277.22	293.91
Soybean oil meal ^e	14.84	0.00	61.37	13.37	117.47	54.00
Minerals ^e	7.19	12.90	10.09	16.10	13.67	19.08
Total	\$503.49	\$481.23	\$596.70	\$572.33	\$690.89	\$666.70
50-50						
Hay crop silage ^b	\$184.53	\$193.33	\$170.69	\$188.26	\$155.02	\$174.42
Corn silage ^c	163.61	155.82	151.32	151.71	137.36	140.58
Shelled corn ^d	71.37	90.93	134.43	141.93	200.59	203.37
Soybean oil meal ^e	61.79	21.68	111.79	70.84	169.89	127.36
Minerals ^e	7.96	12.10	11.32	14.96	14.92	17.83
Total	\$489.26	\$473.86	\$579.55	\$567.70	\$677.78	\$663.56
CORN SILAGE BASED						
Hay crop silage ^b	\$ 91.57	\$100.72	\$ 91.57	\$100.72	\$ 91.57	\$100.72
Corn silage ^c	261.06	264.58	249.97	253.73	226.74	229.17
Shelled corn ^d	15.72	15.88	71.90	71.63	140.52	141.68
Soybean oil meal ^e	105.26	84.21	151.36	129.58	198.52	176.94
Minerals ^e	8.94	10.56	12.04	13.52	15.51	16.85
Total	\$482.55	\$475.95	\$576.84	\$569.18	\$672.86	\$665.36

^aPrices used are contained in Table 1.^dStorage and feeding losses were 13.6 percent of harvested quantities.^bStorage and feeding losses were 20 percent of harvested quantities.^eFeeding losses are five percent of purchased quantities.^cStorage and feeding losses were 14.7 percent of harvested quantities.

Table 5.
Break-even Prices for Corn Grain and Soybean Meal^a

Ration and Feed Ingredient	Average Quality Hay			High Quality Hay		
	Lower Cost	Actual Cost	Higher Cost	Lower Cost	Actual Cost	Higher Cost
ALL HAY						
Corn grain, bu.	\$1.58	\$2.00	\$2.95	\$1.21	\$2.00	\$4.57
Soybean meal, T.	173	200	1,342	168	200	>9,999
50-50 HAY & CORN SILAGE						
Corn grain, bu.	1.81	2.00	5.77	1.71	2.00	2.53
Soybean meal, T.	163	200	568	163	200	962
CORN SILAGE BASED						
Corn grain, bu.	1.90	2.00	2.14	1.90	2.00	2.34
Soybean meal, T.	185	200	406	176	200	335

^aBreak-even price closest to the actual price over the ten months of lactation.

the only exception to these directions. In this ration the nutrient balance of the forage is such that the maximum forage is used given the dry matter intake constraint; consequently, corn grain in the ration would not decrease until the corn grain price became so high that soybean meal would substitute for corn (\$5.77 per bushel). If a higher price for corn grain were used, minor adjustments in rations with high corn silage would occur. Little change in relative ration costs for average and high quality hay would result because similar levels of corn grain are contained in each ration.

CONCLUSION

The results confirmed the importance of high nutrient content hay crops in controlling feed costs; however, the generally accepted principle that larger quantities of alfalfa hay will always be included in the least cost ration was rejected. In rations in which large quantities of protein come from the hay crop, improved nutrient value results in reduced quantities of hay since the protein

contribution is satisfied by smaller quantities of forage. The results underscore the importance of high quality hay and of including the nutrient contents of all feeds when formulating dairy cow rations. These conclusions would, of course, be unaltered as long as relative prices remain constant. In addition, the break-even prices indicated that relative price changes in the relevant range would not substantially alter the conclusions of this article.

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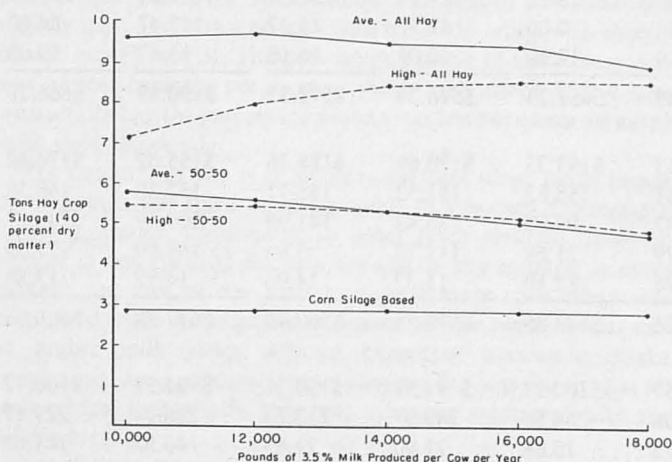


FIGURE 1.

Tons of Hay Crop Silage Included in Annual Feed Requirements Feeding Average and Higher Quality Hay Crop Silage.