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Economic Use of Grain and Forage in Livestock Production

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CIRCULAR 105 JUNE 1954

ECONOMIC USE OF GRAIN AND FORAGE IN LIVESTOCK PRODUCTION

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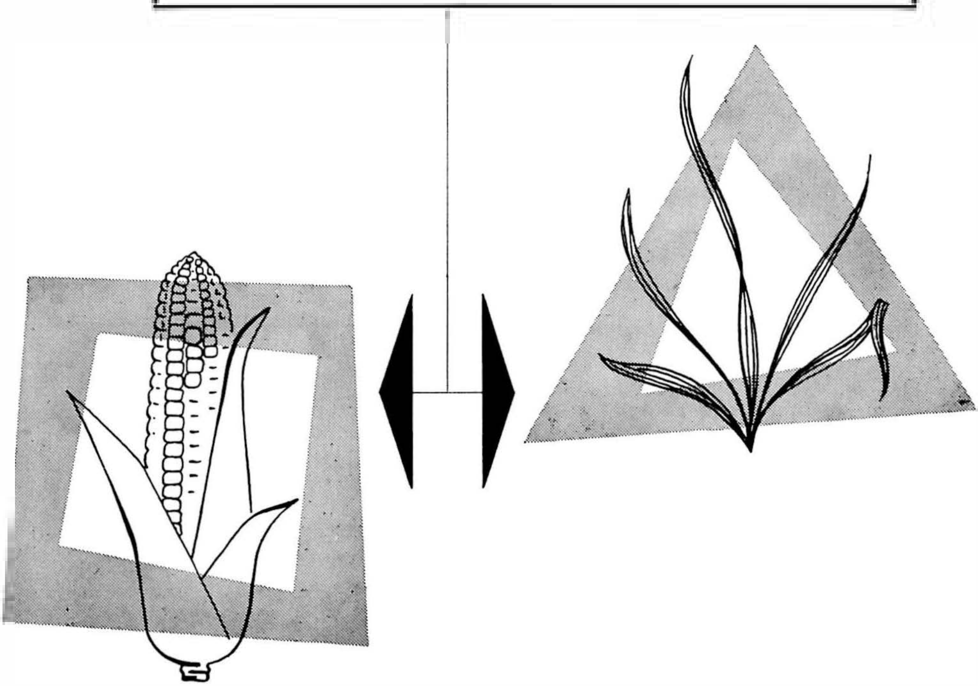

AGRICULTURE ECONOMICS DEPARTMENT
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Acknowledgment

This circular is a revision of Agricultural Economics Phamphlets No. 38, "Input and Output Relationships in Livestock Production" and No. 39, "Estimated Feed Requirements for Livestock and Poultry" by Sigurd R. Stangeland.

Estimates of rations and production were prepared in cooperation with: Richard F. Wahlstrom, Robert M. Jordan, Lawrence B. Embry, William C. McCone, and James J. O'Connell of the Animal Husbandry Department; Charles W. Carlson of the Poultry Department; and Chase C. Wilson, Roy A. Cave, and W. Allan Goodbary of the Dairy Department at South Dakota State College.

Ideas for presentation of the data were obtained from the North Central Farm Management Research Committee.

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Feed Substitution Table*

	Dairy Cattle	Fattening Beef-Cattle	Wintering Beef-Cattle	Fattening Hogs	Fattening Lambs
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Corn	1.00	1.00	1.00	1.00	1.00
Barley	1.00	1.14	1.00	1.05	1.14
Oats	1.00	1.18	1.00	1.18	1.11
Wheat	1.00	0.95	1.00	0.95	1.18
Grain sorghum	1.00	1.09	1.00	1.11	1.00
Rye†	1.00	1.00	—	1.18	1.00
Dried beet pulp	1.05	1.05	1.05	—	1.05
Wet beet pulp	6.67	6.67	6.67	—	6.67

*This table shows the number of pounds of one feed which will replace 1 pound of corn in the concentrate portion of the ration.

†Rye is not as palatable as other grains. It may be dangerous to feed if it contanis an appreciable amount of ergot. Rye should be used only as part of the concentrate portion of the ration.

The substitution rates given in this table represent the approximate rates at which various grains and beet pulp will substitute for corn. The rates are based on animal feeding experiments.

Variations from these rates can be expected. The actual rates of substitution depend somewhat upon the amounts of various feeds included in the ration, the rate at which the ration is fed, and all the variable characteristics of the animal. The substitution rate of many feeds, for example, is usually higher when it is a small part of the total ration than when it is used as the major or only concentrate in the ration.

The rates shown in this table are approximate substitution rates that may be expected when the various feeds are used in appropriate amounts and in well-balanced rations. Literature on livestock feeding should be consulted for more complete information.

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Economic Use of Grain and Forage In Livestock Production

CANUTE M. JOHNSON and SIGURD R. STANGELAND[1]

INTRODUCTION

EVERY FARMER must make production decisions. He must decide which crop and livestock enterprises and what production practices can be profitably employed on his farm. He can make these decisions—hit or miss fashion—with little or no factual information and without the benefit of a plan or production program. In contrast, he can base his decisions upon a carefully planned production program which uses a wealth of information on physical inputs and outputs, costs of production, and prices received for the items produced.

The most effective farm planning is done by means of budgets. Usually several different production plans must be budgeted in order to determine which may be the most profitable. A range of physical input data is needed in planning or budgeting for alternative production programs.

The purpose of this circular is to present physical production data for several types of livestock enterprises which will show the relationship between inputs of various combinations of grain and forage, and outputs of livestock and livestock products in response to these feed combinations.

The level of feeding which will achieve maximum physical production may or may not be the most profitable. The most profitable rate of input depends upon the cost of various input factors (types of feed) relative to the price of the output of livestock products. It is not the purpose of this circular to present "recommended" or "required" or the most "economical" combination of feeds and systems of feeding using fixed amounts of grains, supplements, and forages. Rather, the purpose is to present a range of physical input-output data which show that many combinations of grains, supplements, and forages may be used in livestock production enterprises.

The physical input-output data which are presented in this circular are based upon experiments in livestock feeding. Available experimental data which showed the production (output) obtained by different rates of feeding and qualities of rations (inputs) were examined to secure a range of data for various livestock production enterprises. Production specialists from the Dairy, Animal Husbandry, and Poultry departments of the Experiment Station assisted in interpreting these experimental results and in estimating input-output

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data for livestock production in South Dakota.

Physical production data of this kind will be useful to the farmer in analyzing his farm operations in order to determine what amounts of grain and forage are needed for the livestock enterprises now on the farm; and if the farmer shifts his cropping system so that more or less forage is produced, these data will help him to determine how a new combination of grain and forage can be efficiently utilized for the greatest net profit.

Current prices can be applied to these input-output data in choosing what combination of livestock enterprises and how much livestock to produce and what combination and how much grain and forages to feed for the highest net returns.

The cost of producing livestock varies. It depends not only upon the level of feed prices but also upon the combination of feeds used. The cost of any particular combination of feeds changes not only as price levels go up or down, but also with changes in the price of various feeds in the feed combination. The profitableness of any livestock enterprise is also variable and depends upon the relationship between cost of production and the price received for the livestock or livestock products. In view of the foregoing cost-price considerations, it is easy to see that no single livestock enterprise or combination of enterprises coupled with certain production practices will be the most profitable under all conditions. The type of livestock and size of enterprises, the combinations of grain and forage in feed rations, and the rates of feeding which should be chosen are those which will bring the greatest return over cost for the farm as a whole.

Beef Cattle Rations

THE BEEF CATTLE raiser has numerous opportunities to utilize forages, but the feeder has fewer opportunities to substitute forages for grain and protein supplement in rations for fattening beef cattle. The major substitution possibilities in the beef cattle fattening enterprise involve using systems of limited and deferred feeding instead of full feeding in dry lot.

Rations for Fattening Beef Cattle

Important factors which affect the rate of gain and the amount of feed needed to fatten beef cattle are: (1) the breed and grade of animal, (2) the age and sex of the animal, (3) the feeding system, (4) the length of the feeding period, (5) the degree of finish obtained, and (6) the inherited ability of the animal to gain.

The amount of feed needed to fatten beef cattle will not be the same for each of the three principal feeding systems. These systems are: (a) full feeding in a dry lot, (b) various degrees of limited feeding, and (c) systems of deferred feeding. Estimated amounts of feed to fatten several kinds of feeder cattle using each of the principal feeding systems are presented in Tables 1, 2, and 3. The figure for daily gain given in these tables is the average daily gain obtained during the specified feeding period to attain the slaughter grade indicated. A 10 percent allowance for feeding losses is included in all roughage amounts.

Estimated amounts of feed to fatten cattle in a dry lot on full feed are given in Table 1. Estimated amounts to fatten feeders by limited feeding using two different pasturing systems are presented in Table 2. Calves are fed limited amounts of grain and protein supplement during the winter in both systems. Yearlings under System 1 are fed at full feed throughout the grazing period; while in System 2, they are fed at full feed only during the latter half of the grazing period. Cattle finished under System 2 may be wintered more economically on roughage alone as shown in Table 3.

Estimates for deferred dry-lot feeding are given in Table 3. In this system, calves are fed good alfalfa-brome hay through the winter, grazed with no supplemental feeding during the pasture season, and placed on full feed in a dry lot in the autumn.

Adequate amounts of salt and mineral supplement should be supplied. Actual mineral needs and consumption will vary with the kind of livestock and the rations fed. The amount of minerals in the ration is important but the cost is difficult to consider when comparing different rations. However, the difference in cost of mineral supplement between rations will not be great.

The amount of feed needed to obtain 100 pounds of gain depends directly upon the age at which feeders are put on fattening rations and increases as the length of the feeding period increases and as higher degrees of finish are obtained.

Calves on full feed need less feed for each 100 pounds of gain than yearlings, and yearlings take less feed than 2-year old animals. The average daily gain of older animals on full feed will

Table 1. Estimated Amounts of Feed to Fatten Feeders Full-Fed in Dry Lot

Kind of Feeders	Initial Weight	Final Weight	No. of Days in Feed Lot	Daily Gain	Slaughter Grade	Average Amount of Feed per Head* Corn	40% Protein Supplement	Alfalfa Brome Hay
	Lbs.	Lbs.	Days	Lbs.		Bu.	Lbs.	Lbs.
Calves, good to choice	400	950	275	2	choice to prime	58	175	1700
Yearlings, good to choice	750	1200	205	2.2	choice to prime	55	150	1500

*Adequate amounts of salt and mineral supplement should be supplied.

Table 2. Estimated Amounts of Feed to Fatten Feeders on Pasture

Kind of Feeders	Initial Weight	Final Weight	No. of Days in Feed Lot	Daily Gain	Slaughter Grade	Average Amount of Feed per Head* Corn	40% Protein Supplement	Alfalfa Brome Hay
	Lbs.	Lbs.	Days	Lbs.		Bu.	Lbs.	Lbs.
Winter Phase—Limited Grain Feeding								
Calves, good to choice	400	650	195	1.3	—	10	—	2900
System 1—Grain Full-fed During Entire Grazing Period								
Yearlings, good to choice	650	950	136	2.2	choice	36	80	—
System 2—Grain Full-fed Only During Latter Half of Grazing Period								
Yearlings, good to choice	650	950	158	1.9	good to choice	26	105	—

*Adequate amounts of salt and mineral supplement should be supplied.

Table 3. Estimated Amounts of Feed to Fatten Feeders on Roughage Followed by Full Feed in Dry Lot

Kind of Feeders	Initial Weight	Final Weight	No. of Days in Feed Lot	Daily Gain	Slaughter Grade	Average Amount of Feed per Head* Corn	40% Protein Supplement	Alfalfa Brome Hay
	Lbs.	Lbs.	Days	Lbs.		Bu.	Lbs.	Lbs.
Winter Phase—Roughage Only								
Calves, good to choice	400	537	195	0.7	—	—	—	2900
Grazing Phase—No Grain								
Yearlings, good to choice	537	750	165	1.2	—	—	—	—
Full-fed in Dry Lot								
Yearlings, good to choice	750	1200	205	2.2	choice to prime	55	150	1500

*Adequate amounts of salt and mineral supplement should be supplied.

be larger than for younger animals, but the amount of feed needed to obtain this amount of gain is more than proportionately larger. Steers usually require less feed for 100 pounds of gain than heifers.

High quality animals which have the ability to make rapid gains will usually need less feed for each 100 pounds of gain than lower quality animals when both are fed to attain the same degree of finish. However, if feeder cattle, either steers or heifers, are fed to a finish suited to their grade, the efficiency of gain for each grade of feeder is approximately the same.

Feed inefficiency results from attempting to feed poorer grades of animals to high degrees of finish. Economic inefficiency may result from not fattening cattle to a degree of finish appropriate to their grade. Sound judgment is necessary in determining what age, grade, sex, and type of animal to feed, how long to feed it, and to what degree of finish. Factors which must be considered in making such decisions are: (1) the cost and grade of feeders, (2) the cost of feeds, and (3) the price for fat cattle.

Rations for the Breeding Herd

Estimated annual amounts of feed needed to maintain the breeding herd are given in Table 4. Systems of feeding the breeding herd in South Dakota vary from a pasture season of about six months to a year-round grazing program. Under range conditions, it is estimated that cattle need to be fed hay and protein supplement about two months in the winter. Therefore two systems for wintering the cow herd are given in Table 4.

Substitution Possibilities

Certain roughages and other feed grains may be substituted for corn in the concentrate ration (see Feed Subsituation Table on page 4) within the limits noted below.

Dried beet pulp may be substituted for corn up to 50 percent of the concentrate ration.

Wet beet pulp may be substituted for dry pulp at the rate of 8 pounds of wet pulp for each pound of dry pulp.

Cured beet tops supplemented with calcium may be substituted for alfalfa-brome hay, pound for pound.

Corn silage may be substituted for alfalfa-brome hay and corn in the following manner: 100 pounds of silage plus 1 pound of 40 percent protein supplement may be substituted for 30 pounds of hay and 15 pounds of corn.

Table 4. Estimated Amounts of Feed to Maintain the Breeding Herd

Sex	Average Annual Amount of Feed Per Head*			
	Corn-Oats Mixture	Grass-Legume Hay	Pasture	40% Protein Supplement
	Bu.	Lbs.	Days	Lbs.
Cows (farm conditions)	----	3500	180	----
Cows (range conditions)	----	2000 (native hay)	annual	125
Bulls†	20	4500	180	----

*Adequate amounts of salt and mineral supplement should be supplied.
†One pound per day of 40 percent protein supplement should be fed if the hay is poor in quality or from a late cutting.

Sheep Rations

A SHEEP enterprise presents the farmer with the possibility of using a wide variety of forages. Either fattening lambs or breeding ewes can efficiently utilize rations which contain low proportions of concentrates (grain and protein supplement). There are several possibilities for substituting forages for grain and protein supplement in rations for breeding ewes and fattening lambs.

Rations for Fattening Lambs

Important factors which affect the rate of gain and the amount of feed needed to fatten lambs are: (1) the proportion of concentrates in the ration, (2) the quality of roughage, (3) the length of the fattening period, (4) the total protein content of the ration, and (5) the quality and condition of the lambs when put on feed.

Estimated amounts of feed to obtain 30 or 40 pounds of gain when using alfalfa hay are given in Table 5; estimated amounts when feeding native hay are given in Table 6. Table 7 shows the estimated amounts of feed needed when using sugar beet by-products, and Table 8 gives the amounts when corn or legume silage is fed. Several alternative combinations of roughage and concentrates are given for each kind of roughage along with rates of gain, which increase as the porportion of concentrates in the rations is increased.

The most efficient ration for fattening lambs is one which contains 50 to 60 percent concentrates (grain and protein supplement). Feeder lambs weighing 65 to 75 pounds will reach top slaughter finish with a gain of 30 pounds when fed a ration which contains 50 to 60 percent concentrates. If larger proportions than 60 percent concentrates are used in the ration, the rate of gain may decline and feeding efficiency may be reduced. Approximately 40 pounds of gain are required to make choice slaughter lambs when a ration containing 35 to 45 percent concentrates is fed. When the proportion of concentrates in the ration is reduced, especially to less than 35 percent, the rate of gain is reduced and the amount of feed needed to obtain 100 pounds of gain is increased.

Top slaughter grades may be obtained with rations which are low in concentrates, but high quality roughage must be fed. The feeding period will be considerably lengthened and the lambs will usually be above the market demand weight of about 105 pounds before they are finished to a top slaughter grade. However, if the lamb feeder has a plentiful supply of good quality, low-cost roughage, it may be profitable, depending upon the market price of lambs, to feed good quality light-weight lambs rations containing a high proportion of roughage.

The roughage allowance in all rations includes an allowance of 10 percent for feeding losses. Unless otherwise noted, 2 pounds of salt per lamb are needed during the fattening period.

Rations for the Breeding Flock

Estimated annual amounts of feed needed to maintain the breeding flock as given in Table 9 should be varied according to (1) the size of ewe, (2) the time of lambing, (3) the number of lambs per ewe, (4) the quality of roughage, and (5) the pasturing program.

Ewes in a farm flock should be fed grain during the May lambing period in the following manner: one-half pound per day for 30 days or more before lambing and 1 pound per day for 30 days after lambing. Ewes would need more grain if they lamb

Table 5. Estimated Amounts of Feed to Fatten Western Lambs Using Alfalfa-Brome Hay (Approximate Market Weight 105 Pounds)

Percentage Concentrate in Ration	Days in Feed Lot	Daily Gain	Average Amount of Feed per Lamb*: Corn	Average Amount of Feed per Lamb*: Alfalfa-Brome Hay
%	Days	Lbs.	Bu.	Lbs.
		For 30 Lbs. Gain		
25	125	0.24	1.7	340
40	110	0.27	2.2	220
50	100	0.30	2.5	170
60	93	0.32	2.7	110
		For 40 Lbs. Gain		
25	165	0.24	2.5	440
40	148	0.27	3.1	280
50	133	0.30	3.6	200
60	125	0.32	3.9	140

*Adequate amounts of salt and mineral supplement should be supplied.

Table 6. Estimated Amounts of Feed to Fatten Western Lambs Using Native Hay (Approximate Market Weight 105 Pounds)

Percentage Concentrate in Ration	Days in Feed Lot	Daily Gain	Average Amount of Feed per Lamb*: Corn	40% Protein Supplement	Native Hay
%	Days	Lbs.	Bu.	Lbs.	Lbs.
		For 30 Lbs. Gain			
40	128	0.23	2.2	25	260
50	114	0.26	2.5	20	190
60	100	0.30	2.7	20	120
		For 40 Lbs. Gain			
40	167	0.24	3.1	30	330
50	148	0.27	3.6	30	230
60	133	0.30	3.9	30	170

*Adequate amounts of salt and mineral supplement should be supplied.

Table 7. Estimated Amounts of Feed to Fatten Western Lambs Using Sugar Beet By-Products (Approximate Market Weight 105 Pounds)

Days in Feed Lot	Daily Gain	Average Amount of Feed per Lamb to Obtain 30 Lbs. Gain*: Corn	40% Protein Supplement	Wet Beet Pulp	Dried Beet Pulp	Beet Tops	Alfalfa-Brome Hay
Days	Lbs.	Bu.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
100	0.30	1.8	20	500	—	100	100
100	0.30	1.7	—	—	90	—	120
100	0.30	1.7	—	—	40	160	120
100	0.30	1.7	—	—	—	200	120
100	0.30	1.3	20	—	70	100	100

*Adequate amounts of salt and mineral supplement should be supplied.

earlier than May or if the lamb crop contains a large proportion of twins.

Ewes wintered on the range should receive protein supplement in addition to winter grazing. Both protein supplement and hay should be fed to ewes if the range is short or snow-covered. Rams under range conditions should be fed the same amounts of feed as ewes, and in addition, 1 pound of grain per day during the breeding season. Range ewes lambing on green grass would need no grain after lambing if they are in strong condition.

Substitution Possibilities

Although alfalfa is unexcelled as a roughage for fattening lambs, Tables 6, 7, and 8 present possibilities for utilizing other roughages for part or all of the alfalfa in lamb fattening rations. In each table there is a range of substitution possibilities or alternative combinations of roughage and concentrates which the lamb feeder may use in fattening lambs. The best combination of roughage and concentrates will be the one which will obtain the desired gain at least cost.

Other feed grains may be substituted for corn (see Feed Substitution Table on page 4) as long as the concentrate mixture contains about '75 percent total digestible nutrients.

A good grade of molasses may be substituted on a pound for pound basis for 10 to 20 percent of the grain allowance given in these tables.

Table 8. Estimated Amounts of Feed to Fatten Western Lambs on Either Corn or Legume Silage (Initial Weight 65 to 75 Pounds)

	Average Amount of Feed per Lamb to Obtain 30 Lbs. Gain*					
Days in Feed Lot	Daily Gain	Corn	Alfalfa-Brome Hay	40% Protein Supplement	Corn Silage	Legume Silage
Days	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
90	0.33	135	45	18	225	—
90	0.33	155	45	—	—	225
110	0.27	110	55	22	385	—
110	0.27	135	55	—	—	385
150	0.2	75	75	30	675	—
150	0.2	105	75	—	—	675

*Adequate amounts of salt and mineral supplement should be supplied.

Table 9. Estimated Amounts of Feed to Maintain the Breeding Flock

	Average Amount of Feed per Ewe or Ram*				
	Grain	40% Protein Supplement	Alfalfa Hay	Native Hay	Pasture
Ewes and Rams	Lbs.	Lbs.	Lbs.	Lbs.	Days
Farm flock conditions†	40-60	—	300	400	165
Range conditions‡	15-30	40	—	300	200

*Adequate amounts of salt and mineral supplement should be supplied.
†Native hay may be substituted for alfalfa hay on a pound for pound basis provided that one-fourth pound of protein supplement is fed daily in addition.
‡May lambing is assumed. Range ewes should be fed one-half to three-fourths of a pound of grain daily during the month preceding lambing.

Hog Rations

THE POSSIBILITY of substituting forage for grain and protein supplement in the hog production enterprise is not as great as in the dairy, beef cattle, and sheep enterprises. However, the hog producer can obtain cheaper gains on hogs that are pastured on a good legume pasture than when feeding hogs in a dry lot. An acre of good legume pasture will replace about 500 pounds of grain and 500 pounds of protein supplement when pastured at the rate of 15 to 20 fattening pigs per acre.

Other important factors which affect the rate of gain and the amount of feed needed to fatten pigs are: (1) the quality of feed, (2) the rate of feeding, (3) the market weight, and (4) the prevalence of disease and parasites.

The amount of feed needed to produce 100 pounds of gain depends to a large extent upon the quality and proportion of protein in the diet and the presence of adequate amounts of minerals and vitamins. Pigs fed rations which contain 15 to 18 percent protein in the total ration make larger daily gains than pigs fed rations containing smaller proportions of protein. More feed is required to obtain 100 pounds of gain as hogs reach heavier weights, particularly weights above 200 pounds.

Limited feeding of pigs on pasture may result in some saving in the amount of concentrates (grain and protein supplement) needed to obtain 100 pounds of gain. However, a slower rate of gain results and more time is required for pigs to reach market weights.

The proper use of a vitamin-antibiotic supplement will result in increased rates of gain and reduced amounts of feed needed to obtain 100 pounds of gain. Other benefits from vitamin-antibiotic supplement feeding include reduced time from farrowing to market, more uniform pigs, and fewer occurrences of scouring and other intestinal disorders.

The mineral mixture in all diets should consist of approximately 40 parts of ground limestone, 40 parts of bonemeal, and 20 parts of salt (a commercial salt preparation which contains trace minerals is usually recommended).

Rations for 100 Pounds of Gain

Estimated amounts of feed to obtain 100 pounds of gain on pigs pastured on good alfalfa-brome pasture and on pigs fed in a dry lot are given in Table 10. These rations show the alternative combinations of corn and protein supplement which may be used to obtain 100 pounds of gain as pigs are fattened from an initial weight of 30 pounds to a market weight of 180 to 230 pounds.

The average daily gain is given for each combination of corn and protein supplement in both feeding systems. The rate of gain is reduced when the proportion of corn in the diet is increased; more feed is needed to obtain 100 pounds of gain, and more time is required to reach market weight.

The ration should contain a higher proportion of protein supplement during the early period of growth

Table 10. Estimated Amounts of Feed to Obtain 100 Pounds of Gain on Pigs in Dry Lot and Pigs on Alfalfa-Brome Pasture

Pigs in Dry Lot*			Alfalfa-Brome Pasture*		
Corn	Protein Supplement†	Estimated Average Daily Gain	Corn	Protein Supplement‡	Estimated Average Daily Gain
Bu.	Lbs.	Lbs.	Bu.	Lbs.	Lbs.
15.0	—	0.5	8.5	—	0.9
11.6	8	0.7	7.7	10	1.0
8.8	20	0.9	6.9	20	1.2
7.3	40	1.1	6.2	30	1.3
6.6	60	1.3	5.8	40	1.4
6.0	80	1.4	—	—	—

*Initial weight of pigs 30 pounds. Final marketing weight 180 to 230 lbs. Adequate amounts of salt and mineral supplement should be supplied.
†The protein supplement contains 2 parts of tankage, 1 part of soybean oilmeal, and 1 part of ground alfalfa.
‡The protein supplement contains equal parts of tankage and soybean oilmeal.

Table 11. Estimated Amounts of Feed to Fatten the Gilt and a Litter of Six Pigs in Dry Lot

Feed per Litter*					
		Protein Supplement			
Corn	Oats	Tankage	Soybean Oil Meal	Ground Alfalfa	Average Number of Days to Reach a Market Weight of 230 Lbs.
Bu.	Bu.	Lbs.	Lbs.	Lbs.	Days
191	15	70	70	400	442
150	15	118	94	424	327
117	15	190	130	460	264
99	15	310	190	520	224
90	15	430	250	580	196
83	15	550	310	640	184

*Includes feed for the gilt from breeding time at eight months to a weight of 350 pounds as shown in Table 13. Adequate amounts of salt and mineral supplement should be supplied.

and a smaller proportion as market weights are approached. Protein supplements containing 50 percent animal protein seem to be the best for high efficiency feeding. The protein supplement for pigs in dry lot should contain 25 percent good quality ground alfalfa.

Rations for a Gilt and Litter of Six Pigs

Estimated amounts of feed (including feed for the gilt from breeding time to a weight of 350 pounds) to raise a litter of six pigs to a market weight of 230 pounds in a dry lot are presented in Table 11. The estimated amounts of feed for a litter on good alfalfa-brome pasture are presented in Table 12. These rations show the alternative combinations of corn and protein supplement which may be used in raising a litter of pigs. The average number of days for pigs to reach a market weight of 230 pounds is given for each feed combination in both feeding systems. Here too, it will be noted that when the proportion of corn in the diet is increased, more feed is needed to fatten pigs and more time is required for pigs to reach market weight.

Rations for the Breeding Herd

Estimated amounts of feed for the breeding herd are presented in Table 13. Footnotes to Table 13 specify the feeding periods for the rations.

Substitution Possibilities

Alternative combinations of corn and protein supplement given in these tables present the hog producer with a range of substitution possibilities. The substitution of protein supplement for corn, or vice versa, is of major importance in hog production. The least-cost ration for pigs on good alfalfa-brome pasture may vary from one which contains no protein supplement to a ration which contains up to 14 percent protein. The protein supplement in the ration may vary from 4 to 25 percent for pigs fed in dry lot. Hog rations may contain even larger proportions of protein supplements, but no significant increase in the rate of gain can be expected and the rate of gain may decline at high levels of protein feeding. The feed combination and feeding system which the hog producer will want to adopt is the one which will obtain the cheapest gains according to the cost of feed and the market value of finished hogs.

Other grains may be substituted for corn (see Feed Substitution Table on page 4) until they make up 25 percent of the grain ration.

Fluid skim milk may be substituted for tankage at the rate of 7 pounds of skim milk for 1 pound of tankage. Skim milk is a valuable protein supplement in the ration for growing and fattening pigs. However, the feeding value of skim milk decreases rapidly as the proportion of skim milk in the ration is increased. Its watery composition requires consumption of large volumes to obtain the food value equivalent to that of other feeds. Consumption of large volumes of skim milk reduces the ability of pigs to consume enough other feeds for efficient gains.

Table 12. Estimated Amounts of Feed to Fatten the Gilt and a Litter of Six Pigs on Alfalfa-Brome Pasture

Feed per Litter*					
		Protein Supplement			Average Number of Days
Corn	Oats	Tankage	Soybean Oil Meal	Ground Alfalfa	to Reach a Market Weight of 230 Lbs.
Bu.	Bu.	Lbs.	Lbs.	Lbs.	Days
113	15	70	70	400	264
103	15	130	130	400	242
94	15	190	190	400	208
85	15	250	250	400	196
81	15	310	310	400	184

*Includes feed for the gilt from breeding time at eight months to a weight of 350 pounds as shown in Table 13. Adequate amounts of salt and mineral supplement should be supplied.

Table 13. Estimated Amounts of Feed for the Breeding Herd

	Corn	Oats	Tankage	Soybean Oil Meal	Ground Alfalfa
	Bu.	Bu.	Lbs.	Lbs.	Lbs.
Gilts*	11	15	70	70	400
Boars†	4	6	40	40	200

*Feed needed from breeding time at eight months to a weight of 350 pounds. Adequate amounts of salt and mineral supplement should be supplied.
†Feed needed during a breeding period of 60 days.

Dairy Cattle Rations

A DAIRY enterprise offers the farmer one of the best opportunities to substitute forage for grain and protein supplement in livestock rations. However, the milk or butterfat producer will want to consider the effect upon net income from the entire farm when he substitutes forages in dairy cow rations. Considering the dairy enterprise alone at certain feed-milk-or-butterfat price relationships, it might appear profitable to substitute forage for all the grain and protein supplement; but if all the forage needed was produced on the farm, more net income might be sacrificed in the crop enterprise than would be gained in the dairy enterprise. Therefore, it is necessary for the dairyman to consider both dairy and crop enterprises, together with all other farm enterprises, in determining the most profitable combination of feeds to use in the dairy enterprise.

The most profitable combination of feeds in milk production is not fixed and depends upon price relationships and the milk producing ability of the cows. It ranges from feeding dairy cows only roughage to feeding as much concentrates (grain and protein supplement) as the animals will consume.

Rations for Milk or Butterfat Production

Important factors which affect both the feed intake and the milk or butterfat production of cows are: (1) the inherited milk producing ability; (2) the combination and quantity of feeds fed; (3) the quality of feeds fed, particularly the quality of hay, pasture and silage; (4) the general health and condition of the cows; (5) the distribution of feed during the lactation period; and (6) the size, weight, and condition of the cows.

Feeding experiments indicate that cows fed an all-roughage ration produce 70 to 90 percent as much milk as when they are fed concentrates (grain and protein supplement) at rates of 1 pound to each 4 to 6 pounds of milk produced and roughage free choice. Limited concentrate feeding usually stimulates the appetite so that more forage is consumed than when no concentrates are fed. Ultimately, if appreciable amounts of concentrates are fed, forage consumption declines.

Concentrates are fed to dairy cows to increase the nutrient intake, and thereby, to increase milk production. However, the increase in milk production resulting from each additional pound of nutrients becomes smaller as high levels of nutrient intake and milk production are approached. Experimental data show that at the lowest level of milk production, 1 pound of added nutrients will produce 1.7 pounds of 4 percent milk; while at the higher levels of milk production, 1 pound of added nutrients will produce only 0.6 pounds of 4 percent milk.

Therefore, it is very important to consider cost and returns from the use of more or less forage or concentrates in the dairy enterprise. The dairyman will want to determine by means of a detailed farm budget whether it is economically feasible for him to produce the necessary amounts of grain and forage; and whether the net returns from these feeds in the dairy enterprise add more to net farm income than if this amount of feed were sold or utilized in some other livestock enterprise. The dairy farmer with a market for fluid milk may find it profitable to feed more grain and protein supplement with less roughage than one who sells cream.

Dairy nutrition and production data which will permit development of a set of input-output tables to fit all levels of production, feeding conditions, and qualities of cows are not available. New types of forages and new methods of harvesting and storing forages have made the production of forages with high nutritional values possible. This has caused dairy nutritionists to believe that high levels of milk production can be obtained from all forage rations, provided the forage has a high nutritional value.

Accordingly, some dairy nutritionists have taken the view that the feeding principle in utilizing forages with high nutritional values is that of feeding the animal all the roughage it will consume supplemented with enough grain to obtain the desired level of milk production. Tables 14 through 19 show rations based on this principle. A constant amount of forage is assumed in most of the tables. Thus, these tables present only alternative amounts of grain which may be fed with fixed amounts of

Table 14. Estimated Feed Requirement for Feeding Dairy Cows of Low Producing Ability, Using Corn Silage and Low Grain Feeding*

Butterfat	Milk	Annual Feed Requirements†				
		Corn	Oats	Corn Silage	Alfalfa-Brome Hay	Pasture
Lbs.	Lbs.	Bu.	Bu.	T.	T.	Days
		On Fair Native Pasture				
150	4285	—	—	2.7	3.0	120
200	5714	7	10	2.7	3.0	120
225	6428	9	15	2.7	3.0	120
235	6714	10	16	2.7	3.0	120
245	7000	11	18	2.7	3.0	120
255	7285	12	20	2.7	3.0	120
		On Good Brome-Alfalfa Pasture				
175	5000	—	—	2.7	3.0	120
200	5714	—	—	2.7	3.0	120
225	6428	1	2	2.7	3.0	120
235	6714	2	4	2.7	3.0	120
245	7000	4	6	2.7	3.0	120
255	7285	5	8	2.7	3.0	120
		On Excellent Brome-Alfalfa Pasture				
200	5714	—	—	2.7	2.5	120
225	6428	—	—	2.7	2.5	120
235	6714	1	3	2.7	2.5	120
245	7000	3	5	2.7	2.5	120
255	7285	4	6	2.7	2.5	120

*This table was prepared by R. A. Cave, Extension Dairyman, and Chase C. Wilson, Associate Dairyman, South Dakota Agricultural Experiment Station.

†Fifty pounds of steamed bonemeal and 35 pounds of iodized salt are required per head annually. A weight of 1200 pounds per cow is assumed.

Table 15. Estimated Feed Requirement for Feeding Dairy Cows of Medium Producing Ability, Using Corn Silage and Low Grain Feeding*

		Annual Feed Requirements†				
Butterfat	Milk	Corn	Oats	Corn Silage	Alfalfa-Brome Hay	Pasture
Lbs.	Lbs.	Bu.	Bu.	T.	T.	Days
On Fair Native Pasture						
239	6831	10	17	2.7	3.0	120
275	7857	14	24	2.7	3.0	120
300	8571	16	30	2.7	3.0	120
325	9268	18	31	2.7	3.0	120
330	9429	19	34	2.7	3.0	120
340	9714	20	35	2.7	3.0	120
On Good Brome-Alfalfa Pasture						
250	7143	4	6	2.7	3.0	120
275	7857	6	11	2.7	3.0	120
300	8571	9	16	2.7	3.0	120
325	9268	12	20	2.7	3.0	120
330	9429	12	21	2.7	3.0	120
340	9714	13	23	2.7	3.0	120
On Excellent Brome-Alfalfa Pasture						
264	7551	—	—	2.7	3.0	120
275	7857	1	2	2.7	3.0	120
300	8571	4	6	2.7	3.0	120
325	9268	6	10	2.7	3.0	120
330	9429	7	12	2.7	3.0	120
340	9714	8	13	2.7	3.0	120

*This table was prepared by R. A. Cave, Extension Dairyman, and Chase C. Wilson, Associate Dairyman, South Dakota Agricultural Experiment Station.

†Fifty pounds of steamed bonemeal and 35 pounds of iodized salt are required per head annually. A weight of 1200 pounds per cow is assumed.

Table 16. Estimated Feed Requirement for Feeding Dairy Cows of High Producing Ability, Using Corn Silage and Low Grain Feeding*

		Annual Feed Requirements†				
Butterfat	Milk	Corn	Oats	Corn Silage	Alfalfa-Brome Hay	Pasture
Lbs.	Lbs.	Bu.	Bu.	T.	T.	Days
On Fair Native Pasture						
350	10000	23	40	3.0	3.0	120
400	11429	30	50	3.0	3.0	120
450	12859	34	60	3.0	3.0	120
470	13429	36	63	3.0	3.0	120
475	13571	36	63	3.0	3.0	120
On Good Brome-Alfalfa Pasture						
350	10000	16	28	3.0	3.0	120
400	11429	21	38	3.0	3.0	120
450	12859	27	47	3.0	3.0	120
470	13429	29	50	3.0	3.0	120
475	13571	30	52	3.0	3.0	120
On Excellent Brome-Alfalfa Pasture						
350	10000	12	21	3.0	3.0	120
400	11429	16	28	3.0	3.0	120
450	12859	21	37	3.0	3.0	120
470	13429	23	40	3.0	3.0	120
475	13571	24	41	3.0	3.0	120

*This table was prepared by R. A. Cave, Extension Dairyman, and Chase C. Wilson, Associate Dairyman, South Dakota Agricultural Experiment Station.

†Fifty pounds of steamed bonemeal and 35 pounds of iodized salt are required per head annually. A weight of 1200 pounds per cow is assumed.

Table 17. Estimated Feed Requirements for Feeding Cows of Low Producing Ability, Using Alfalfa Silage and Low Grain Feeding*

		Annual Feed Requirements†				
Butterfat	Milk	Corn	Oats	Alfalfa Silage	Hay	Pasture
Lbs.	Lbs.	Bu.	Bu.	T.	T.	Days
On Fair Native Pasture						
150	4285			7.5	1	120
200	5714			8.0	1	120
225	6428			8.5	1	120
235	6714			8.5	1	120
245	7000			8.5	1	120
255	7285			8.5	1	120
On Good Brome-Alfalfa Pasture						
150	4285			6.5	1	120
200	5714			6.5	1	120
225	6428			7.0	1	120
235	6714			7.0	1	120
245	7000			7.0	1	120
255	7285			7.5	1	120
On Excellent Brome-Alfalfa Pasture						
200	5714			6.5	.6	120
225	6428			7.0	.6	120
235	6714			7.0	.6	120
245	7000			7.0	.6	120
255	7285			7.5	.6	120

Table 18. Estimated Feed Requirements for Feeding Dairy Cows of Medium Producing Ability, Using Alfalfa Silage and Low Grain Feeding*

		Annual Feed Requirements†				
Butterfat	Milk	Corn	Oats	Alfalfa Silage	Hay	Pasture
Lbs.	Lbs.	Bu.	Bu.	T.	T.	Days
On Fair Native Pasture						
239	6831	—	—	8.5	1	120
275	7857	2	3	8.5	1	120
300	8571	4	7	8.5	1	120
325	9268	7	13	8.5	1	120
330	9429	8	14	8.5	1	120
340	9714	9	16	8.5	1	120
On Good Brome-Alfalfa Pasture						
250	7143	—	—	7.5	1	120
275	7857	2	2	7.5	1	120
300	8571	4	7	7.5	1	120
325	9268	6	11	7.5	1	120
330	9429	7	12	7.5	1	120
340	9714	8	14	7.5	1	120
On Excellent Brome-Alfalfa Pasture						
264	7551	—	—	7.5	1	120
275	7857	1	1	7.5	1	120
300	8571	3	4	7.5	1	120
325	9268	4	7	7.5	1	120
330	9429	5	8	7.5	1	120
340	9714	5	9	7.5	1	120

*This table was prepared by R. A. Cave, Extension Dairyman, and Chase C. Wilson, Associate Dairyman, South Dakota Agricultural Experiment Station.

†Fifty pounds of steamed bonemeal and 35 pounds of iodized salt per year are needed for each head. A weight of 1200 pounds per cow is assumed.

Table 19. Estimated Feed Requirements for Feeding Dairy Cows of Higher Producing Ability, Using Alfalfa Silage and Low Grain Feeding*

		Annual Feed Requirements†				
Butterfat	Milk	Corn	Oats	Alfalfa Silage	Hay	Pasture
Lbs.	Lbs.	Bu.	Bu.	T.	T.	Days
		On Fair Native Pasture				
350	10,000	13	23	8.5	1	120
400	11,429	19	33	8.5	1	120
450	12,859	24	42	8.5	1	120
470	13,429	27	47	8.5	1	120
475	13,571	27	47	8.5	1	120
		On Good Brome-Alfalfa Pasture				
350	10,000	13	22	7.5	1	120
400	11,429	18	31	7.5	1	120
450	12,859	23	40	7.5	1	120
470	13,429	25	44	7.5	1	120
475	13,571	25	44	7.5	1	120
		On Excellent Brome-Alfalfa Pasture				
350	10,000	8	14	7.5	1	120
400	11,429	12	21	7.5	1	120
450	12,859	17	30	7.5	1	120
470	13,429	19	34	7.5	1	120
475	13,571	19	34	7.5	1	120

*This table was prepared by R. A. Cave, Extension Dairyman, and Chase C. Wilson, Associate Dairyman, South Dakota Agricultural Experiment Station.

†Fifty pounds of steamed bonemeal and 35 pounds of iodized salt per year are needed for each head. A weight of 1200 pounds per cow is assumed.

Table 20. Estimated Annual Amounts of Feed for Dairy Cows with Low Producing Ability, Using Corn Silage and High Grain Feeding

		Annual Amounts of Feed per Cow*					
Butterfat	Milk	Corn	Oats	Protein Supplement	Corn Silage	Hay	Pasture
Lbs.	Lbs.	Bu.	Bu.	Lbs.	T.	T.	Days
		On Fair Native Pasture					
150	4285	—	—	—	2.5	2.8	120
200	5714	9	17	114	2.5	2.7	120
225	6428	17	30	226	2.5	2.4	120
235	6714	20	36	267	2.5	2.3	120
245	7000	28	48	361	2.5	1.9	120
255	7285	38	66	497	2.5	1.4	120
		On Good Brome-Alfalfa Pasture					
175	5000	—	—	—	2.5	2.8	120
200	5714	6	10	75	2.5	2.6	120
225	6428	9	15	112	2.5	2.4	120
235	6714	12	22	161	2.5	2.3	120
245	7000	18	33	245	2.5	2.0	120
255	7285	28	49	368	2.5	1.5	120

*Fifty pounds of steamed bonemeal and 35 pounds of iodized salt per year are needed for each head. A weight of 1200 pounds per cow is assumed.

roughage. These rations do not show the possibilities for substituting forages for concentrates or vice versa. If price data are applied to these physical production data, which assume constant forage consumption, then maximum grain feeding and milk production appear profitable for most price levels and price relationships. Moreover, the level of concentrate feeding may not be high enough to obtain the indicated levels of production and may need adjustment to fit actual dairy feeding conditions.

Dairy cow rations with variable amounts of both grain and forage are presented in Tables 20 through 22. These tables show the possibilities for substituting forages for concentrates and vice versa. This set of tables is useful for budgeting alternative feeding programs which utilize more or less forage. However, the level of concentrate feeding may be higher than the amount needed to obtain the indicated levels of production. Therefore, the level of concentrate feeding may need adjustment to fit actual dairy feeding conditions.

Estimated annual amounts of feed needed for cows with low, medium, and high producing abilities weighing 1200 pounds are given in the tables. A range in milk and butterfat production is given for each of the three production levels to correspond with a range of grain and forage feeding. The milk or butterfat produced by cows at each level of production and fed any given amount of feed is assumed to contain at least 3.5 percent butterfat.

Cows weighing less than 1200 pounds but having the same milk producing ability would require less feed than the amounts indicated in these tables. Similarly, cows weighing more than 1200 pounds would require more feed to produce the same amounts of milk. This is accounted for by the fact that the amount of

Table 21. Estimated Annual Amounts of Feed for Dairy Cows with Medium Producing Ability, Using Corn Silage and High Grain Feeding

		Annual Amounts of Feed per Cow*					
Butterfat	Milk	Corn	Oats	Protein Supplement	Corn Silage	Hay	Pasture
Lbs.	Lbs.	Bu.	Bu.	Lbs.	T.	T.	Days
		On Fair Native Pasture					
239	6831	—	—	—	3	3.2	120
275	7857	5	10	71	3	3.2	120
300	8571	14	25	186	3	2.8	120
325	9268	27	47	354	3	2.5	120
330	9429	30	53	400	3	2.3	120
340	9714	38	66	497	3	1.5	120
		On Good Brome-Alfalfa Pasture					
250	7143	—	—	—	3	2.7	120
275	7857	4	6	48	3	2.6	120
300	8571	11	19	143	3	2.3	120
325	9268	21	37	277	3	2.2	120
330	9429	24	42	313	3	1.8	120
340	9714	32	55	415	3	1.3	120

*Fifty pounds of steamed bonemeal and 35 pounds of iodized salt per year are needed for each head. A weight of 1200 pounds per cow is assumed.

Table 22. Estimated Annual Amounts of Feed for Dairy Cows with High Producing Ability, Using Corn Silage and High Grain Feeding

		Annual Amounts of Feed per Cow*					
Butterfat	Milk	Corn	Oats	Protein Supplement	Corn Silage	Hay	Pasture
Lbs.	Lbs.	Bu.	Bu.	Lbs.	T.	T.	Days
On Fair Native Pasture							
350	10000	15	26	199	3.3	2.5	120
400	11429	28	48	362	3.3	1.9	120
450	12859	42	74	555	3.3	1.6	120
470	13429	49	87	650	3.3	1.4	120
475	13571	54	95	712	3.3	1.2	120
On Good Brome-Alfalfa Pasture							
350	10000	12	21	157	3.3	1.9	120
400	11429	23	41	307	3.3	1.6	120
450	12859	37	65	485	3.3	1.5	120
470	13429	44	77	577	3.3	1.3	120
475	13571	48	84	627	3.3	1.1	120

*Fifty pounds of steamed bonemeal and 35 pounds of iodized salt per year are needed for each head. A weight of 1200 pounds per cow is assumed.

feed needed for maintenance varies according to the size of the animal.

The hay in the rations is assumed to be high-quality hay containing 70 percent or more legumes. The amount of roughage in all rations includes an allowance of 10 percent for feeding losses.

It is assumed that each cow on pasture during the 120-day pasture season will obtain digestible nutrients at a daily rate of 8 pounds from the native pastures and 13 pounds from the alfalfa-brome pastures. If the pasture contributes a greater amount of digestible nutrients, then less grain and protein supplement would be necessary to obtain the corresponding level of milk production. If, on the other hand, the pasture yields less than the assumed amount of nutrients, the diet would have to be supplemented with grass or corn silage, high quality hay, or more grain and protein supplement to maintain the milk production levels indicated.

Normally, the dairyman can obtain greater milk production with the same quantity of grain, or he can obtain the same milk production with less grain by varying the rate of feeding during the lactation period. Grain and protein supplement should be fed so that the heaviest rate of feeding comes when lactation is greatest. The rate of feeding grain and protein supplement may be reduced to little or none during the late stages of lactation depending upon the physical condition of the cow.

The combination of grain, protein supplement, and forage which the dairyman should use is the one which will obtain the greatest return above feed cost. Table 29 demonstrates the income advantage in having high producing dairy cows at the present price levels. Besides being more efficient, high producing dairy cows represent an opportunity to utilize more forages because they have the ability to utilize larger amounts of feed than low producing animals of the same weight. However, an important consideration would be the cost of obtaining high quality cows.

Rations for Replacement Stock

An estimated annual ration for replacement stock and the dairy bull is given in Table 23. Other feed combinations and feeding rates may be substituted in place of those indicated in this table.

Substitution Possibilities

Reduced costs of production or increased profit margins will accrue to the dairy enterprise whenever milk or butterfat production can be maintained by substituting low-cost for high-cost feeds in dairy rations.

Alfalfa hay may be substituted for silage at the rate of 1 pound of hay for each 2.5 pounds of silage.

Wet sugar beet pulp may be substituted for corn silage at the rate of 2 pounds of beet pulp for each pound of silage.

Other feed grains may be substituted for corn and oats (see Feed Substitution Table on page 4) as long as the concentrate ration contains approximately 75 percent digestible nutrients. Grains in the concentrate ration should be the cheapest ones which will supply the amount of nutrients needed.

Commercial feeds may be substituted for the concentrate ration listed in these tables. The cost of using commercial feeds should be considered because ordinarily farm-grown feeds will be cheaper.

Table 23. Estimated Annual Amounts of Feed Needed for Replacement Stock and Dairy Bull

	Annual Feed Requirements						
	Milk	Skim Milk	Corn	Oats	Alfalfa Hay	Iodized Salt	Pasture
	Lbs.	Lbs.	Bu.	Bu.	T.	Lbs.	Days
Veal calves (fed to 180 lbs.)	1300	—	0.5	0.5	—	—	—
Calves (birth to 12 months)*	240	720	6	10	0.5	5	50
Yearlings (12 to 24 months.)		—	3	5	1.5	10	120
Bull		—	15	30	3.0	20	—

*Fall freshening is assumed.

Poultry Rations

THE POSSIBILITIES of substituting forages for grain in poultry rations are limited. Home-mixed feeds can be substituted for commercially prepared feeds, or one feed grain for another. The profitability of these two substitutions depends upon the results obtained from the commercial feeds and home-mixed feeds, the difference in cost, and the relative feeding and market values of the various feed grains.

Estimated amounts of feed needed to obtain given levels of egg production in the poultry enterprise will enable the poultryman to anticipate, according the the cost of feed and the price of eggs, whether it will be profitable to raise poultry; and if so, what quality diet and quantity of feed should be fed for the most profitable level of egg production.

Rations for Egg Production

Some of the more important factors which govern the relationship between feed inputs and the output of eggs are: (1) the feeding rate, (2) the quality of feed, (3) the type of breed, (4) the health of the hens, and(5) housing and management.

Feeding the proper amount of a good diet is important in making poultry raising a profitable farm enterprise. Egg production decreases rapidly as the rate of feeding is reduced from full feed. Hens fed at 90 percent of full feed produce only about 70 percent as many eggs as hens on full feed. Less feed is needed to produce a dozen eggs at full feed than at various levels of limited feeding.

The diet for laying hens should contain water and the proper kinds and amounts of energy sources, vitamins, protein, and minerals. A deficiency of any of the essential dietary elements will result in reduced egg production. Laying hens need a full quota of all nutrients to maintain health, body weight, and maximum feed efficiency and egg production.

High quality hens are essential in obtaining high, profitable egg production. Light breeds of chickens will usually produce more eggs on less feed than heavy breeds.

Estimated amounts of grain and mash needed per year for 100 hens of both light and heavy breeds are presented in Table 24. These annual feed estimates are specified for three different diets. A range in annual egg production is given for each feeding rate and diet to allow for variations in the effective use of these feeding practices and other important flock management practices, such as, good housing, culling, and disease control which may affect egg production to a large extent.

The diets contain the following proportions of ingredients by weight:

	Corn %	Oats %	Mash %
Diet A	25	25	50
Diet B	40	26	34
Diet C	50	50	---

A higher quality of laying mash is used in Diet A than in Diet B. The formula for each grade of mash is given in Table 25. Diets B and C contain no vitamin supplement and Diet C contains no laying mash. Each diet should be supplemented with 300 pounds of oyster shells and 100

Table 24. Estimated Amounts of Feed per Year for Each 100 Hens

Diet and Rate of Feeding	Estimated Annual Egg Production Per 100 Hens	Estimated Annual Feed Needed for Each 100 Hens Corn	Oats	Mash	Pounds of Feed per Dozen Eggs Average Total Production
	Doz.	Bu.	Bu.	Lbs.	Lbs.
Light Breeds 4—4½ Pounds					
Diet "A"*					
Full feed	1420–1500	39	69	4400	6.0
90% of full feed	1150–1230	35	62	3900	6.6
80% of full feed	810–890	31	54	3500	8.2
Diet "B"*					
Full feed	1380–1440	62	71	3000	6.2
90% of full feed	1040–1120	56	64	2700	7.3
80% of full feed	780–840	50	57	2400	8.7
Diet "C"*					
Full feed	400–600	58	109	—	13.5
90% of full feed	300–500	52	98	—	15.1
80% of full feed	200–400	46	87	—	17.9
Heavy Breeds 5—5½ Pounds					
Diet "A"*					
Full feed	1320–1400	44	77	4900	7.2
90% of full feed	990–1070	39	69	4400	8.5
80% of full feed	750–830	35	62	3900	9.9
Diet "B"*					
Full feed	1280–1360	70	80	3300	7.4
90% of full feed	960–1040	63	71	3000	8.8
80% of full feed	730–810	56	63	2700	10.2
Diet "C"*					
Full feed	400–600	66	125	—	15.4
90% of full feed	300–500	59	112	—	17.2
80% of full feed	200–400	53	100	—	20.6

*Each diet should be supplemented with 300 pounds of oyster shells and 100 pounds of granite grit per year for each 100 hens. The contents of the mashes in diets A and B are given in Table 25.

Table 25. Laying Mash Formulas for Diets A and B

Diet "A" Mash (20% Protein)*	%	Lbs./T.	Diet "B" Mash (26% Protein)	%	Lbs./T.
Ground yellow corn	30	600	Wheat bran	20	400
Ground oats	10	200	Wheat middlings	20	400
Wheat standard middlings	20	400	Ground oats	20	400
Wheat bran	10	200	Meat scraps	20	400
Fish meal	2	40	Soybean meal	13	260
Meat scraps	5	100	Alfalfa meal	5	100
Soybean meal	14	280	Salt mix†	1	20
Dried buttermilk	2	40	Fish oil‡	1	20
Steamed bonemeal	2	40	Total	100	2000
Alfalfa meal	3	60			
Salt mix†	1	20			
Fish oil‡	1	20			
Total	100	2000			

*A vitamin supplement containing 2 grams of riboflavin and 5 milligrams of vitamin B_{12} per ton should be furnished.
†A mixture of 39 pounds of iodized salt and 1 pound of manganese sulfate.
‡Fish oil should contain at least 300 units of vitamin D and 750 Units of vitamin A per gram.

pounds of granite grit per year for each 100 hens.

Rations for Fryer (Broiler) and Pullet Production

The heavy chicken breeds are the most efficient for meat production and require less feed for each pound of gain than light breeds. Male birds of both heavy and light breeds make faster and more efficient gains than female birds.

Estimated amounts of feed needed to raise 100 fryers or pullets for both light and heavy breeds to specified weights are presented in Table 26. A starter mash should be used until the chicks are eight weeks old. After eight weeks, the chicks may be fed equal parts of growing mash and grain. The proper use of a vitamin-antibiotic supplement in both starting and growing mashes will increase the feed efficiency and rate of growth in chicks.

Table 26. Estimated Total Amount of Feed to Raise 100 Fryers or Pullets to Specified Weights

Weight	Light Breeds		Heavy Breeds	
	Male	Female	Male	Female
Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
2.0	600	700	500	600
2.5	800	900	650	750
3.0	1000	1200	900	1000
3.5	1400	1700	1200	1400
4.0	--------	2100*	—	1800
4.5	--------	—	—	2400*

*Approximate replacement age: 25 weeks. Pullets normally reach laying maturity in 25 weeks or less. The contents of chick starter and growing mashes are given in Table 27.

Chick starter and growing mash formulas are given in Table 27. The growing mash for chicks over eight weeks old should be supplemented with equal parts of grain and a free choice of oyster shells and granite grit.

Substitution Possibilities

Any commercial laying or chick mash which contains the ingredients or their equivalent as indicated in the mash formulas may be used, or the

Table 27. Chick Starter and Growing Mash Formulas

Starter Mash (20% Protein)*	%	Lbs./T.	Growing Mash (20% Protein)†‡	%	Lbs./T.
Ground yellow corn	40.0	800	Ground yellow corn	25	500
Ground oats	15.0	300	Ground oats	15	300
Wheat flour middlings	5.0	100	Wheat standard middlings	15	300
Wheat standard middlings	5.0	100	Wheat bran	10	200
Meat scraps	5.0	100	Meat scraps	5	100
Fish meal	2.5	50	Soybean meal	15	300
Soybean meal	19.0	380	Alfalfa meal	10	200
Dried buttermilk	2.5	50	Steamed bonemeal	4	80
Alfalfa meal	3.0	60	Salt mix§	1	20
Steamed bonemeal	1.0	20	Total	100	2000
Ground limestone	1.0	20			
Salt mix§	0.5	10			
Fish oil‖	0.5	10			
Total	100.0	2000			

*A vitamin-antibiotic supplement containing 1 gram riboflavin, 3 milligrams of vitamin B_{12} and 2 grams of penicillin per ton should be furnished.
†A vitamin-antibiotic supplement containing 3 milligrams vitamin B_{12} and 2 grams of penicillin per ton should be furnished.
‡The growing mash should be fed with equal parts of grain to birds over eight weeks old on green range.
§A mixture of 39 pounds of iodized salt and 1 pound of manganese sulfate.
‖Fish oil should contain at least 300 units of vitamin D and 750 units of vitamin A per gram.

mash may be mixed on the farm using the ingredients or their equivalent as listed in Tables 25 or 27.

If liquid skim milk is available, it may be substituted for part, or, in some cases, for all of the meat scraps in either laying or chick mashes at the rate of 1 gallon for each pound of meat scraps.

Oats may be replaced by wheat, milo, millet or barley and corn may be replaced by wheat or milo, on a pound for pound basis, in either laying or chick mashes.

The Whole Farm Approach to Ration Selection

In recent years the need for more grasses and legumes and more livestock in the production pattern on South Dakota farms has been stressed. If more grasses and legumes are grown, farmers will be faced with the problem of deciding what combination of livestock enterprises and feeding practices will efficiently utilize the additional forages produced. In planning livestock programs that utilize more forages, farmers need to know how much forage they can economically use in livestock rations.

Production of forages and their use in livestock rations will be profitable only as long as the net income from the entire farm is increased. The effect upon net farm income will depend upon: (1) the productive capacity of the farm, (2) the effect which growing more legumes in crop rotations has upon total grain production, (3) how well the crop and livestock programs are fitted to each other, (4) the effect which various proportions of forages in livestock rations have upon livestock production, (5) the value of grain and forage in alternative livestock enterprises or on the market, and (6) the market grade and price of livestock and livestock products in relation to feed costs. Therefore, both crop and livestock enterprises must be considered together in examining the income effects from greater forage utilization.

Forage utilization is not a problem whenever the use of legumes increases the total amount of grain produced on the farm, provided tenure conditions permit farmers to realize the benefits from using legumes in rotations. Legumes are then "complementary" to grain production; and even if the farmer plowed the legumes under, the use of legumes would be profitable as long as the value of the increased amount of grain produced at least covered the cost of the legume seed and planting expenses.

The complementary effect of legumes depends upon the soil type and its fertility level. It is usually recommended that soil fertility should be maintained at some desirable or optimum producing level. The use of legumes (properly supplemented by other fertilizer treatments) for this purpose may not result in greater total grain production; but rather, in maintaining a stable, high level of grain production. In either case, the additional forage produced could be sold or it could be fed to roughage consuming livestock to increase income still further.

Efficient utilization of forage becomes important when legumes compete with grains for the use of the land. When the number of acres in legumes is increased beyond a certain proportion, the total production of grain on a farm will decline even though the yield per acre has increased. This is true simply because: as the number of acres in grain production is decreased, yields per acre will not be increased enough to compensate for the reduced acreage in grain crops. But it will be profitable to increase legume production at the expense of total grain production if the additional forage can be utilized so that net income from the entire farm is increased above the amount that could be achieved by growing more grain and less forage. This depends upon crop and livestock programs that are carefully fitted to each other.

The effect of legumes on grain production can be illustrated by data in Table 28 which show the probable effect of legumes on corn and oat yields and total grain production

Table 28. Estimated Effects of Varying Amounts of Forage on Crop Yields*

	Acres of Land Out of 100 Acres in			Per Acre Yield of			Total Annual Production per 100 Acres		Hay Gained per Ton of Grain
	Forage	Corn	Oats	Corn	Oats	Hay	Grain	Hay	Sacrificed
Rotation†	A.	A.	A.	Bu.	Bu.	T.	T.	T.	T.
1. CO (Brookings County)	0	50	50	31‡	37‡	—	73	—	—
2. COCOCOCOS	11	44	44	45	51	—	92	---§	Comp.¶
3. COCOCOS	14	43	43	47	53	—	93	---§	Comp.¶
4. COCOA	20	40	40	50	56	2.0	92	33‖	33.0
5. COCOAA	33	33	33	53	59	2.0	80	55‖	1.8
6. COCOAAA	43	28	28	53	59	2.0	69	72‖	1.5
7. COCOAAAA	50	25	25	52	59	2.0	60	88‖	1.8

*Estimated effects of legumes on crop production per 100 acres on Barnes loam in eastern South Dakota under excellent management and with weather similar to that of 1943-50. These estimates were prepared in cooperation with several members of the Agronomy Department. It was assumed: (1) that the rotations have been established long enough to show the major effects of the legumes in the rotation, except in rotation 1 where the yields are expected to decrease in the future; (2) that the alfalfa-brome would stand three years in rotations 4 and 5 before being moved to another field; (3) that enough phosphate is applied to the rotations to avoid limiting effects on crop yields; and (4) that the sweet clover crop and the second crop of the last year of alfalfa is plowed under in late summer; (5) that 2.5 bushels of sweet clover seed and 1 ton of alfalfa hay is harvested before the last crop is plowed under.

†C=corn; O=oats; S=sweet clover; A=alfalfa-brome.

‡For comparison purposes, and as a starting point, the average corn and oats yield per planted acre for 1943-50 was used in rotation 1. It is not assumed that these yields will remain at this level in the future .

§No hay is harvested, but 2.5 bushels of sweet clover seed per acre can be expected.

‖These figures do not agree with acreage and yield columns because the last crop of alfalfa-brome in the final year is not harvested but plowed under. One ton of hay is harvested as a first crop in the last year.

¶Complementary. No grain was sacrificed even though the acres of forage increased. The legumes stimulated or "complemented" the grain production per 100 acres.

per 100 acres of Barnes loam cropland in eastern South Dakota. The effect of legumes upon grain production might be less in central and western South Dakota because of a more limited rainfall. Nevertheless, these data demonstrate the probable effects and some of the factors which must be examined in deciding whether to grow more or less legumes.

For instance, Rotation 3 in which 14 out of every 100 acres are seeded to legumes (14 percent legumes) will produce 20 tons more grain per 100 acres than Rotation 1. Rotation 3 with 14 percent legumes is therefore more profitable than Rotation 1 or 2 since it greatly increases total grain production.

Rotation 4 with 20 percent legumes is also clearly profitable. Even though Rotation 4 results in 1 ton of grain less in total grain production than Rotation 3, it produces 33 tons of alfalfa-brome hay instead. Just how profitable Rotation 4 will be depends upon the market value of the 33 tons of legume hay in relation to the market value of the ton of grain sacrificed in producing it, or upon how efficiently the legume hay is utilized in livestock production.

At 1952 average prices for corn ($1.40 per bushel) and baled hay ($18 per ton) the market value of 33 tons of legume hay would be $549 and the market value of 1 ton (36 bushels) of corn would be $50.40. The difference between the market value of 33 tons of legume hay and 1 ton of corn would represent the addition to gross farm income from using Rotation 4 in grain crop production. The addition to net farm income would not be correspondingly as large as the addition to gross income because the cost of producing and marketing 33 tons of legume hay could be expected to be greater than the cost of producing and marketing 1 ton of corn. Thus, Rotation 4 with 20 percent legumes is clearly profitable even though complete cost data have not been computed. There is no particular need to calculate costs carefully when the income advantage from using Rotation 4 instead of Rotation 3 is as obvious as it is here. It is also obvious that around 20 percent legumes on Barnes loam cropland in Brookings County will be profitable over a period of years even if the legume hay produced is not used for feed.

However, a farmer may be able to increase net income still further by utilizing the forage for livestock now on the farm or in feeding additional roughage-consuming livestock. The dairy farmer, for example, could increase his returns above feed cost at 1952 prices and utilize more forage by replacing low producing cows with high producing cows which also have the ability to consume larger amounts of feed. This relationship can be seen in Table 29 which shows 1953 production, feed consumption, and returns above feed costs at various production levels for dairy cows in the South Dakota Dairy Herd Improvement Associations.

Livestock rations which include large amounts of legume forages may not be profitable on a *whole farm basis* if the production of the required amounts of forage causes a sharp drop in total grain production. For instance, if a farmer should employ Rotation 5 with 33 percent legumes, the efficient utilization of the additional legume hay produced becomes very important, because 1 ton of grain will be sacrificed for each additional 1.8 tons of legume hay produced. Here, assuming the costs of producing 1.8 tons of legume hay or 1 ton of grain are equal, the feed value or selling price of 1.8 tons of legume hay must equal or exceed the feed value or selling price of 1 ton of grain, if Rotation 5 is to be profitable.[2]

Based upon a cash crop farming system and 1952 average prices for alfalfa, corn, and oats, Rotation 5 would not be profitable because a gross crop income of $50 from corn or $48 from oats would be sacrificed for each $32 in gross income gained from the sale of the additional legume hay produced. The loss in gross income on 100 acres of Barnes loam cropland would be $181. However, Rotation 5 might be made profitable on a livestock-grain farm by substituting forages for grain and protein supplement in livestock rations.

Ordinarily, farmers produce their entire supply of forage. If it is assumed that the farmer in this illustration can efficiently utilize the additional legume forage produced by employing Rotation 5, then the profitability of Rotation 5 would have to be determined by means of a complete farm budget that included all farm enterprises. It is possible that a budget analysis might show that Rotations 6 and 7 could also be profitably employed. However, it is very likely that the livestock enterprise would have to be expanded with the use of Rotations 6 or 7. In this event, adequate housing facilities and the additional labor

[2]The estimated yield data used to illustrate the effect of legumes on grain crop production is for level Barnes loam soil where erosion is not a serious problem. Where erosion is serious, rotations with large proportions of legumes may be necessary and may prove to be profitable in the long run.

Table 29. Feed Costs for Producing Milk and Value of Product Above Feed Costs*

Butterfat* Production (Range)	No. Records	Average Production			Annual Amounts of Feed§						Feed Cost Total	Milk and Fat Value Above Feed Cost
		Milk	Butterfat	Value‡	Pasture	Hay	Silage	Protein Supplement	Corn	Oats		
Lbs.		Lbs.	Lbs.		Days	T.	T.	Lbs.	Bu.	Bu.		
175-224	90	4,756	208	$210.00	120	1.4	3.6	......	17	32	$107.00	$103.00
225-274	248	6,705	255	$269.00	120	1.4	3.6	......	18	33	$109.00	$160.00
275-324	846	8,586	299	$356.00	120	1.4	3.6	......	22	40	$120.00	$236.00
325-374	741	9,545	349	$391.00	120	1.5	3.7	......	22	40	$124.00	$267.00
375-424	429	10,832	396	$436.00	120	1.7	4.3	100	23	42	$142.00	$294.00
425-474	196	11,957	441	$503.00	120	1.7	4.3	175	28	50	$155.00	$348.00
475-524	56	13,265	492	$587.00	120	1.7	4.3	250	30	54	$163.00	$424.00

*This table was prepared by R. A. Cave, Extension Dairyman, and Chase C. Wilson, Associate Dairyman, South Dakota Agricultural Experiment Station.

†These production data are from approximately 2,600 cows located in the eastern half of South Dakota and in the Black Hills area. These cows are in herds which were enrolled in Dairy Herd Improvement Associations in 1953.

‡The milk from these cows was marketed in different forms. Some of it was sold as cream to butter making plants with the skim milk being fed on the farm. Some was sold to cheese plants while some went into Grade A milk channels to be consumed as fluid milk. Thus the average selling price from one group to the next may vary somewhat.

§Average prices used were: corn $1.40 per bushel; oats $0.77 per bushel; soybean oilmeal as protein supplement $5.00 per hundred pounds; baled alfalfa hay $18.00 per ton; and silage (corn or grass—legume) $7.00 per ton.

and capital or credit needed would be important factors to consider.

This illustration also points out the necessity for using the *whole farm approach in ration selection.* Unless the whole farm approach is used, a loss in net farm income may result through failure to recognize that the most profitable combination of livestock enterprises and feed combinations at one time will not necessarily be the most profitable combinations at another time, or through failure to recognize the effect of changing prices and price relationships. At times it might be profitable to substitute forage for grain in a previously established feed combination. This will be the case when the grain saved by doing so has greater value on the market or has greater feeding value in some other livestock enterprise than the forage replacing it. Usually a budget analysis that includes crop *and* livestock enterprises is necessary to show the value of both grain and forage in alternative livestock enterprises. A budget would also show the effect of these alternative uses of grain and forage upon labor and capital requirements and net farm income.

In summary, the proportion of land which a farmer can afford to devote to legume crops depends upon: (1) the productive capacity of the farm; (2) the effects which legumes have upon total grain production; (3) the amount of legume forage which can be economically substituted for grains and protein supplements in livestock rations; (4) the combination of livestock enterprises employed on the farm; (5) the mutual adaptation of crop and livestock production programs; and (6) the prices of the various feeds in relation to each other and in relation to the prices of livestock and livestock products. Usually, it will be profitable to substitute forage for grain in livestock rations as long as the market value of the forage is less than the market value of the grain it replaces (assuming equivalent feeding value and that relative prices reflect relative costs of production).