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Roughage Production in New Hampshire

An Economic Study

BY M. F. ABELL

UNIVERSITY OF NEW HAMPSHIRE
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ROUGHAGE PRODUCTION IN NEW HAMPSHIRE

An Economic Study

By M. F. Abell

A sufficient and suitable supply of roughage to meet the demands of the dairy herd on each farm is fundamental to the dairy industry of the State. The raising of this roughage is an integral part of the dairy enterprise. It therefore involves the whole farm organization and makes necessary the study of the problems as to what forage crops to raise, and the methods used for their economic production and handling.

SOURCE OF MATERIAL

The material for this study was obtained by personal survey on 81 farms for the crop year 1928 and on 247 for 1929, a total of 328 farms, distributed throughout the State. Of these farms, 281 grew silage corn. Some of the pertinent facts on these farms are given in Table 1. It was not the intent to obtain simple enterprise costs of production for hay and for silage except as incidental to the whole question of what roughage to grow and how. Since some of the costs such as land use, building use, are common to all farms and can be varied only with difficulty, they were omitted from the analysis.

Those costs which can be modified by changes in practices or methods are extremely important and have been stressed. Some of these methods, however, involve so many changes, reaching through the type and amount of equipment even to harnesses, as well as to type of storage space that they are difficult to carry out especially on some farms.

TABLE I. *Number of farms, areas and amount of roughage with numbers of stock on the 328 farms included in the survey of which 281 grew silage.*

	Hay only	Hay and silage	Total
Number of farms	47	281	328
Area in roughage	97.4	55.2	69.2
Area in hay	97.4	47.7	62.8
Yield of hay	125.2	69.2	83.7
Area in silage		7.5	6.4
Yield of silage		87.4	74.9
Number of cows	22.7	21.1	21.4
Number of young stock	14.4	13.1	13.3
Hay per cattle unit	3.26	1.78	2.97
Silage per cattle unit		3.16	2.67

I. WHAT ROUGHAGE SHOULD BE GROWN?

Silage:

The first point of attack in solving the question of what roughage to grow appeared to be whether or not to raise silage. There has been a marked tendency for many dairymen to give up silage production even where silos are present. It is felt, however, that this tendency was caused partly by the cost of getting corn into the silo and partly by the high milk prices of a few years ago and the consequent possibility of

producing milk with less physical inconvenience by using hay and purchased grain. The improved methods of handling silage which have been quite generally adopted in recent years have made the task of filling the silo less burdensome, and the price of milk no longer encourages the purchase of additional grain to offset the lack in quality or quantity of roughage.

Sometimes in the past, this problem has been approached by adding up all the possible costs of silage and hay, including use of land, use of buildings, and labor of operator and hired men at assumed rates per hour, and then making an arbitrary comparison of the costs of equivalent feeding units of silage and hay. But decisions based on such enterprise cost accounts are not sufficient and lead to erroneous decisions. Many of the costs involved are not cash costs. The labor and buildings may be present on the farm, horses may be idle, and equipment may be available in the neighborhood.

The most satisfactory way to determine what roughage or combinations of roughage to grow is to compare the probable results in income or convenience. The best use of available labor, horses and equipment may thus be considered, and adjustments made within the organization to handle the new combination of roughage to the best

TABLE 2. *Number of farms, areas and amounts of roughage, stock and materials of the 281 farms included in the survey raising silage.*

		Averages	
		Per farm	Per acre
Number of farms	281		
Acres hay	13403.7	47.7	
Tons hay	19445	69.2	1.45
Acres silage	2097.4	7.5	
Tons silage	24575	87.4	11.6
Number of cows	5937	21.1	
Number of young stock	3693	13.1	
Quarts seed corn—Silage	22659		10.8
Sweet Corn	262		.1
Number of men	1549	5.53	
Number of harvesters	139		
Number of tractors	118		
Number of cutters	214		
Tons manure	16441.4	58.5	7.8
Pounds of fertilizer	411395	1469	196.5
Hours of man labor	134006.5		64.0
Hay per cattle unit		1.78	
Silage per cattle unit		3.16	
Hours per ton		5.51	

advantage. This can often be made by starting with the present organization and noting the effect any change may have on added cash income and added cash expense.

Figures on the farms having silage are shown in Table 2. The farms averaged 7.5 acres of silage, equivalent to 11.9 per cent. of the total tillable area, 62.9 acres. Yield was 11.6 tons per acre or 86.7 tons of silage per farm. The farms were somewhat larger than the average, having 21 cows and 13.2 head of young stock. A part of this number,

particularly young stock, is the result of an accumulation during the years of high milk and cattle prices. The slump came too quickly for unloading to take place.

The season of 1930 was favorable to high yields of silage corn. The usual applications of some commercial fertilizer and manure were made. Some of the fertilizer was acid phosphate, applied either in the stable gutter or at planting time. A few used some complete fertilizer. Manure was applied at the rate of 19.5 tons per acre, of which it was estimated 7.8 tons were used by the crop. It required 64.0 hours of man labor and 64.5 hours of horse labor per acre to grow and harvest an acre of silage corn. Of this, 25.6 hours were used to grow and 38.6 hours to harvest the crop. On the basis of the yield obtained it required 5.5 hours each of man and horse labor per ton, or 1.9 hours to grow and 3.6 hours to harvest the crop.

On these farms production of hay and silage provided for a ration of 1.78 tons of hay and 3.16 tons of silage per cattle unit per year.

The inclusion of silage in the cropping system increases the stock-carrying capacity per acre of tillage land. This can be taken advantage of by either having a larger herd—a very important factor especially on the smaller farms—or by retaining the same sized herd, utilizing the tillage land no longer needed for roughage, for cash crops or for pasture. (Table 3.)

TABLE 3. *Cattle units per acre of roughage, and percentage of roughage area in silage.*

Cattle units per acre of roughage	Per cent. roughage acreage in silage	Cattle units per farm	Hay		Silage	
			Acres per farm	Yield in tons per acre	Acres per farm	Yield in tons per acre
.40	7.5	26.	61.6	1.16	5.4	11.2
.50	12.0	30.5	52.9	1.38	7.2	11.6
.60	17.0	37.1	51.2	1.58	10.5	11.9
.70	25.4	34.3	34.6	1.80	11.8	12.1

On the basis of the data obtained it requires about 2 acres of hay alone to feed a cow for the year. It will roughly require about ⅓ acre of silage to replace a ton of hay. For every ton of hay replaced by silage an acre of hayland is released for silage production; or for each acre of silage 3 acres of hay are released for other uses—either for cash crops or for pasture. An acre of silage has approximately three times the total digestible feed units of an acre of hay.

As may also be seen from Tables 3 and 4, yields of hay are greater where silage has been included in the rotation, and are still greater where the percentage of silage is increased. Quality is also better. This is due partly to the shorter rotation necessary and partly to the greater amount of organic matter in the manure applied for corn and from a better sod to plow under, a condition which is accumulative. The total effect of silage corn on carrying capacity of the land is shown graphically in Figure 1. A close study of the distribution of the dots in this scatter diagram shows a marked correlation between per cent. of area in silage and carrying capacity. An increase of 5 per cent. in

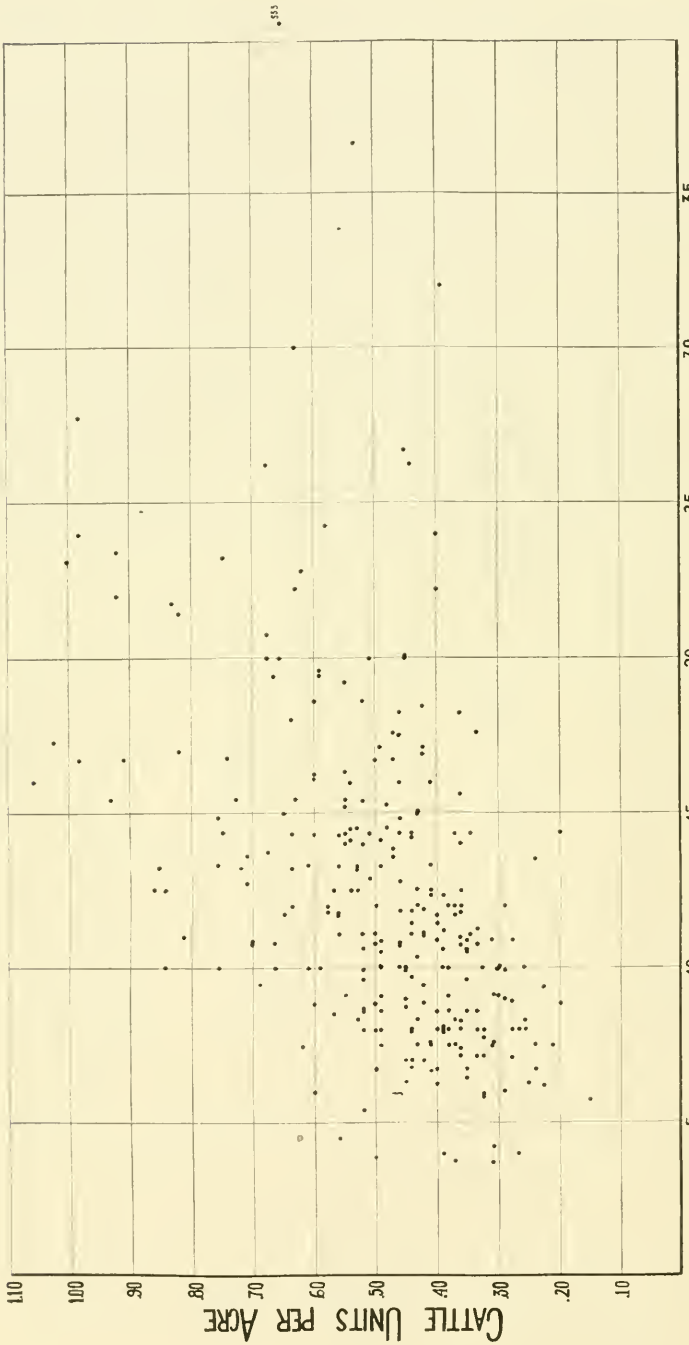

Fig. 1. Distribution of farms by cattle units per acre and percentage of roughage area in silage.

tillable area used for silage resulted in an increased carrying capacity of .2 cattle unit per acre of tillage land.

TABLE 4. *Influence of corn in rotation on yield of hay.*

Rotation	Acres hay per farm	Hay yield per acre
With corn	46.4	1.62
Without corn	44.4	1.45

It is interesting to note in Table 5 that from an enterprise cost point of view with assumed rates for labor, the cost per acre of roughage increased greatly with the increased per cent. of tillage land in silage, but that even under this comparison the cost of roughage per cattle unit tended to be lower with increased silage acreage. In other words, even though the operator could use his time and his team on the road at 40 cents an hour for his own labor and 20 cents an hour for each horse, he could still afford to grow silage.

The actual advantage of growing silage will, of course, depend on the conditions on the particular farm, the number of cows desirable, the method of replacement, the season of production of milk, the price received, the soil conditions and the size of the farm, the amount of labor available, the equipment already present on the farm or readily available in the community. In fact, all the factors of production are involved. There is the possibility of increasing the gross sales from a farm by 20 per cent. by raising silage.

Whether or not to raise silage sometimes depends on the presence or absence of a silo and of harvesting and filling equipment. However, most dairy farms have one or more silos that are in satisfactory condition or can be made so inexpensively, and through cooperation and exchange of labor may make purchase of new and additional equipment unnecessary.

When the silo is present, and machinery, harvester, blower and power are owned or readily available in the neighborhood, the decision should depend largely on the cash costs, the distribution of labor and the influence on farm organization.

TABLE 5. *Relation of cattle units per acre of roughage to percentage of roughage area in silage.*

Number of farms	Percentage of roughage area in silage	Average percentage	Ave. No. cattle units per acre of roughage	Cost of roughage per acre	Cost of roughage per cattle unit
92	3.8- 9.9	7.5	.388	$ 8.02	$33.80
97	10.0-13.9	11.5	.507	13.77	31.17
46	14.0-16.9	15.1	.601	16.69	30.74
46	17.0-53.3	22.7	.739	19.36	30.02

As indicated in Table 6, the peak in labor requirements on hay came in July and August, while the peak in silage production came

TABLE 6. *Percentage distribution of labor by months on various combinations of forage crops.*

	Hay	Hay and oats hay	Hay, oats hay and Hungarian	Hay, oats hay Hungarian and alfalfa	Hay, oats hay and silage	Hay, Hungarian and silage
Jan.	5.0	3.8	3.1	2.9	2.9	2.9
Feb.	5.3	3.9	3.0	2.9	3.0	2.9
Mar.	6.2	4.6	3.7	3.5	3.5	3.5
Apr.	6.4	9.7	10.9	10.3	8.1	7.4
May	4.5	7.2	10.0	9.6	8.8	10.0
June	4.6	3.6	3.7	5.8	7.0	7.6
July	32.0	32.5	25.2	24.7	22.4	20.2
Aug.	18.3	18.3	21.9	21.8	19.8	18.2
Sept.	5.6	5.5	8.9	8.9	8.1	11.4
Oct.	2.4	3.1	2.8	2.9	9.7	9.1
Nov.	4.3	3.7	3.2	3.0	3.4	3.3
Dec.	5.4	4.1	3.6	3.8	3.3	3.5
	100.0	100.0	100.0	100.0	100.0	100.0

in spring and September so that there is no serious competition in labor requirements. Thus, the regular labor available for hay production could, in addition, produce silage. A study of the individual records shows that the labor side of the crop can usually be taken care of almost entirely from within the farm organization, either with the labor already available or by exchange with neighbors, involving no direct cash outlay.

A comparison of Figures 2 and 3 indicates that the labor on a combination of hay and silage is much better distributed than on hay

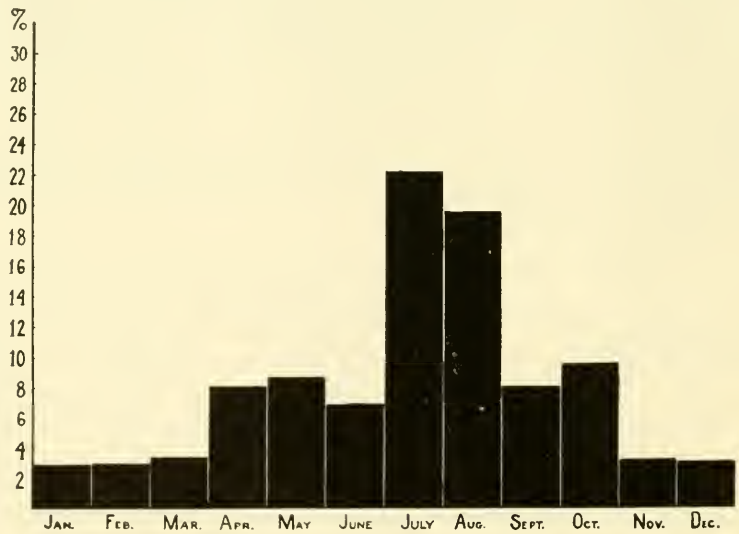

FIG. 2. Percentage distribution of labor on hay, oats hay and silage.

alone, and with the available labor in mind the combination could be grown with less extra hired labor than hay alone. The available labor would work more total hours, but the peak requirements for labor would be less.

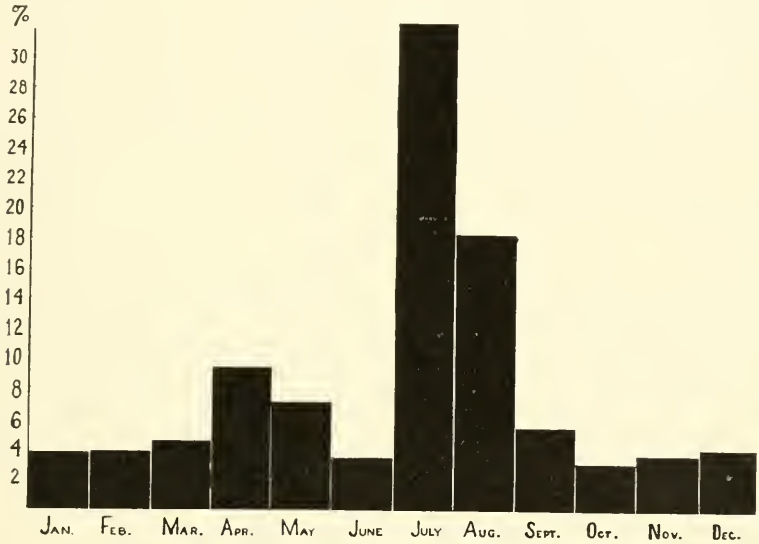

FIG. 3. Percentage distribution of labor on hay and oats hay.

As shown in Table 7 the cash out-of-pocket costs in producing silage are not large. On those farms raising corn for silage, 10.8 quarts of seed costing $1.57 were used per acre. In addition $5.31 was paid for 312 pounds of fertilizer, and $2.30 was the cash outlay for gas, oil and repairs for tractor operation up to harvesting, or $9.18 total cash outlay in growing costs per acre.

Twine cost $.62 per acre, gas and oil for silo-filling $1.02 and miscellaneous costs, knives, parts, repairs, etc., $.19, or a total harvesting cost of $1.83 per acre. The total cash costs for raising and harvesting were $11.01 per acre, or $.94 per ton exclusive of labor, taxes and insurance. This is approximately $1.00 cash outlay per ton of silage.

The situation can best be studied from the effects on income in the case of a particular farm. With 50 acres of tillage land devoted to the raising of hay only for the dairy, this study indicates that it would be possible to maintain a herd of 24.5 cows. It would require 565 hours of labor to harvest this area in hay, and either extra hired labor would be necessary at harvest or a poorer quality of hay would result from a harvest season long enough to permit the regular labor to handle it.

With silage in the cropping system the labor required for the care of the cows would be adequate to handle the roughage production and harvest, but with hay alone some extra labor would have to be hired. This extra labor cost would be somewhat less than the additional cash

Table 7. *Miscellaneous cost items in raising and harvesting silage corn.*

Before harvest:	Per acre	Per ton
Seed	$1.57	$ .12
Fertilizer	5.31	.46
Gas, oil, repairs	2.30	.20
Total	$9.18	$ .78
Harvesting:		
Twine	$ .62	$ .05
Gas	.87	.07
Oil	.15	.01
Repairs, etc.	.19	.02
Total	$1.83	$ .16
Cash costs	$11.01	$ .94

costs for silage production, but would be more than offset by the added income possible from 7.5 new cows; or if no extra cows were kept, the land released from hay could be advantageously used as pasture.

This same area growing 41 acres of hay and 9 acres of corn would provide roughage for 32 cows. With this combination of crops there would be 464 hours of man labor on hay and 576 hours on silage. The work on hay with some diversity of hay crops could be spread over nearly 5 weeks' time from early-cut grass hay and clover to late-cut rowen. One-third of the work on silage would be manuring and fitting before haying started, and the other two-thirds could be fitted into a two weeks' period in the fall.

If the decision is made to raise silage, the question naturally arises as to how much to grow. Provided there is no desire to increase the size of the herd, an area of silage should be raised that will (1) produce about 3 tons of silage per cattle unit, and (2) provide for a rotation of 4 to 6 years including one year of corn, one year of an annual hay or grain crop and 2 to 4 years of hay, depending on soil. In addition, there should still be opportunity to produce some cash crop or product in sufficient amount to be economic.

Hay:

The general data for producing hay on the 328 farms are shown in Table 8. These farms produced 1.43 tons per acre on an average of 58.5 acres of permanent hay and 1.79 tons per acre on 4.3 acres of annual hay. The greater proportion of the permanent seeding mixture was timothy. Oats or oats and peas made up by far the largest part of the annual hay crop. An average of 5.7 acres was seeded per farm each year. Part of this new seeding was manured after the annual hay was removed, and some was also applied to the annual hay crop. By far the largest amount of manure was applied for silage corn. Where manure was plentiful a large part of all the hay land was also top dressed with manure, although on the average only one-tenth of the hay area was manured with an application of 11.2 tons

TABLE 8. *Number of farms, areas and amounts of roughage, stock and materials on the 328 farms included in the survey.*

	Total	Per farm	Per acre
Number farms	328		
Acres permanent hay	19196	58.5	
Tons yield	27450.7	83.7	1.43
Acres annual hay	1406	4.28	
Tons yield	2524	7.7	1.79
Number of cows	7007	21.4	
Number of young stock	4371	13.3	
Number of men	1056	3.2	
Pounds seed	43736		
Acres seeded	1908.8		
Tons manure	23722 (2116 A.)		11.2
Tons fertilizer	14.8		1.8 lbs.
Tons lime	146.2		18. lbs.
Hay per cattle unit	2.97		

per acre. As yet, top-dressing hayland with commercial fertilizer is little practiced. A part of that used is acid phosphate applied with manure. Less than ½ ton of lime is used per farm. Most of this was in connection with the seeding of alfalfa.

The dairyman has usually a rather wide choice of crops which he may grow successfully to supply the roughage needs of his farm. The most common as indicated by its predominance in the grass seeding mixture is timothy. (Table 9) With its low protein content, however, it is unwise to place too much emphasis on the crop unless some measures are taken such as early cutting, or combining it with higher protein hay crops or both to improve its quality.

The mixed grasses are usually the result of a long hay rotation. Some improvement in their quality may be obtained by early cutting. Yields, however, are usually low. Those farms where plowing and re-

TABLE 9. *Amounts of seed of the various crops raised for hay.*

Kind of seed: Permanent hay	Total amount	Amount per acre
Timothy	18686 lbs.	9.88 lbs.
Red clover	10112	5.30
Alsike clover	7375	3.86
Red top	4937	2.59
Alfalfa	2368	1.24
Other grasses and clovers	76	
	43,736	22.87
Annual hay		
Oats	2535 bu.	
Peas	7840 lbs.	
Millet (Hungarian)	5139	
Vetch	575	
Rye	1232	
Millet (Japanese)	192	
Soybeans	2510	

seeding occur more frequently—four years or less in hay rather than six or more—obtain considerably larger yields and are able to incorporate the higher protein legume hays in the mixture. (Table 10)

TABLE 10. *Relation between length of hay rotation and yield of hay on 328 farms.*

Years in hay	Yield hay per acre
0-3	1.57
4-5	1.50
6	1.34
7+	1.26

Alfalfa. The use of alfalfa as a forage crop is increasing. There has been some change in the method of establishing it. Rather than attempting to obtain clear stands on difficult soils, more and more farmers are relying on a seeding mixture including alfalfa.

Fifty of the 328 farms were growing some alfalfa. The 710 acres reported was 4.6 per cent. of the total permanent hay acreage, and the crop of 1775 tons made up 8 per cent. of the total hay. From the frequent occurrence of alfalfa in every county in the State in stands of varying age and mixture, it seems advisable to use a hay seeding mixture combining 4 to 5 pounds of alfalfa seed per acre on all fields except those too wet to grow red clover satisfactorily.

Such a practice on many farms would eventually result in more legumes in most of the hay and would indicate those fields where alfalfa does well enough to warrant heavier applications of lime and a larger proportion of alfalfa in the seeding mixture, or in a few instances, pure seedings of alfalfa.

On the larger more intensively operated dairy farms, quite a large proportion of the permanent hay is in alfalfa or alfalfa mixtures. The large yields of better quality roughage make possible greater amounts of stock.

The small amount of seeding done each year, 5.7 acres per farm on the average, Table 11, gives a small amount of legume roughage for milk production, and is associated with a long rotation. Where alfalfa is grown in the longer rotations it increases both the total yields of hay and the quality in the later years of the rotation.

TABLE 11. *Amount of permanent and annual hay seeded each year.*

Seeding	Number farms	Acres seeded	
		Total	Per farm
Permanent	328	1908.8	5.8
Annual	296	1406.	4.7

Most of the farms including alfalfa in the rotation either alone or in mixture cut the crop usually less than six years—only a slightly longer period than that for all permanent hay. That group of farms raising some alfalfa where the hay crop was regularly left down less

than six years had by far the larger area in alfalfa and the larger proportion of alfalfa growers, 14.8 per cent. as compared with 9.4 per cent. where the rotation in hay was six years or more.

Corn does so well after alfalfa that it is usually advisable to plow rather frequently to obtain the most advantages from a legume sod in securing larger yields. Seeding costs for later alfalfa crops are reduced either because the soil is already inoculated or requires less lime.

Clover. On those fields and farms where hay is left down but two years, greater dependence should be placed on red clover, using only a sufficient amount of timothy to insure a hay crop. With the longer rotations, more alsike clover can well replace some of the red clover, supplying more legume hay after the first year even on those farms well-manured. The objection to its use is the production of but one crop a year, but where it is used in a mixture with red clover this objection is not serious. The red clover furnishes a second crop of hay the first year and usually an excellent fall feed, while the alsike supplies the legume in later years.

The amount of so-called native hay on the farms included in this study is very small. Its place in the roughage program is confined almost entirely to those areas too rocky or too wet to be plowed, much of which requires harvest by hand.

Unless there is an absolute need for the hay any particular year, these areas could well be dropped from the hay production area, and in so far as possible used for pasture. Yields are low, the quality of hay usually poor, and, under present conditions, time and effort cannot well be spent on anything but the highest producing land.

Annual hay crops:

In addition to these permanent hay crops, annual forage crops are widely used in the State. Some of these are usually grown as a nurse crop, and others cannot be so used satisfactorily.

The oat crop has quite largely been changed from a grain to an oat hay and used as a nurse crop for the seeding of permanent hay. In many instances this has furnished a low quality of hay since its protein content is about that of timothy. The incorporation of a legume such as peas or vetch with the oats has added to the value and improved the quality, partly because of necessary early cutting. Where a smaller area is necessary and in cases of emergency, Hungarian millet and soybeans have given variety and have lengthened the roughage harvest season materially. This crop has made possible early fall seeding of a permanent hay mixture. A labor requirement greater than oats and peas or oats and vetch, because of the necessity for a second plowing or fitting, is partly offset by a greater yield and a better distribution of labor with no greater cash costs. The work can be done with labor, horses, and equipment already available.

Annual hay when used as a nurse crop furnishes a return from land newly seeded to permanent hay which would otherwise produce no crop that year. Seeding hay with oats-grain gives much the lowest cost for obtaining the permanent seeding. The extra labor of plowing and fitting is then chargeable directly against the oats, the only extra charge being the cost of seed. Seeding costs by this method were

$7.29 per acre under 1929 conditions as shown in Table 12. When oats are omitted and seeding is done in corn the extra operation of seeding added somewhat to the expense. Acre costs were $8.33. The extra labor seeding with an annual hay crop adds still more to the expense. $8.67 per acre. The greatest cost, $10.46 per acre, is when the seeding is done after the annual hay crop. The ton costs varied from $4.58 to $7.60.

Table 12. *Material and labor cost of seeding permanent hay by different methods.*[1]

Method of seeding	Cost per acre	Cost per ton	Number of farms
With oats grain	$7.29	$4.58	80
After corn[2]	8.33	4.69	17
With annual hay[3]	8.67	6.10	208
After annual hay[4]	10.48	7.60	21

[1] This does not take into consideration the length of the hay rotation, nor the advantages from better labor distribution.
[2] After corn, extra labor and some extra seed.
[3] With annual hay extra seed cost for annual hay.
[4] After annual hay, extra seed cost and extra labor cost in fitting.

The annual hay crop, moreover, can be so adjusted and balanced to the whole needs of the farm that seeding and harvesting can be kept within the limits of the regular labor. In combination with the permanent hay crop it thus distributes labor through a longer harvest period.

Most labor is required in spring in preparation for the annual hay crop, but this extra labor comes at a period and in such amounts as not to interfere with the other farm work. The tendency is to extend the labor on roughage and provide a better labor distribution.

Annual hay also furnishes a means of reseeding those small irregular pieces that, because of size or shape or soil condition, cannot be readily included in the regular corn-hay rotation.

In the case of Hungarian and soybeans, seeding to permanent hay is frequently more satisfactory if done after they have been harvested. This requires more labor, but results are such that the extra labor seems justified. (Table 13)

Table 13. *Fitting and seeding labor per acre and per ton with and after annual hay.*

Method of seeding	No. of records	Acres in annual hay	Yield per acre	Labor	
				Per acre	Per ton
With annual hay	98	5.1	1.80 T.	6.64	3.51
After annual hay	21	7.7	1.95 T.	8.51	4.35

When seeding is done after annual hay is cut, it requires 28.1 per cent. more fitting and seeding labor per acre or 23.9 per cent. per ton.

The saving in labor possible, 1.9 hours per acre, when the permanent hay is seeded with the annual hay crop, is about balanced by the

value of the greater yield of annual hay, .15 ton, when seeding is done after the annual hay crop is harvested. A part of the increase in yield is due to the larger proportion of Hungarian and soybeans used in this group. This increase of about 8 per cent. in yields is obtained at an increase of 28 per cent. in labor because of the extra fitting and seeding.

Conclusion:

Where silo and machinery are already available, silage production will undoubtedly increase the dairyman's income. With the advantages to be gained in greater stock-carrying capacity per farm, in better quality and larger amount of roughage, and in better use of labor, it would be better for most dairy farms, where the climate does not prevent, to raise silage.

The permanent hay crop should furnish the bulk of the high protein roughage. While timothy offers the cheapest and surest permanent hay seeding, the low protein content of the hay and the short period of harvest emphasize the need for early cutting, and the inclusion of the clovers, red and alsike, in the mixture. Where soil conditions warrant, alfalfa either in mixture or in clear seeding should constitute more of the roughage. Besides the better quality, a better yield follows the more frequent seedings necessary to insure a high proportion of legumes in the permanent hay. This variety of crops extends the harvest period so that the available labor is better able to put the crop in the barn in good condition.

So far as the annual hay crop is concerned, it should serve one of two purposes, as an emergency crop or as a means of getting a permanent hay crop. Any further extension of this annual production is done at the expense of the regular seeding program and at considerably higher costs per acre and per ton than the crop seems to warrant on the basis of yield as shown in these records. The shift from oats grain to oats hay may well go one step further by the addition of a legume, peas or vetch, to the seeding, a practice that will be more readily followed when better adapted legumes or better methods are available, assuring a more satisfactory mixed legume annual crop. This combination offers one of the cheapest annual hay crop seeding mixtures and the lowest cost method as well as a method that involves the least change in farm practice.

Suggested rotation systems:

Any satisfactory roughage production program should meet several conditions. It must first supply all of the roughage for the livestock now on the farm, and take into account possible future expansion of the herd. It should include such forage crops as to provide a satisfactory roughage ration, permitting economies in purchased grains. It should provide for such a distribution of labor throughout the crop growing season that most of the field work can be done with the labor already regularly employed in caring for the stock. It should fit the soil conditions on the farm. It should make possible greater net income through reduced out-of-pocket costs.

To meet these conditions no one rotation system will be satisfactory for all farms. A few systems are suggested in order that one may have some starting point, making adaptations to fit individual conditions. Knowing the amount of roughage necessary for production and maintenance of the dairy cow, the average yield and digestible nutrients available from the various roughage crops, as well as the total amount and the distribution of labor by individual crops and combinations, the farmer may easily develop a rotation system adapted to his specific needs.

The simplest cropping system is that of continuous hay. It has, however, definite disadvantages. Of the total labor 32 per cent. occurs in July, or 50 per cent. outside of manure topdressing (Fig. 4). Probably the nearest approach to such a system is in the northern part of the State at those elevations where silage is not grown, and where soils and moisture favor long hay rotations. Because of the large area to handle in a short period, either labor cost is higher than necessary, or the extended period of harvest produces a poorer quality of hay. Under such a system 60 acres of permanent hay on the basis of yields obtained in the survey would provide 85.8 tons of hay or roughage for 29 cows, a two-man herd.

This 85.8 tons of roughage would be largely grass hay with a digestible nutrient content of 82,650 pounds.* (Table 14) This same area in hay would require 536 hours of labor. Two men with opportunity between chores for an 8-hour day in the field would require 33.4 working days to harvest the crop. Ordinarily, not more than two-

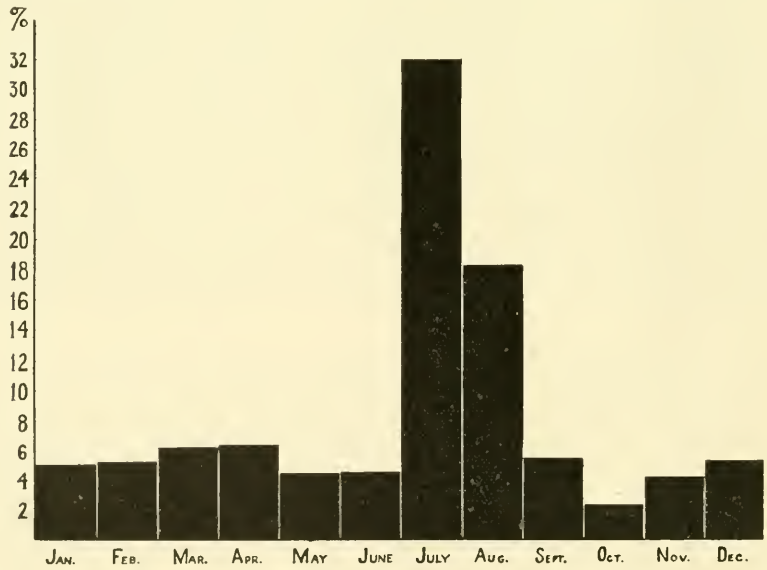

Fig. 4. Percentage distribution of labor on hay.

* Henry and Morrison "Feeds and Feeding," Table III, page 728.

thirds of the days are suitable for haying so that 50 working days would elapse before haying would be finished. In order to obtain a good quality of roughage, it would be necessary, therefore, to hire two extra men for 25 days each or 50 days of extra labor.

TABLE 14. *Suggested rotations.*

	Acres	Crop	Total hours labor	Pounds digestible nutrients	Carrying capacity in cows
A.	10 acres	silage corn	645		
	10 acres	oats and vetch	225		
	40 acres	hay	404		
			1274	116,653	39
B.	10 acres	silage corn	645		
	10 acres	Hungarian and soybeans	249		
	40 acres	hay	404		
			1298	119,231	39
C.	60 acres	hay			
	or	(seeded in oats and peas)	605	82,097	29
	60 acres	hay (seeded in Hungarian and soybeans)		82,650	29

Various modifications of this all-hay program may be made. Raising crops which require spring or fall plowing and in which a legume may be included, such as oats and peas, oats and vetch, Hungarian and soy beans, for annual hay will supply more roughage and larger amounts of digestible nutrients as well as a better labor distribution. See Figs. 6, 7, and 8. Each additional legume assists in all three ways, particularly in the matter of labor distribution.

For instance, including in the rotation 5 acres of a legume mixture such as oats and peas results in a somewhat better distribution of labor with a little shorter period in permanent hay and eventually in larger average yields. This would increase the total digestible nutrients to 87,097 pounds and total yield of roughage to 88.6 tons. The early plowing, fitting and seeding, and later harvest after the permanent hay crop was cared for would require a period of 45 days; or the extra hired labor could be reduced by 5 days. The extra seed cost would be about $15 but would result in a cash saving in labor of $12.50 and an increase in yield of 3 to 5 tons of hay. Hungarian and soy beans as the annual hay crop would accomplish the same results in added hay yield but would reduce the outlay for labor by 10 days or a saving in cash of $25, since all of the harvest would occur after permanent hay harvest. This reduces the July peak to about 25.5 per cent. of all hay roughage labor.

As noted earlier in this report, oats or oats and peas for hay have largely replaced oats for grain. This ordinarily would make no change in labor except for harvest. This change, however, has advanced harvest to late July, conflicting slightly with permanent hay harvest. But starting haying earlier on the reduced area in permanent hay would remove this difficulty. This combination increases the per cent. of labor in July to 32.5, but does extend the labor period because of spring plowing and fitting. Hungarian and soy beans occupy the same period in soil preparation but because of the later harvest, August, extend the labor and reduce the July peak from 32.5 per cent. to 25 per cent. Such a practice reduces the July peak load to 23 per cent. of the total labor required. The advantage of an even distribution of labor and distribution of expense for seed over a longer period, combined with the experience already acquired raising oats hay, indicate an advantage in combining oats and peas, Hungarian and soybeans with the permanent hay crop to produce the necessary hay roughage.

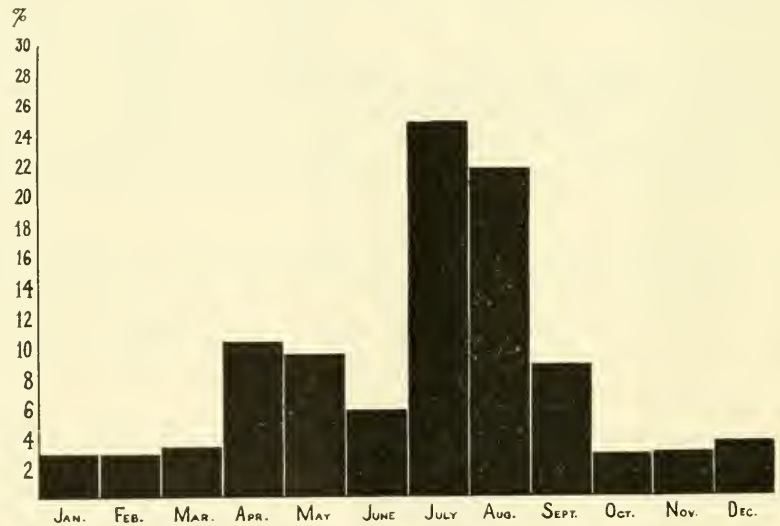

Fig. 5. Percentage distribution of labor on hay, oats hay and Hungarian.

More clover, red and alsike, and alfalfa as part of the permanent seeding mixture are all of value in making a better labor distribution with a less cash labor expense, while the greater yield obtained and its higher protein content would pay for the somewhat greater seed cost.

When silage is included in the roughage program, its combination with both annual and permanent hay has decided advantages. The better distribution of labor makes it possible to care for and harvest the roughage from 60 acres with no other hired labor than that already available to care for the cows. The labor on 40 acres of permanent

hay will require 357 hours, or 22.3 eight-hour days. But a part of this is early cut grass hay followed by clover then with the later maturing mixed hay. (Fig. 7) The peak labor load is reduced more than half if we assume the old method of starting haying after the Fourth, no matter when we would finish. Five acres of oats and peas and 5 acres of Hungarian and soybeans would require 121 hours or 8 days, fitting into the program after permanent hay harvest, and followed by 341 hours or 21.3 days of corn harvest and silo-filling. Exchange of labor with two neighbors would eliminate need for any additional hired labor at this time. The whole 60 acres of roughage could, therefore, be cared for by the two men using approved methods without hiring extra labor. This combination reduces the July labor peak to less than 20 per cent. of the total roughage labor, and provides roughage with a total digestible nutrient content of 116,650 lbs. to 119,230 lbs., sufficient to care for 39 cows—10 more than with hay alone.

If no increase in stock is desired, the combination of roughage, noted above, needed to maintain the 29 head could be grown on 45 acres, leaving 15 acres of the 60 to be used either as permanent or as annual pasture. Where good permanent pasture is limited, such a use of land not needed for roughage production presents the opportunity for supplying the cows with pasture and eliminating the necessity for supplementing the small amount of pasture with expensive green feed.

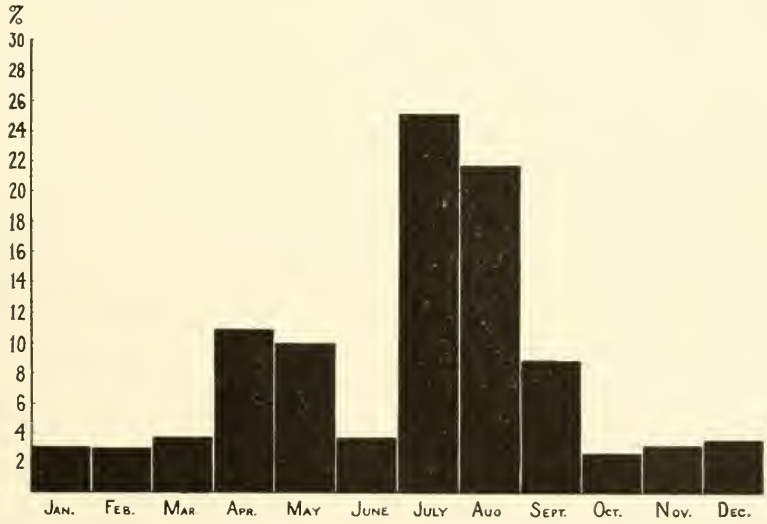

FIG. 6. Percentage distribution of labor on hay, oats hay, Hungarian and alfalfa.

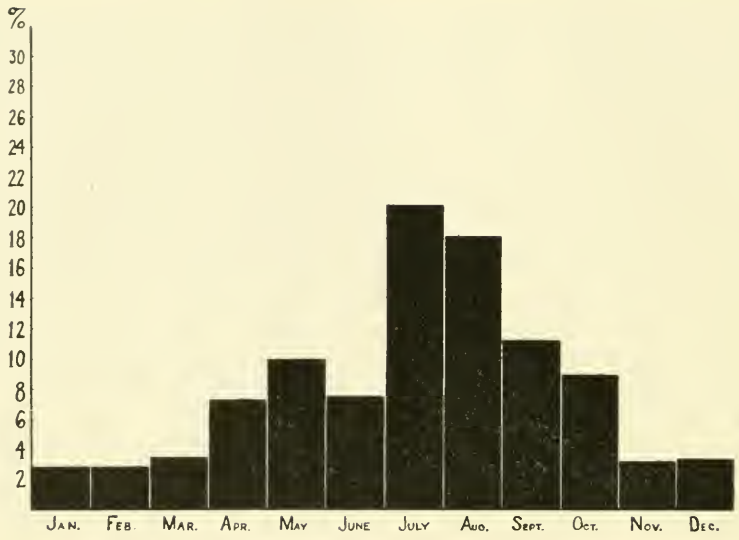

FIG. 7. Percentage distribution of labor on hay, Hungarian and silage.

II. SILAGE PRODUCTION—MANAGEMENT AND COSTS

Labor requirements on silage:

The labor by operations required for silage is shown in Table 15.

TABLE 15. *Hours of labor per acre and per ton on 24,575 tons of silage grown on 2,101.4 acres.*

	Hours per acre			hours per ton		
	Man	Horse	Tractor and truck	Man	Horse	Tractor and truck
Manuring	6.48	11.48	.10	.55	.98	.009
Plowing	4.06	4.89	1.61	.35	.42	.14
Fitting	3.43	4.13	1.32	.29	.35	.11
Marking	.16	.13		.01	.01	
Fertilizing	.02	.03		.01	.003	
Planting	2.20	3.06	.03	.19	.26	.002
Weeding	.98	1.40	.02	.08	.12	.001
Cultivating	4.41	8.23	.07	.38	.70	.006
Hand hoeing	.86	22.60		.07	1.93	
Cutting	4.91	3.46	.11	.42	.30	.010
Hauling	19.2	15.73	.82	1.64	1.34	.070
Filling	16.68	11.93	.42	1.42	1.02	.036
Miscellaneous	.80	41.59	.04	.01	.07	3.55	.004	.0004
Total	64.19	64.51	4.51	5.48	5.51	.385

There are opportunities for reducing labor in almost every operation. The time for fitting, planting, and cultivating may be very much re-

duced. Hauling and filling, however, occupy the largest proportion of time. These two operations take a little more than half the total hours required to raise and harvest a crop of corn. It is easier to accomplish economies in handling than with hay. Labor-saving equipment such as harvesters and low-down wagons cut labor required about in half in the more favorable situations, and reduce it by 25 to 30 per cent. on all farms.*

Manuring:

A great deal of time spent in handling manure could be eliminated by direct hauling. Many basement manure pits are so inconveniently arranged that much extra time is consumed in the spring that could be better spent on some other operation. There is still a small amount of manure hauled out and piled in small piles to be spread later. In so far as weather will permit the usual practice recommends spreading as the manure is made from day to day.

If the practice were to be more widely followed of fertilizing the rotation less time would be used hauling manure for corn and more labor would then be used in applying manure to hay. This would make possible a better distribution of manure and labor. There seems to be little difference in yield of silage whether manure is applied on sod and plowed under or applied on plowed land and harrowed in. Fitting in this operation with the other farm work seems to be much more important than any influence on yield because of the method of applying. Applications of much more than 15 to 18 tons do not seem warranted.

Fertilizing methods:

Not all farms used fertilizer in addition to manure although some slight advantage in yield and in labor required is indicated in Table 16.

When manure alone was applied, 8.3 tons were used by the crop, while 7.6 tons were used where 311 pounds of fertilizer supplemented the manure. Yield was increased with fertilizer by .4 of a ton. There is also some saving in labor when a smaller amount of manure is supplemented with fertilizer. Seed used is practically the same.

TABLE 16. *Yield of corn as influenced by supplemented fertilizer.*

	Manure alone—106 farms		Manure and fertilizer—160 farms	
	Per acre	Per ton	Per acre	Per ton
Tons of fertilizer			.16	.01
Tons of manure	8.26	.71	7.61	.63
Acres	6.88		7.87	
Tons of silage	11.71		12.07	
Quarts of seed	11.49	.98	11.34	.94
Length of rotation	4.8 yrs.		4.4	
Man labor	67.8 hrs.	5.8	61.7	5.1

* See Extension Circular 80, University of New Hampshire.

TABLE 17. *Varieties of corn used for silage purposes.*

Sweepstakes	98
Leaming	81
E. Lakeside	44
Gold Nugget—Gold Dollar	15
Lancaster Sure Crop	9
Sanford White	7
Canada Leaming	6
Eureka	6
Flint	6
Bloody Butcher	5
Big Crop Ensilage	2
Early August	2
Decato Early	2
Desoto Early	2
Hickory King	1
E. Rochester	1
Early Wonder	1
Early Mastodon	1
Golden Queen	1
Minn. No. 13	1
Excelsior	1
Cuban Giant	1
Lothrop's Ensilage	1
Jap. Millet	1
Sweet Corn	9
	304

Plowing and fitting:

Plowing and fitting labor offer little chance for reduction. The practice of plowing as much as possible in the fall reduces the rush of labor in the spring and makes better fitting possible.

Where planting is done by hand and sometimes where it is done with the one-horse planter, the ground is previously marked out. For more than an acre or two, hand planting is decidedly not economical. So, also, is the practice of having a man lead the horse for plowing, marking, planting or first-time cultivating. Marking, planting, and fertilizer distribution should all be combined in one operation.

Any extra operation for fertilizer application seems unjustifiable. Planters are equipped with fertilizer distributors, and acid phosphate can be more economically applied through the manure as an absorbent in the gutter.

Two-row planters are desirable on the larger areas of 10 acres or more.

Varieties:

Twenty-five varieties of corn including some flint corn, and stalks and waste from sweet corn were used for silage purposes; (Table 17) but three varieties constituted the bulk of the crop. Sweepstakes was raised on 98 farms, Leaming on 81 and Early Lakeside on 44. Gold Nugget apparently also has its place on the higher elevations along with Canada Leaming, a cross between Canada Flint and Leaming.

It seems advisable to use a variety for silage that has the ability to produce a minimum of about 10 tons of corn per acre.

The five varieties listed above seem to meet the conditions to be found in New Hampshire, and emphasis should be placed on those that will just about mature in the locality. Some years if left such varieties would produce grain, and occasionally would have to be harvested too immature because of early frost. The attempt should be made to obtain a corn that will produce the maximum in yield of a variety that ordinarily will produce corn beginning to dent.

Cultivation:

Weeding at the proper time either with the regular weeder or with the spike-tooth or smoothing harrow will eliminate the need for one or two later cultivations and all of the hand hoeing now done. Cultivating took 4.4 hours per acre for the season, or a total for all cultivating of 6.25 hours per acre for about 5 cultivations. Harvesting operations will be hastened and made easier if level cultivation is practiced. Ridging does not seem to prevent corn from blowing down, and does interfere seriously with harvesting and hauling.

Harvesting:

Cutting and putting into the silo constitute about two-thirds of the total labor on silage corn. More attention should be given to methods and practices that will reduce this labor cost, and the first should be to eliminate hand cutting. (Table 18)

TABLE 18. *Labor in harvesting operations when cutting is done by hand and with machine.*

Method	By hand		By machine	
Number of farms	128		152	
Acres	5.3		9.3	
Tons	61.2		109.9	
Hours	Per acre	Per ton	Per acre	Per ton
Cutting	8.5	.73	3.5	.29
Hauling	20.0	1.74	18.8	1.59
Filling	17.5	1.52	16.3	1.38
Miscellaneous	.8	.07	.8	.07
Total	46.8	4.06	39.4	3.33

This is not only a laborious task in itself but lengthens all the operations that follow. Loading hand-cut corn requires a man on the load, and the work is slower picking up. Loads are usually smaller, and more hauling is necessary. Unloading at the cutter also takes more time and usually more men. Effort should be made, wherever possible, to exchange labor with a neighbor for the use of his harvester. It is not often desirable to cooperate with more than two men on harvesting and silo-filling machinery; but with divided ownership of the three important items no one individual is overloaded with machinery overhead and the work can be done quickly enough to avoid disagreeable and sometimes costly waiting for a chance to use the machine.

There seems to be plenty of machinery for handling the corn crop provided some planning is done to make the best use of it. (Table 19)

Table 19. *Silage machinery available on the 281 farms.*

	Owned	Used
Harvesters	128	158
Cutters	214	281
Tractors	118	167
Stationary engines	86	114

On the 281 farms studied there were 158 harvesters used. Some of these were exchanged for labor in filling. Altogether, 26 were hired or exchanged. Many more could have been so used. The use of a harvester reduces the time cutting from approximately 8.5 hours per acre to 3.5 hours, and this time could be still further reduced by driving over the corn row without previously hand cutting into lands for harvester operation. The amount of corn lost is so small, particularly with the opportunity for later pasturing to get down stalks, that the practice of first cutting roads by hand is not to be recommended.

Those farms owning a harvester averaged 10.1 acres of silage corn per farm. When those farms that hired or exchanged work for a harvester were included, the area per farm was 9.1 acres. Those hand cutting had 5.3 acres of corn per farm.

Hauling was done with a variety of equipment, from wood wagons and tip carts to truck and low special wagons. The use of the low flat rack made primarily for hauling corn is becoming fairly common throughout the State, having spread from one locality in Grafton County. (For description see Extension Circular 80.) Modifications of this low special rack are to be found on scattered farms. A few use a narrow rack which is pulled off the flat wagon-bed at the cutter and replaced with another; this saves on wagons but is somewhat too high; it requires a man on the wagon to load and also involves stooping to pick up the stalks and put on the cutter table. In one instance, a rope on the wagon under the load is looped over the top and fastened to a stake at the cutter. As the horses are started up, the load is pulled off. This also reduces the number of wagons needed but leaves the corn tangled. Some lacking the extra wheels have built low down flat hay-racks, not quite so convenient as the special rack but serving a double purpose.

The low rack saved on the average about 15 per cent. of the time loading and hauling. (Table 20) This saving of time, of course, is in picking up and loading. Efficiently used, the low wagon requires only from 40 to 50 per cent. as much labor in the field as the high wagon and tipcart.

TABLE 20. *Labor required in hauling silage and filling silo, comparing special low racks with other means of hauling.*

Type of wagon	Number of farms	Total acres	Total tons		Total hours	Hours per acre	Hours per ton
Special low rack	120	1136.5	13734	Loading and hauling	20258.2	17.82	1.48
				Filling silo	16810.5	14.79	1.22
Other means of hauling	161 (160 filling silo)	960.88	10841	Loading and hauling	20011.9	20.83	1.84
				Filling silo	18315.6	19.06	1.69

Loading should ordinarily start at the back, piling the corn as high as necessary to make a load, butts all on the side of the wagon that will be next the cutter. Two men per wagon are sufficient. Carry only 3 or 4 rows of corn, letting the team step ahead more frequently to reduce man carrying to a minimum. Level cultivation makes this operation still easier.

Filling labor can also be materially lessened where corn is bound and low wagons are used as suggested. Some of the advantages are not shown in Table 19 because of extra and excess men at the cutter and in the silo. The practice is all too common of cutting and removing bands from bound corn requiring an extra man at the cutter. Ordinarily, with the low racks and the recommended size of cutter for the usual farm, the teamster can feed out his own load. This would make possible a still greater saving over high rack or tip cart methods with loose corn. Several growers have entirely eliminated the man in the silo, even in square silos. The silage must be directed into the center of the round silo and successively into the four corners of the square silo. This plan will not work as well with corn where a part of the leaves are dry. A very large number have reduced the labor in the silo to the time between loads, or even twice a day. This has some disadvantages in that the pockets made in the loose silage by insufficient tramping will later develop a red mold because of the presence of imprisoned air. Experience seems to indicate that no one in the silo gives best results, with thoroughly tramped silage next, and part time leveling least satisfactory. Size of silo up to 16 feet in diameter seems to have no influence on keeping quality under this system.

With some exchange and cooperation 214 cutters filled the silos on the 281 farms. Width of cutter varied from 9 to 17 inches. (Table 21) Small-sized cutters 9-10 inches were used on 38 farms. Because of the inclusion of tractors, and because tractors are more frequently hired or exchanged, the horse power available is higher than necessary.

TABLE 21. *Size of cutter, hours of labor filling, and horse power used in filling silo.*

Size of cutter	Number of farms	Per farm: Area in silage	Per farm: Tons yield	Hours filling per ton	Horse power used
9-10	38	5.8	61.8	.385	9.5
11	108	5.7	68.6	.315	10.6
12-13	113	9.4	110.9	.247	14.6
14-17	22	9.0	103.9	.252	16.4
Total	281				
Average		7.5	87.4	.281	12.5

The rapidity with which silage is put into the silo increases with size of cutter up to 13 inches. Beyond that point there appear to be some inefficiencies on the farms studied; either the cutter was too large for the crew, or the large crews, to insure against stoppage of equipment because of lack of help, got in each other's way and used more labor per ton of silage. (Table 22)

TABLE 22. *Size of crew and efficiency of labor.*

Size of crew, Men	Number of farms	Acreage in silage	Man hours per acre: Cutting	Hauling	Filling	Misc.	Total	Man hours per ton
1-3	41	7.1	4.3	15.8	13.3	.7	34.1	3.00
4-5	102	6.0	5.8	18.7	17.5	.8	42.8	3.71
6-7	99	8.0	4.8	20.4	17.7	.8	43.7	3.72
8+	39	10.0	4.4	19.0	21.2	.9	45.5	3.74

In all of these operations, however, it was possible to save 5 hours per acre cutting, 2 hours per acre hauling, and 1 hour per acre filling—a total of 7.4 hours per acre, or .7 hour per ton, when corn was cut with a harvester and bound as compared with hand cutting. With an average tonnage per farm of 87, this means a saving of 60 hours per farm, or it would be equivalent to the time required to raise an acre of silage corn.

Size of crew and labor requirements for silage harvest:

The small crew, operating usually with its own machine, is most efficient. (Table 20) As the size of crew is increased, the speed at which the corn is handled is reduced. The time required per acre varies from 34.1 hours per acre and 3.0 hours per ton for the 2-3 man crew to 45.5 hours per acre and 3.7 hours per ton for the 8+man crew. The smaller crews rarely had a man in the silo or in the field. In the larger crews, it was more common to have a man, sometimes two, in the silo and one or more in the field to help the teamsters load.

Type and size of silo:

Data indicate that the silo is rarely used on farms with less than eight cows. The difficulties in the way of machinery for growing and harvesting the crop are usually too great for the smaller dairyman to overcome. Where two or three can cooperate, owning the machinery together, it is still possible, however, to grow silage economically.

The new steel, hollow tile and concrete slab silos seem to supply the larger producer with a permanent low waste silage container but for the smaller dairyman are still too expensive.

The square inside silo, so long as it is in good condition and does not occupy space needed for hay, offers a cheap means of supplying silage. Unless kept fairly tight, however, the waste from decay is frequently very large, and losses because of extra corn, labor and materials in growing and preserving are sometimes sufficient to make it desirable to put up a better silo.

No data were obtained on the cost and upkeep of silos. However, with hay at or near its present low level, it will not pay to raise silage at all unless costs are kept at the lowest figure possible consistent with good keeping ability. On most of our dairy farms there is sufficient timber to supply stave material for a satisfactory silo and keep the cost for materials under a hundred dollars.

The tendency in size of silo seems to be toward a smaller diameter. The 12 or 14 foot silos are the more common, even with the larger herds. There is no chance for surface molding because of slow feeding. With smaller silos the cost of green feed may be reduced by feeding summer silage during the season when pastures are dried up. Spoilage losses in hot weather when feeding is slower are also less.

Power costs for harvesting and filling:

Based on assumed values for labor in silo filling there seems to be little advantage in cost whether the power is tractor or stationary. The somewhat greater cost of operation of the tractor is offset by the longer time with smaller cutters and less power in the case of stationary engines. (Table 23)

TABLE 23. *Harvesting and filling costs with various kinds of power.*

Power	Tractor	Stationary engine	Hired power
Number of farms	152	110	20
Area in silage	9.1	5.8	4.2
Tons silage	105.9	67.1	53.8
Harvesting and filling costs*			
Per acre	$26.23	$26.81	$30.92
Per ton	2.24	2.32	2.42
Hours per ton	1.84	3.99	

* Costs in this study include labor, horses and equipment at assumed rates; machine, cutter, power, gas, oil and repairs, and materials at cost. Buildings, land and manure are not included.

With labor already available, cash outlay may be reduced by the use of the smaller stationary outfit. If labor has to be hired, the larger outfit would be advisable.

There is, however, a distinctly higher cost for those farms hiring their silage cut, partly due to the smaller amount. Although the cost is greater by about $4.00 per acre, it still is not uneconomic except in a very few instances where the farm is too small to carry a one-man dairy unit, and should indicate some need for study of methods employed in order to bring about economies in handling. It may be possible to own a stationary engine and cutter on those farms too small to wisely invest in a tractor. The new blowers are built to operate satisfactorily with five and six-horse-power motors.

Cost does not change much with various methods of ownership of machinery. The significant difference seems to be the influence of area in silage on whether or not a man owns a machine. The men raising smaller areas of silage corn usually hire, or exchange labor for power and cutter. Those who use stationary power have some advantage other than lower investment cost. The stationary engine permits of power ownership on those farms too small for satisfactory operation of tractors for draw-bar work.

Hours per acre and per ton of silage:

Labor per acre and per ton is greatest on those farms having the smaller area in silage. This is largely due to less need for hurry, since those growers have as long a time to take care of the crop as have the larger growers and usually take as long.

There is little difference in yield per acre whether a large or small area is grown, but much difference in labor required. With the same area in silage, savings in labor must be accounted for by better handling methods. When the farms were divided into three groups on the basis of the amount of labor required to grow and harvest an acre of silage, the same farms in each group were also more efficient in the handling of hay. (Table 24)

Table 24. *Hours per acre and per ton on silage.*

Labor requirement per acre	Number of farms	Acres per farm	Yield per acre	Labor on silage		Labor on hay
				Hours per acre	Hours per ton	Hours per ton
Small	86	10.8	11.7	50.4	4.3	6.54
Medium	98	7.5	11.6	66.3	5.7	6.86
Large	97	4.8	12.0	86.0	7.2	7.41

It is easier, however, to reduce labor requirements in handling silage by changing from a tipcart to a low special wagon, than it is to change the construction of a barn.

III. HAY PRODUCTION MANAGEMENT AND COSTS.

Labor requirements on hay:

The labor by operations required for hay is shown in Tables 25-27.

TABLE 25. *Hours of labor by operations per acre and per ton on 22,102.5 tons of permanent hay raised on 15,270.5 acres.*

	Total hours	Hours per acre			Hours per ton		
		Man	Horse	Tractor and truck	Man	Horse	Tractor and truck
Plowing	45	.003	.006		.002	.004	
Fitting	60	.004	.005	.001	.003	.004	.0009
Seeding	26	.002	.002		.001	.002	
Manuring	17009.8	1.111	2.047	.003	.770	1.414	.002
Fertilizing	585.5	.038	.062	.0023	.026	.043	.0012
Cutting	18471.3	1.210	2.296	.058	.836	1.586	.040
Raking and tedding	18074.8	1.184	1.327	.023	.818	.917	.015
Hauling	50801.3	3.326	2.811	.034	2.299	1.942	.024
Unloading	45565.3	2.984	2.248	.033	2.062	1.553	.023
Miscellaneous	3415.0	.224	.001		.154	.0008	
Total		10.088	10.805	.155	6.970	7.465	.107

Seeding:

Four methods of seeding permanent hay are usually as follows: seeding with oats cut for grain, seeding with oats or some other annual plant cut for hay, seeding in late summer after some annual hay crop, and seeding in corn after the last cultivation.

Only a small amount of plowing was done for permanent hay. Plowing labor was charged to the small grain or annual hay crop, except on those areas unsuitable for inclusion in the regular rotation, which were plowed, fertilized and reseeded without the use of an annual hay or a cultivated crop.

Seeding as such is included with the annual hay-crop seeding. The usual better hay stand obtained where seeding follows the harvest of the annual hay crop, warrants the extra labor involved. The items of plowing, fitting and seeding constitute a small proportion of the total time per acre, yet good practice in these operations is so essential for a good hay crop that any change should be directed toward obtaining a better roughage. The most common seeding mixture is about 10 pounds of timothy, three pounds of red top, four of alsike, and six of red clover. This is modified to meet special conditions such as wet land, light soil, suitable alfalfa soil, permanence of seeding, amount of manure available, and pasture use. Many farms are able to obtain a better quality of hay by reducing the amount of manure applied for corn and using more as a light top dressing for hay. The shorter rotation makes possible the production of a larger proportion of legume hay, including more alsike and red clover, and on suitable soils alfalfa in the seeding mixture. Such an alfalfa mixture contains not more than six pounds of timothy, eight pounds of red and five of alsike clover with four to six of alfalfa. This has produced very satisfactory results on several of the farms studied.

When all hay is considered there is some increase in plowing and fitting because of the annual hay crop, and some additional time because of the somewhat greater difficulty in curing the annual hay crop.

Fertilizing:

Manuring required a little over an hour per acre. Better results in crop yields were obtained on those farms where lighter applications of manure, 15 to 18 tons per acre, were applied for silage corn. This practice leaves a balance of manure for top dressing hay and the lack of plant food for corn may be made up by 300 to 500 pounds of acid phosphate applied with the manure and 100 pounds of a nitrogen fertilizer at planting. Top dressing new seeding and old hay land with six to eight tons of manure gives greater yields of hay and more organic matter to plow under for corn. A part of the greater yield of hay where corn is included in the rotation was due to this top dressing, a part to the shorter period in hay because of a shorter rotation than with hay alone, and part to a greater amount of plant food available. This method of fertilizing will require some more labor because of the greater area manured each year, but the extra cost is more than returned in greater yields.

Table 26. *Hours of labor by operations per acre and per ton on 2,524 tons of annual hay raised on 1,406 acres.*

	Total	Man hours per acre	Man hours per ton
Plowing	6605	4.70	2.62
Fitting	6077	4.32	2.41
Seeding	2682	1.91	1.06
Manuring	1004	.71	.40
Cutting	1611.5	1.15	.64
Raking and tedding	4287.0	3.05	1.70
Hauling	5744.7	4.08	2.28
Unloading	5366.4	3.82	2.13
Totals		23.74	13.24

Acres seeded:

On the 328 farms, 5.8 acres of permanent hay were seeded per farm, and 4.7 acres of annual hay were grown per year on 277 of these farms. The permanent hay yielded 1.43 tons per acre while the yield of annual hay was 1.79 tons. This annual seeding of 5.8 acres would mean a hay rotation of about eight years on 51.3 acres of all hay per farm. The practice on the better farms and the cropping system giving the largest yields of hay and silage, approach a five or at the most a six-year rotation—a year of corn, a year of small grain or annual hay seeded to permanent hay for three or four years.

Harvesting:

Several factors influence the labor requirement in cutting hay. Ordinarily the first consideration is the length of the cutter bar, but the size of machine to use depends on the topography, the size of field, and

TABLE 27. *Hours of labor by operations per acre and per ton on 24,626.5 tons of all hay on 16,676.5 acres.*

	Total man hours	Hours per acre			Hours per ton		
		Man	Horse	Tractor and truck	Man	Horse	Tractor and truck
Plowing	6650	.40	.661	.071	.27	.448	.048
Fitting	6137	.37	.611	.067	.25	.414	.045
Seeding	2708	.16	.243	.002	.11	.165	.001
Manuring	18013.8	1.09	2.00	.003	.74	1.358	.002
Fertilizing	585.5	.04	.057	.0023	.02	.039	.0012
Cutting	20082.8	1.21	2.303	.057	.82	1.560	.038
Raking and tedding	22361.8	1.35	1.360	.024	.91	.921	.016
Hauling	56546	3.41	2.898	.039	2.31	1.962	.026
Unloading	50931.7	3.07	2.329	.036	2.08	1.577	.024
Miscellaneous	3415	.21	.001		.14	.0008	
Total	187431.6	11.31	12.46	.298	7.66	8.443	.200

the area in hay. Rough, steep, small fields and a small total area in hay will need smaller machines and will require more labor per acre and per ton than large level fields and a large area in hay. The size of mower and its relation to area in hay and labor required are shown in Table 28. The four-foot mower is too small for efficient work while the seven-foot machine is almost entirely tractor operated. From the point of view of labor saving, there is little choice between a five and a six-foot mower when replacement is necessary.

Cutting was done at any and all times of the day. The most common practice was to cut in the morning as soon as the dew was off, raking just before or right after dinner, and hauling the next morning. Many cut in the afternoon, the hay was raked in the late afternoon, stirred out in the morning and hauled in the afternoon. A very few, because of the large area in hay, cut any time and all day except in case of rain. Poor curing weather will slow up the process some, but the decided tendency to handle hay less by hand in the field and barn will shorten the time under the old methods and produce a better quality of roughage.

TABLE 28. *Variations in width of mower used and in hours per acre and per ton cutting.*

Width of mower—feet	Area per farm—acres	Hours per acre	Hours per ton
4	20.0	2.55	1.76
5	39.8	1.29	.93
6	50.1	1.20	.80
7	93.6	.80	.56

"Drying" in the swath is receiving less and less favor. A better quality of hay is ordinarily produced where raking is done, preferably with a side-delivery rake, within three or four hours of cutting. The hay is allowed to cure in the windrow. If stirring is necessary after

a dew or rain, the side delivery rake is again used to turn the windrow over, shaking out the hay and leaving it in such loose condition that the air gets through readily. Only a small area in the windrow is exposed to bleaching by the sun.

The best time to cut seems to be early in the afternoon. The ground as well as the hay is dry and curing in preparation for raking takes place more rapidly. The hay is raked before night, stirred out with the side delivery in the morning and hauled beginning at least by afternoon. If a loader is used no further handling is necessary, but if hand pitched, time will be saved by bunching with the dump rake.

However, necessary dependence on the weather makes haying almost "catch as catch can" series of operations, and whether one cuts hay morning or afternoon will depend on the amount to be cut and how it is cared for after cutting. Long drying in the field involves much hard work and produces a poorer quality of hay with greater loss from shattering in the field and too high a labor cost.

Because of the greater ease of loading a low wagon in the field, low flat racks are helpful, once the hay is ready to haul, particularly where unloading is done by fork or sling.

Many older barns are bank barns located in such fashion that the drive floor is in the peak. In such barns it is possible to unload hay without special hay-unloading equipment. The hay is pitched off by hand since all the hay storage space is below the level of the wagon. This type of construction is expensive to build and wasteful of space. The cross-floor-drive type of barn is cheaper to construct and more of the space is used for hay storage.

The peak type of barn, however, requires less labor per acre and per ton in unloading than does the main-floor drive. There is no scaffold to pitch onto and off from, and no high beams to pitch over. (Table 29)

Table 29. *Labor requirements unloading by hand in barns with peak drives and with main floor drives.*

Method of unloading	No. of records	Acres per farm	Tons per farm	Hours per acre	Hours per ton	Hours per ton hauling
In peak drives	23	60.0	100.8	1.66	2.78	1.89
Main floor drives	52	36.3	49.2	2.53	3.43	2.51

The usual type of barn with the long main-floor drive is extremely wasteful of space and building costs are high. Since this is the type most commonly found some attempt to reduce the labor requirements in unloading should be made. One change is the use of a grapple fork in place of the harpoon, particularly in connection with grass hay.

Some barns have been equipped with a hay slide consisting of smooth poles or boards supported on the purloin plate at one end and on the tie beams beside the drive at the other end. When the fork is dumped on this, the hay slides into the mow. If the hay is dropped well to the back of the mow from the slide it comes out much easier during the feeding season, since the higher part of the mow is then under

the eaves. Such an arrangement makes it possible to eliminate the man on the scaffold or high beams as well as part of the labor in the mow.

Another arrangement permits making a saving in time unloading, even in the smaller barns. Where unloading with the horse fork is possible in the center bent of the barn, it required two-tenths hours less time per ton than when unloading was done through the end of the barn or in the first bent. In barns averaging approximately 100 feet in length savings of three-tenths hours per ton were made with center as compared with endbent unloading.

The cross-floor type of barn furnishes the greatest amount of usable storage capacity at the lowest cost and permits the best use of fork or slings in unloading. The elimination of all cross beams makes it possible to use a type of car which will carry the fork or sling load at any height, doing away with the necessity of raising each fork to the track to trip the car. Such an arrangement also gives the man in the mow an opportunity to place the load by swinging it, doing away with much of the hand pitching. Slings under these conditions produce the best results.

The principal reason for these savings in labor is in the matter of equipment. Wider mowers and rakes are possible. The large farms averaging 93.6 acres of hay quite generally had seven-foot tractor-operated mowers. As the area in hay decreases the size of mower and rake decreases. An organization of the work to eliminate unnecessary handling, cutting a larger acreage, thus making it necessary to use more haste to get the hay into the barn in good condition, will shorten the time required to handle hay but unless the labor saving in field handling is also carried into methods of unloading, the time saved in the field may be more than lost in the barn.

The latest development in hay-unloading methods is the cutter and blower. This method was not observed on any farm included in

TABLE 30. *Labor per ton by operations as influenced by different methods of handling and by amount of hay handled.*

Operation	Under 50 tons per farm	Over 50 tons per farm
Raking and curing	1.11	.76
Hauling and unloading	5.13	4.23
Unloading with		
Hand	2.64	1.91
Harpoon	2.32	2.31
Grapple	2.29	1.93
Unloading in		
End of barn	2.35	2.15
Middle of barn	2.05	1.85
Raking with		
Dump rake	.61	.50
Side-delivery rake	.64	.50
Time curing when raked with		
Dump rake	.57	.41
Side-delivery rake	.40	.30

the study. It seems to have possibilities, at least on the larger farms where silage is also grown, and deserves some study to determine its adaptability.

All these haying operations are also influenced by the area in hay. On those farms where less than 50 tons of hay are raised, labor per unit in all harvesting operations is greater than where more than 50 tons are grown. When more hay is to be handled, methods must be improved in order to harvest it in the best possible condition. Considering the operations, raking, curing, loading, hauling and unloading, as shown in Table 30, a saving of 1.25 hours per ton is shown in favor of the larger amount of hay.

The rate at which the haying operations are done depends more on total amount of hay than on size of field. Size of field in most sections of New Hampshire is a matter of topography rather than size of farm. Many large farms are cut up into smaller fields, yet in their haying operations these farms carry on more efficiently than the smaller ones. On these larger farms with a lot of work to do, much can be and is done even on small fields. On small farms with less to do the tendency is to let the work drag, taking as long to care for 25 acres on the small farm as for 40 acres on the larger farm. The data show savings in labor of 5.5 hours per acre or two hours per ton on the larger farms.

When the influence of size of field is eliminated by taking farms with the same acreage per field but with more fields there is still a marked difference in labor used, those farms with the smaller area in hay using 1.6 hours more time per ton for harvesting.

SUMMARY

When silage was included in the roughage-production program, the most important advantage was in providing a greater amount of roughage for an increased dairy herd. An increase from five acres to 6.5 or seven acres of silage permitted the addition of five cows to the herd without increase in total roughage area. If no increase in number of cows was desired a smaller area of land than that in hay alone would provide the necessary roughage, releasing land either for cash crops or pasture.

Silage production extended the roughage harvest into the fall reducing the peak labor load during hay harvest as a result of the smaller area in hay. The five or six acres necessary to produce 60 tons of silage will release 12 to 13 acres from hay production.

The better labor distribution with silage makes it possible for the regular labor to handle the extended roughage harvest with the minimum of extra hired help.

Permanent hay alone limited stock carrying capacity, created difficult labor peaks at harvest, resulted in lower quality of hay, and increased management costs.

The inclusion of some annual hay crop provided a more satisfactory roughage. This furnished the means of more frequent reseeding to permanent hay, improved the quality of the resulting hay both through legumes in the annual hay and more legumes in the permanent hay crop, and reduced the amount of hired labor needed for hay harvest by extending the harvest period.

Hungarian and soybeans furnish an annual hay at the lowest cash expense per acre. Oats and vetch are somewhat higher in cost, and oats and peas the highest of the three most important annual hay crops. The extra labor required for fitting the Hungarian-soybean land for permanent hay seeding is apparently an advantage in increasing the yield of permanent hay. Hungarian and soybeans reduce the peak labor load by extending the harvest period. Oats in combination sometimes interfere with early hay harvest, but the farmer's possession of equipment and experience for handling oats place it first as an annual hay.

Silage required 64.2 man hours per acre and 5.5 hours per ton and cost with assumed rates for labor $4.52 per ton to produce. No charge was made for land, buildings or manure. The cash costs, omitting labor and machinery use, were $11.01 per acre or 94 cents per ton.

Hay required 11.3 man hours per acre and 7.7 hours per ton and cost with assumed rates for labor $8.45 per acre and $5.71 per ton. The cash costs were $2.94 per acre and $1.99 per ton.

Labor-saving methods on some farms have reduced the labor on corn silage 21.5 per cent., and on hay 26.7 per cent.