ANALYSIS OF THE POTENTIAL ECONOMIC FEASIBILITY OF THE ALL-SILAGE FORAGE HARVESTING METHOD FOR WILLAMETTE VALLEY DAIRY FARMS

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INTRODUCTION

Willamette Valley dairymen long have used silage as a succulent forage for winter feeding. This study was designed to determine the practicality of using silage, or a combination of silage and hay, as the roughage component of dairy rations during the spring and summer months.

Forage producing crops are well adapted to many soils of the Willamette Valley that have limited adaptability for other crops. Forage crops also are grown in crop rotations to aid in maintaining soil productivity.

In order to use the feed produced, a livestock enterprise becomes necessary. Maximum utilization of a roughage-type feed can be obtained only by feeding to ruminant animals. Thus, livestock alternatives are limited to beef, sheep, or dairy enterprises. This paper will consider the utilization of forage by dairy animals only.

Since land resources may be fixed in area and productivity at a given time, the farm operator must adapt his other resources to the land if he is to produce efficiently. Economic pressure on todays' agriculture is forcing the farmer to make an increased effort to obtain maximum utilization of his available resources. A farm operator who is either unwilling to accept or unable to put into practice the economic principles involved in resource use will find it increasingly difficult to operate profitably.

Dairymen of the Willamette Valley are not exempt from this economic pressure. Thus, they need to be in constant search of means to allocate their productive resources more efficiently. This leads to consideration of the overall farm organization. Management decisions pertaining to forage harvesting must be examined from the standpoint of their effect on the total farm organization.

One of the more important decisions a dairyman must make in forage production is which method, or combination of harvesting methods, will be most profitable on his farm. There are five alternatives from which the dairyman may choose in deciding upon the method to use in harvesting green or succulent forage. The alternatives available for harvesting forage fed during the pasture season are: continuous grazing, rotational grazing, daily ration grazing, green chopping, and the all-silage program. In addition, the crop may be harvested and stored for later feeding as either hay or silage. Silage often substitutes for hay when weather interferes with field curing of hay. Feed harvested for storage will be considered in this report only as it influences harvesting methods used to supply forage during the pasture season.

The combination of two or more forage harvesting methods on a farm may be more profitable than the use of a single method. Winter feeding requirements make it mandatory that a harvesting program permit storage of feed, unless all such forage is to be purchased. Grazing programs and green chopping considered singly make no provision for storage of feed.

There are two main classifications of methods for harvesting succulent forage; those which utilize animals to remove the forage and those which mechanically remove the forage from the field. The animal removal methods are; continuous grazing, rotational grazing, and daily ration grazing. Green chopping and the all-silage program are dry-lot feeding methods requiring that the forage be mechanically harvested and hauled to the cows.

A brief description of the main characteristics of each harvesting method will aid in understanding and interpreting information presented later in the paper. The methods will be described starting with continuous grazing and progressing through the more intensive harvesting methods. Each method will be explained individually even though it is common for two or more of these methods to be used on the same farm.

Continuous Grazing and Rotational Grazing

Continuous grazing allows animals to graze the same field during the entire season. This method is used only to a limited extent in the Willamette Valley and will not be discussed as a separate harvesting method.

Under rotational grazing, the first step from continuous grazing towards a more intensive harvesting method, fields are divided into two or more plots. The herd is moved to a fresh plot of pasture every two to ten days. This allows forage plants a recovery period in which top growth may replenish the root reserves.

Pasturing under the rotational method furnishes forage only during the summer or grazing season. No provision is made for handling excess plant growth during the lush growing season or storage of this feed for winter feeding. This results in the need for inclusion of either a haying or ensiling operation in conjunction with grazing. Thus, on most farms the harvesting of hay or silage or both is combined with the grazing program.

Daily Ration Grazing

As the name implies, this method of pasturing provides the cow herd with a fresh plot of forage each day, or in some instances more often. The terms daily ration and strip grazing are both used to denote this method of pasture management which is designed to furnish a fresh supply of pasture each day, but not so much that the herd can selectively graze the plants.

Pasture fields may be divided into small plots by two methods. In one method the pasture is divided into strips just large enough to furnish the cow herd with a days supply of forage. In the other the field is divided into long strips which are large enough to supply more than one days forage requirements. A short piece of movable electric fence is then used to divide each strip and allow the herd access to a restricted amount of new forage each day.

Daily ration grazing provides forage only during the pasture season. Some means of harvesting needs to be combined with this method to facilitate handling of surplus feed during the lush growing season. Thus, it is common for ensiling or hay production or both to be combined with daily ration grazing.

Green Chopping

Green chopping, as previously stated, requires mechanical removal of forage from the field. The common practice is to use a field chopper to cut the forage and either a wagon or truck to haul it to the cows in a dry-lot. Freshly chopped forage may be blown directly into a self-feeding wagon, thus eliminating the need for unloading. If cows do not eat directly from a wagon, the forage must be placed in a feed bunk.

A fresh supply of green feed is cut either once or twice daily. Twice daily chopping is usually practiced when climatological conditions are such that heating occurs if forage is allowed to stand for a day. Heating of cut, green feed lowers its palatability and consumption by the cows.

The handling of unused forage during periods of surplus pasture growth and the need to provide a supply of roughage for winter feeding require that green chopping be combined with either silage or hay production.

All-silage Program

The remaining method and the one which will receive the most emphasis is the all-silage method. This method is similar to green chopping in that forage is mechanically removed from the field. Freshly cut forage is not, however, immediately fed to the herd but is placed in a silo.

The all-silage method eliminates daily chopping, but not the necessity of handling the herd's forage requirements each day. Silage must be removed from the silo each day of the feeding period. Time and labor required may be reduced by mechanization of the silage feeding program.

It is not necessary to combine another harvesting method with the all-silage program in order to handle storage of surplus feed. However, silage as the only source of roughage is not regarded as adequate by most dairymen, and hay production may be combined with an all-silage program for nutritional purposes. A more detailed discussion of nutrition as related to various forage harvesting methods appears in the literature review.

OBJECTIVES AND METHODOLOGY

Objectives

This study was designed to determine whether an all-silage forage harvesting program would prove more profitable than rotational grazing, daily ration grazing, or green chopping on dairy farms in the Willamette Valley.

For the all-silage method to be more profitable one of the following conditions must hold:

1. The all-silage program must result in harvesting costs lower than the alternative methods without reducing revenue a comparable amount.
2. An increase in revenue under the all-silage program without a corresponding increase in costs. This would result from an increased nutrient production per acre which would permit (1) a reduction in acres devoted to forage production, (2) an increase in the number of cows carried, or (3) some combination of these.
3. If the first two conditions are not satisfied, then other considerations must be great enough to offset the higher costs. Among these considerations may be such things as the ability to more fully utilize unpaid family labor, a uniform feed supply resulting in less seasonality in milk production with its reduced price during surplus periods, or other advantages dependent upon the individual farm.

Information on the following relationships will be necessary to determine whether these conditions are satisfied:

1. The capital outlay and investment required by the alternative forage harvesting methods.
2. Physical requirements and operating costs incident to the particular harvesting methods.
3. Relationships of the different harvesting methods to the total farm organization and problem areas in an all-silage program.
4. Effect of an all-silage program on the quantity and quality of forage produced on the farm.

Methodology

Sources of information

Two sources of information were used in this study. Experiment station and extension service publications were the major source of secondary data. The primary data were obtained from a survey of Willamette Valley dairy farms.

Records were taken from twenty nine farms, of which twenty six were useable in their entirety. Thirteen of the farms used rotational grazing, seven daily ration grazing, seven green chop, and two were under an all-silage program. This number appears small, however, the grazing methods and green chop were analyzed in a study conducted in 1956. (11) It was believed the sample for this study need only be large enough to allow comparison of an all-silage program with the alternative methods and to supply data on the costs of harvesting silage.

During the 1956 study an attempt was made to survey all dairymen in the Willamette Valley known to be using the daily ration and green chop harvesting methods. A total of 39 useable records were taken of which 13 were on green chopping, 14 on daily ration grazing, and 12 on rotational grazing operations. Some data from this prior survey on farmers' opinions concerning the advantages and disadvantages of the alternative harvesting methods have been used in this thesis. All other data presented were obtained from the 1957 survey.

Twenty six of the farms surveyed in this study were selected from among the dairymen surveyed for the 1956 study. The farms using rotational grazing, daily ration grazing, and green chop methods were selected on the basis of their close proximity to the average for their harvesting method and completeness of the information they furnished for the previous study.

Only three farms in the Valley were found to be using the all-silage method. Two of these farms supplied complete records, the other was unable to furnish sufficient data for a useable record. Although data from only two all-silage operations are used it will be assumed that these farms are typical of an all-silage program in the Valley.

Since farms for this survey were not randomly selected and there is only a small number of farms under each method, caution must be used in drawing inferences. The wide variation among farms in the Valley make the direct application of survey data to a particular farm situation difficult.

Area surveyed

This study was designed to cover the entire Willamette Valley of Oregon. Records were taken in Benton, Lane, Linn, Marion, Washington, and Yamhill counties. This Valley is predominantly a fluid milk production area and one of the major dairy areas in Oregon. Production of milk strictly for manufacturing purposes has become of relatively little importance.

Many dairy farms in the Valley are small in acreage. The farms surveyed had a range in improved acreage of from 56 to 536 acres. More than one-half of these farms had less than 100 acres of cultivable land. Much of this improved land was devoted to production of forage crops for the dairy herd.

Dairy farming in the Willamette Valley is now in a transitional state, changing from one of several enterprises on a general or diversified farm to a specialized type of farming. Dairy farm numbers in the Valley are decreasing faster than the number of cows. This is resulting in fewer dairy farms with larger herds.

Records were taken from both general and specialized dairy farms. The relationship of the dairy to other enterprises on a farm will influence size of equipment inventory, availability of labor, and the entire farm organization. This fact needs to be considered when interpreting data presented later in the text. Every farm has certain unique conditions and management decisions should be made in light of these conditions.

There is a wide variety of soils in the Valley. The dominant soil series found on the valley floor are: Amity, Chehalis, Dayton, Newberg, and Willamette. Aiken, Melbourne, and Olympic are the dominant soil series of the hill-lands in the region.

Rainfall is characteristically high in the winter months, averaging 48.6 inches precipitation annually. The summer months are short of rainfall with less than five percent of the annual precipitation occurring in June, July, and August. The summers are moderate with a mean temperature of approximately 60 degrees during the growing season. Although winters are generally mild, the pasture season seldom extends beyond the month of October. An average growing season of 210 days exists on the Valley floor, extending from April through October.

Irrigation was used to some extent on the forage crops of 83 percent of the farms surveyed. The remaining farms either had no irrigation facilities or did not use them on their forage crops during the 1957 crop year.

<u>Type of analysis</u>

Two approaches were used in the analysis of data in this study. One approach presents the conditions actually found on the farms surveyed. The other uses a synthetic farm situation in which some of the inter-farm variables are held constant.

The first section of this thesis is devoted to presenting the equipment inventories, labor use, and harvesting costs as they existed on farms in 1957. Averages and ranges of these factors are presented for the alternative harvesting methods.

A synthetic farm situation is used in the second section to determine the difference in costs of harvesting under the alternative methods. Data secured in the survey were used to synthesize costs under this farm situation. These cost differences are used to determine the increase in forage production necessary to offset any additional costs of harvesting under the alternative methods.

LITERATURE REVIEW

Attempts by dairymen to produce more forage per acre or to produce forage at a lower cost per pound of digestible nutrient have led to the introduction and trial of various methods of pasturing and mechanical grazing of forage plants. These trials have included research designed to compare continuous grazing, rotational grazing, daily ration grazing, and green chopping. Also several studies have been conducted on methods and costs of producing and harvesting silage to serve as a succulent feed during the winter or barn feeding period. This chapter presents a summary of the findings of these studies.

Forage Harvesting Trials

Chesnutt, of Oregon State College, conducted an experiment in 1954 comparing the productivity of irrigated pasture under rotational and strip grazing. (8, p.14-17) Fourteen lactating dairy cows were used to harvest the forage over a 96 day pasture season. The strip grazed pasture produced a significantly greater amount of total digestible nutrients (hereafter referred to as TDN) per acre. Strip grazing yielded 4,145 pounds of TDN per acre as compared with 3,560 pounds per acre for rotational grazing - a 16 percent greater yield.

Daily ration grazing also gave a greater production than rotational grazing in experiments conducted in England and Alaska. Brundage and Sweetman calculated a 22 percent greater yield under strip grazing. (6, p.936) Two groups of six Ayrshire cows were used in a 116 day grazing trial conducted in England. (16, p.391) The increased production was expressed in terms of gallons of milk produced per acre. The study indicated a 28.5 percent greater yield under daily ration grazing.

A report by Hoglund stated that farmers in Michigan who chopped and hauled forage to their cows used 25 percent less acreage per cow of both first and second crop forages. (15, p.631-636) The gain from increased forage yield was partially offset by an average increased investment in forage harvesting and feeding equipment of $1,200 per farm.

Average milk production response was near the same for green chop fed and rotational grazed cows for the first part of the forage season. Milk flow from the green chop group leveled off about July 20 at a point approximately 15 percent above average for the winter barn feeding period. Cows on pasture continued a steady downward trend in milk production from a peak flow in May till the end of the pasture season.

Hoglund stated that the profitability of green chopping in Michigan depended primarily upon timely use of the forage saved. The extra forage may be used to provide a more adequate forage supply towards the end of the pasture season or during the winter feeding period. Size of herd also may be increased with the extra forage.

The relatively new practice of strip grazing reduced pasture acreage from that required for rotational grazing by the same percentage as green chopping according to the Michigan report.

Experimental work at Pennsylvania indicated that average production of forage per acre may be increased 25 percent by green chopping as compared with rotational grazing. (22, p.3-4) The report stated that green chopping is best adapted to conditions where size of dairy enterprise is limited by land resources.

Advantages of green chopping stated in this report were similar to those given in other reports on green chopping. The major advantage reported was greater utilization of forage than is achieved by either continuous or rotational grazing. Green chopping avoids losses from selective grazing, trampling, and refusal due to droppings. Also it lessens damage to soil and plants from compaction and less energy is expended by cows in obtaining the forage component of their ration.

The most commonly stated disadvantage of green chopping was the added capital investment required for harvesting machinery. Green chopping increases the labor and power requirements. Also daily chopping may interfere with other farm work during peak labor periods.

A progress report from Rhode Island also reported a greater yield from soilage feeding (green chopping) than grazing. (13, p.936) The pasture area required per cow was 1.7 acres for soilage fed cows and 3.1 acres for pastured cows. This was a 45 percent reduction in pasture area under green chop.

Continuous grazing was compared with rotational grazing and daily ration grazing at Ohio and Minnesota. Continuous grazing gave a lower yield in both trials. The Ohio study comparing rotational with continuous grazing reported that during a three year trial rotational grazing yielded an average of 42 percent more TDN per acre. (9, p.8)

Four sets of monozygotic dairy cattle twins were used as grazing animals in the 1951 trial conducted at Minnesota. (5, p.623-630) Production of digestible nutrients per acre of pasture was nearly three times greater under the daily ration method.

Green chopping and daily ration grazing were compared in three trials. A greater yield was obtained under daily ration grazing in two of the trials and green chopping in the other.

In 1955 forty lactating cows were used at Oregon State College in a 107 day grazing trial to compare yields from strip grazing with yields from green chopping. (8, p.14-17) Strip grazing yielded 2,288 pounds TDN per acre while green chopping produced 1,267 pounds per acre. There was an additional 2,133 pounds TDN per acre taken off both fields in the form of either hay or silage. The low productivity of the green chopped acreage was attributed to two factors; the forage plants were of a low growing type not favorably adapted to harvesting with a field chopper, and mechanical conditions that permitted abnormally high wastage. The report stated that green chopping will definitely yield a greater amount of forage when plant species are used that make rapid and tall growth above stubble height.

Smith and Keyes reported a 1.1 percent greater yield under daily ration grazing than green chop in a 70 day trial conducted in Montana. (29, p.43) For this trial twenty seven cows were divided into three groups. In addition to the groups on daily ration and green chop one group was placed on a 10 day pasture rotation.

During the 70 day trial the daily ration group consumed the greatest amount of TDN per acre. The green chop method produced 6.4 percent and the daily ration method 7.6 percent more TDN per acre than rotational grazing.

The trial which gave a greater yield under green chop than under daily ration grazing was part of an experiment conducted in California that compared pasture yields under daily ration grazing, green chopping, rotational grazing, and wilt soiling. (20, p.37-43) Green chopping resulted in 69 percent greater beef production per acre than rotational grazing, daily ration grazing only a 36 percent greater yield.

No literature was found which dealt directly with the economic feasibility of an all-silage harvesting program. However, since many problems encountered in an all-silage program are similar to those arising when silage is used as a winter feed, much of the published material on silage is applicable to an all-silage program.

Handling forage growth in excess of herd requirements during the lush growing season gives rise to problems under all harvesting methods. Maximum utilization of this forage requires that it be harvested at its optimum nutrient level. This usually entails harvesting it for either hay or silage. Rauchenstein published figures on the profitability of harvesting this forage as hay and as silage. (27, p.628-642)

The principal cause of loss from field curing hay in Wisconsin was leaching of nutrients due to rain. Based on 1954 hay prices in Wisconsin, and an average yield of 1.3 tons per acre, savings of from $2.75 to $4.45 per acre resulted from harvesting alfalfa as silage rather than as hay. Oregon dairymen are faced with a similar problem of weather damage to early season cuttings of forage crops.

Ensiling Process and Nutrient Losses

The ensiling process results in certain chemical and bacteriological changes which take place both in the field and in the silo. These changes result in a loss of nutritive value from the forage as it stands in the field. This thesis is concerned with the economics of silage harvesting. Thus, chemical and bacteriological changes in the ensiling process will be considered only as they effect the value of silage through loss of nutrient value.

Nutrient losses in silage are dependent upon many factors. Research conducted in this area has resulted in a wide range of figures for the various types of losses. Some losses are to a large extent controllable by the operator, others are subject to little or no control.

Field loss of dry matter is of less importance since the wide adoption of field choppers with direct cut attachments. (27, p.4) Rauchenstein stated that loss of dry matter in the field did not exceed two percent until moisture content of the forage dropped below 70 percent. Dry matter loss in the field increased rapidly as the moisture content of forage dropped below 70 percent.

The remaining loss of nutrients occurs while forage is in the silo. Losses in the silo come chiefly from three sources; top spoilage, seepage of juices through the bottom or sides of the silo, and fermentation. (23, p.239-256) There also is a partial loss of nutrients from forage immediately below the top spoilage. This silage, although feedable, has neither the quality or palatability of silage further down in the silo. In silos with poor drainage there may be some silage at the bottom which becomes lowered in palatability.

This report stated that top spoilage varies with the amount of silage and height of silo, assuming equal compaction of the forage. Other factors such as condition of silo, use of a cover, etc. will effect the amount of top spoilage. Top spoilage was estimated to average 6.1 percent for a 24 foot upright silo and 3.3 percent for a 36 foot upright silo.

Dry matter losses from seepage over seven years of trials using a 100 ton capacity wood silo ranged from .12 to 1.08 percent. The average loss from seepage of juices was .54 percent of the dry matter.

Extensive tests by Vermont workers show an average intangible or unaccountable loss of 11.5 percent of the dry matter. However, the accuracy of fermentation loss figures was questioned since volatile products are often driven off as moisture in the oven-drying method of moisture determination.

Chemical analysis of feed coming out of the silo indicated it was not materially different from the crop going into the silo. The digestion coefficient for crude protein was lowered by excessive heating. However, in silos where little heating took place the digestibility was little affected.

Seepage losses from tower silos varied with the moisture in the crops when placed in the silo according to a report by New Jersey workers. (1, p.13) Dry matter loss through seepage was 10 percent when the crop ensiled contained 85 percent moisture. Seepage dry matter losses dropped to one percent when the crop contained 70 percent moisture and no loss was recorded with a moisture content of 65 percent.

Seepage losses amounting to 13.5 percent of the total dry matter in the ensiling of an alfalfa and bromegrass mixture at 82.4 percent moisture were reported by a group of Illinois workers. (12, p.619)

Allred and Kennedy reported juice and fermentation losses in untreated silos ranged from 11.9 to 27.4 percent of the total dry matter. (2, p.308-313) Silage treated with sodium meta bisulfite at eight pounds per ton of silage had a range in dry matter loss of from 9.8 to 22.4 percent of the total dry matter.

Stallcup, of Arkansas, reported dry matter losses in the ensiling process with different types of preservatives. (30, p.7-11) In an oat silage experiment the use of calcium formate at 10 pounds to the ton of silage resulted in a dry matter loss of 6.3 percent. The control silo had a dry matter loss of 14.4 percent. Untreated third cutting alfalfa harvested in the early bloom stage and placed in the silo at 82 percent moisture had a 7.5 percent loss of dry matter.

An experiment conducted by Bateman in 1954 compared dry matter losses in alfalfa silage when using eight pounds sodium meta bisulfite per ton of silage with losses when using 200 pounds of molasses dried beet pulp per ton of silage. (3, p.60-67) Juice loss from the silo in which sodium meta bisulfite was used resulted in loss of 14.86 percent of the dry matter. Juice loss in the silo where molasses dried beet pulp was used had a total dry matter loss of 3.76 percent and a forage dry matter loss of 5.17 percent. Unaccountable or fermentation dry matter losses were 5.48 percent with sodium meta bisulfite and 7.15 percent with molasses dried beet pulp.

Huber and Ewalt reported that with well made silage, the loss of nutritive value will usually be five to ten percent of the total value of the original forage. (17, p.3) Top and side spoilage in trench and stack silos is relative to the depth and exposed surface area. Poor compaction and leaching due to excessive rainfall on open trench and stack silos will reduce both the nutritive value and palatability of silage. The losses in poorly constructed open trench and stack silos, could easily amount to forty or fifty percent and in some cases the total loss of feeding value of the ensiled crop.

The cost per ton of silo storage capacity varies with the size and type of silo construction. Magee reported that in the Blackland and Grand Prairie area of Texas the unlined trench, lined trench, and upright type silo predominate. (21, p.4-6) The major difference among the three types was the cost of construction. The average investment per ton storage capacity for a 150 ton capacity silo was $.73, $7.40, and $12.65 for unlined trench, lined trench, and upright type silos respectively.

Cost per ton of storage capacity is lowered as the capacity of the silo increases. The practical size of a silo is limited by the number of cows in the dairy herd. During periods of warm weather sufficient quantities of silage must be fed each day to keep silage fresh and avoid spoilage.

An offsetting factor to the advantage of lower construction cost for trench silos was the increased spoilage due to a larger area being exposed to the atmosphere. Spoilage in both lined and unlined trench silos averaged eight percent, whereas, spoilage in upright silos averaged only four percent. The short life of unlined trench silos partially offset their advantage in low cost of construction.

Bohstedt stated that the type of silo is unimportant as long as it excludes air and provides a means for the compression of the silage. (4, p.337)

MACHINERY INVENTORIES UNDER ALTERNATIVE METHODS

The method of forage harvesting practiced on a farm will influence the investment in machinery inventory. Other factors such as acreage of farm, type and acreage of crops grown, and size of cow herd also will affect machinery inventories on individual farms.

Table 1 presents the average acres per farm, acres of forage crops, acres of other cultivated crops, and the average number of cows per farm under the alternative harvesting methods. These conditions, in conjunction with the method of forage harvesting, will influence both the size and kind of machinery inventory found on the farm.

Table 1. Land use and size of cow herd under alternative harvesting methods

Method of Harvesting	Average number of acres			Average No. of cows per farm
	Farm	Forage crops	Other cultivated crops	
All-silage	107	47	39	36
Green chop	146	66	59	55
Daily ration	170	98	43	67
Rotational	190	80	66	46

Investment in Inventory of Forage Production and Harvesting Machinery

The average investment in both forage production and harvesting machinery found on the farms appears in Table 2 of the text. The investment figures have an upward bias since much of this machinery also was used for enterprises other than forage production. An

Table 2. Investment per farm and per cow in farm machinery used in forage production and harvesting under alternatives harvesting methods 1957

Type of Equipment	Average investment in farm machinery							
	All-silage		Green chop		Daily ration		Rotational	
	Per Farm	Per Cow	Per Farm	Per Cow	Per Farm	Per Cow	Per Farm	Per Cow
	$	$	$	$	$	$	$	$
Field chopper	794	22	797	15	1061	16	516	11
Rake and baler	—	—	477	9	449	7	767	17
Conveyances	773	22	537	10	310	5	780	17
Elevators & blowers	434	12	385	7	400	6	335	7
Tractors /1	1758	50	2300	42	2034	30	1689	37
Mowers	20	1	106	2	104	2	100	2
Cultural equipment /2	3452	97	3848	70	3880	58	3067	67
Fences	--/3	--/3	--/3	--/3	541	8	157	4
Total	7231	204	8450	155	8779	132	7411	162

/1 Includes all tractors on farm
/2 All cultural equipment including irrigation system
/3 Fences excluded since not required under these methods of harvesting forage

inventory of the individual items of machinery on each farm appears in Table 2 of the Appendix. The depreciation schedule used for computing the depreciated values of machinery appears as Table 1 of the Appendix.

An inventory of machinery capable of both production and harvesting of forage was found on most farms. However, methods of harvesting forage are of primary concern in this paper with production techniques of secondary concern. The most common inventory of forage harvesting machinery on those farms surveyed included; a field chopper, forage blower or elevator, chopper wagons or trucks, mower, rake, and from one to three tractors. Field choppers were both auxillary engine and power take-off models. Forage pick-up attachments for the field choppers on individual farms included direct cut, windrow, and row crop types.

The wide ownership of field choppers is explained by the need of farmers for a means to harvest excess forage growth in the spring months. Harvesting of first cutting pasture growth for silage was popular due to the danger of rain damage. Silage was used as a winter feed by all the dairymen in this study except one. There were two farms that hired custom operators to harvest their silage and therefore did not include ensiling equipment in their machinery inventory.

Investment in Harvesting Machinery Used Under Alternative Methods

Table 3 gives the investment per cow in forage harvesting machinery used only for harvesting feed requirements during the pasture season under the method by which the farms were classified. Only the number of tractors used to perform the harvesting operations are included. On those farms having more than this number of tractors the figure is an average depreciated value of all tractors on the farm.

Table 3. Average investment per cow for forage harvesting machinery used under alternative methods to furnish feed during the pasture season

Type of equipment	Average investment per cow			
	All-silage	Green chop	Daily ration	Rotational
	$	$	$	$
Field chopper	22	15	—	—
Conveyances	12	5	—	—
Elev. & blowers	10	—	—	—
Tractor	50	19	10	16
Mower	—	—	2	2
Fences	—	—	8	4
Total	94	39	20	22

Table 3 does not include investment in silos. The average silo space provided per cow for all farms in the survey was 323 cubic feet. This compares with an average of 253 cubic feet provided by the two farms under the all-silage method. Thus, it is assumed that unless herd size is increased upon changing to an all-silage program, most farms would not be required to construct additional silo storage.

Investment in forage harvesting machinery was greatest under the all-silage method. The differences in investments under the alternative methods as shown in Table 3 are partially attributable to unequal herd sizes among the methods.

If the machinery inventory under each method were capable of furnishing forage for a 60 cow herd and no additional silo space were required under an all-silage program the following investments per cow, adjusted to a 60 cow herd, would result:

Method of harvesting	Investment per cow
All-silage	$ 56
Green chop	36
Daily ration grazing	17
Rotational grazing	22

The all-silage harvesting method used one or more tractors, field chopper, chopper wagons, and either an elevator or blower for placing forage in the silo. Green chopping used the same machinery as an all-silage program except that no elevator or blower was needed and only one wagon for transporting the forage. Grazing methods required fencing and a tractor and mower for pasture clipping. It should be understood that all but two of the farms under grazing programs also maintained an inventory of ensiling machinery which is not shown in Table 3.

The use of averages to indicate machinery investments per farm or per cow fails to disclose some of the important differences among farms. Table 4 presents the ranges in per farm and per cow investment for forage harvesting equipment used only in performance of the harvesting method by which the farms are classified.

Table 4. Ranges in investment per farm and per cow for forage harvesting machinery under alternative harvesting methods

Method of Harvesting	Investment in forage harvesting machinery			
	Per Farm		Per Cow	
	Low	High	Low	High
	$	$	$	$
All-silage	3296	3407	94	95
Green chop	360	3464	8	81
Daily ration	338	3390	7	31
Rotational	113	2360	4	39

The farms with low investments have pieces of machinery in their inventory that are old enough to be nearly, or completely depreciated out, according to the depreciation schedule used in this study. Size of dairy herd in relation to value of machinery inventory explains part of the wide variation in investment per cow.

LABOR USE UNDER ALTERNATIVE HARVESTING METHODS

The length of pasture and green chop season varied considerably among individual farms. The harvest season varied from 29 days under green chop to 210 days under rotational grazing.

These wide variations in length of harvesting season make figures on labor use per season unrealistic for purposes of comparison. Labor used under the selected harvesting methods is expressed in terms of hours of labor per cow per 30 day month during the harvest season. This procedure eliminates the difficulty of comparing labor use for seasons of different length and herds of different size.

Since this thesis is primarily concerned with harvesting methods, only labor for those cultural practices influenced by harvesting is included.

All-Silage Program

Labor used under the all-silage method will be divided into two categories: harvesting or ensiling, and feeding of the ensiled product.

The size of crew for putting up silage may vary among farms. In this study the size of ensiling crew ranged from one to eight men. The tasks included chopping forage in the field, transporting it to the silo, elevating or dumping it into the silo, and compacting the forage.

Operation of the tractor and chopper requires one man. All others are involved in either transporting the forage or placing it in the silo. The size of ensiling crew, method of transporting the forage, and type of silo dictate the disposition of the crew other than the operator of the chopper. One of the two all-silage farms studied used a two man crew exclusively. The other used a three man crew for the first cutting and a two man crew on the remaining cuttings.

The specialized equipment used for chopping and handling forage dictates care in the hiring of labor for ensiling operations. On the farms surveyed the farm owner operated the chopper. Ensiling equipment also requires a competent operator to function at optimum efficiency. In addition, all help utilized for hauling or elevating forage into the silo must be capable of operating machinery.

Table 5 presents the hours of labor used for harvesting and feeding silage on those farms under the all-silage program.

Table 5. Hours of labor used per cow per 30 day month under the all-silage method

Operation	Hours of labor per cow per 30 day month		
		Range	
	Average	Low	High
Harvesting	.68	.34	1.01
Feeding	.74	.64	.83
Total	1.42		

Harvesting labor comprised 48 percent and feeding time 52 percent of the total silage labor. These labor inputs vary with management and degree of mechanization. Labor for feeding will decrease as it is replaced with capital investment in automatic unloading and feeding devices. The same farm was low on both harvesting and feeding labor use. This farm used a two man harvesting crew exclusively. Also it has an automatic silo unloader, whereas, both unloading and feeding are by hand on the other farm. Having only two farms under the all-silage program limits usefulness of these average labor figures. The section in this paper on ensiling costs encompasses a larger number of farms and provides figures on labor use which may be more representative than those in this table.

Elimination of cross fencing under the all-silage program may reduce labor for field operations such as irrigation and fertilization. Regular cutting of the forage may aid in reducing labor for weed control. Dry lotting of cows will increase labor requirements for manure handling since the manure must be physically removed and returned to the land. This may be partially offset by the opportunity, weather permitting, to control the amount and timing of manure applications.

Green Chopping

For green chopping, labor is required to perform the functions of chopping, transporting, and feeding the forage. Four of the six farms that green chopped, cut two loads per day. Generally one load was cut in the morning and another in the afternoon prior to the evening milking. The remaining farms cut only one load per day. On those farms chopping once a day, part of the green forage is fed in the morning, the remainder that afternoon.

One-half of the farms surveyed used two men in the green chopping operation. One man drove the tractor and operated the chopper, the other drove either a truck used to haul the forage or a tractor pulling a wagon into which the forage was blown. Where only one man performed the chopping function he operated the tractor and chopper with a wagon attached.

Loads varied in size according to the number of cuttings per day and size of herd. Loads ranged from 1.5 to 5.5 tons with an average for all farms surveyed of 3.3 tons.

Time required for cutting of green chop will vary with size of chopper and yield of forage per acre. Hauling time is dependent upon the method of hauling and distance from barn to field. Unloading time varies with the degree of mechanization, which ranged from mechanical unloaders to throwing the forage off by hand.

Labor used for the three operations of cutting, hauling, and unloading are presented in Table 6.

Table 6. Hours of labor used per cow per 30 day month under the green chop method

Operation	Hours of labor per cow per 30 day month		
		Range	
	Average	Low	High
Cutting forage	.70	.13	2.14
Hauling forage	.22	.10	.71
Unloading forage	.60	.00 /1	1.43
Total	1.52		

/1 Self-fed from wagon

Cutting time represented the largest portion of the labor, comprising 46 percent of the labor hours. Unloading time represented 39 percent of the green chop labor. One farm used a self-feeding wagon which reduced unloading labor to merely unhitching the wagon. Two farms had chopper wagons equipped with mechanical unloading devices. Unloading time on these two farms was one-fourth of that on the three farms that unloaded their green chop by hand. Hauling time represented the smallest portion of the labor with 15 percent utilized for travelling to and from the field.

Mechanical removal of forage permits elimination of cross fencing under green chop as it did under the all-silage program. Similarly, this may reduce labor used for irrigation and tractor field work. Dry lotting of the herd increases labor required for manure handling.

Daily Ration Grazing

Labor used for daily ration grazing falls into two categories: moving cows and fence, and clipping and harrowing of pastures. The first category involves walking to and from the pastures and in some instances the moving of a short piece of electric fence. Clipping and harrowing require labor capable of operating a tractor and farming equipment.

Labor for clipping and harrowing has been included since these operations are practiced when forage is pastured rather than removed mechanically. Clipping was designed to aid in weed control, prevent clumping of grasses, and to scatter droppings. Harrowing was done to break up and scatter droppings.

The hours of labor used for moving cows varies with distance to fields, speed of the individual worker, and whether any fence is moved. On some farms the cows go to pasture by themselves and only need to be gone after at milking time. It is necessary on other farms to walk both in taking the cows to and returning them from pasture.

Labor used in moving cows, moving fence, clipping, and harrowing pastures appears in Table 7. Labor for moving cows and fence was computed from daily time figures given by the farm operators. Clipping and harrowing times were computed for the pasture season on each farm. The season was then broken down into 30 day periods and clipping and harrowing labor allocated to these periods.

Table 7. Hours of labor used per cow per 30 day month under the daily ration grazing method

Operation	Hours of labor per cow per 30 day month		
		Range	
	Average	Low	High
Moving cows	.16	.07	.20
Moving fence	.02	.00 /1	.09
Clipping pasture	.07	.03	.15
Harrowing pasture	.01	-- /2	-- /2
Total	.26		

/1 Four farms did not move any fence
/2 Only one farm harrowed pastures

Moving cows was the largest item of labor under daily ration grazing, comprising 62 percent of the total labor hours. Clipping of pastures was next in importance, representing 27 percent of the labor. Moving fence and harrowing were of less importance, comprising only 11 percent of the total.

Rotational Grazing

For rotational grazing, labor is required for moving cows to and from pasture, clipping, and harrowing, as with the daily ration method.

Forty five percent of the farms surveyed clipped their pastures only once during the season. The remaining farms clipped either two or three times with the exception of one farm which clipped eight times and one that did not clip at all this year. Only three farms harrowed their pastures and each only once during the season.

Table 8 presents the hours of labor used for moving cows, clipping, and harrowing under the daily ration method.

Table 8. Hours of labor used per cow per 30 day month under the rotational grazing method

Operation	Hours of labor per cow per 30 day month		
		Range	
	Average	Low	High
Moving cows	.27	.10	.50
Clipping pastures	.16	.06 /1	.57
Harrowing pastures	.01	.02 /2	.05
Total	.44		

/1 Excluding farm that did not clip pasture this year
/2 Excluding farms that did not harrow pastures this year

Moving cows used the largest amount of labor under rotational grazing, comprising 61 percent of the total labor hours. Clipping pastures represented 36 percent of the labor with harrowing accounting for the remaining three percent.

Summary of Labor Use

The hours of labor used under the alternative harvesting methods are summarized in Table 9. Averages and ranges are presented for each method. These figures indicate that harvesting methods utilizing animals to remove the forage used considerably less labor than mechanical harvesting methods.

Table 9. Summary of hours of labor used per cow per 30 day month under alternative forage harvesting methods

Method of Harvesting	Hours of labor per cow per 30 day month		
		Range on farms	
	Average	Low	High
All-silage	1.42	.98	1.84
Green chop	1.52	.37	2.88
Daily ration grazing	.26	.10	.38
Rotational grazing	.44	.17	.85

Lower labor use per cow on farms under daily ration grazing compared with farms using rotational grazing may be partially explained by the fact that these farms averaged 21 more cows per farm. Also the cows were confined to a smaller area under daily ration grazing which lessened the walking time involved in returning the cows from pasture.

COST OF HARVESTING FORAGE UNDER ALTERNATIVE METHODS

Forage costs are incurred in two different time periods, the pasture season and the non-pasture or winter barn feeding season. This chapter refers only to those costs incurred during the pasture season.

Differences in herd size and length of pasture season make it difficult to compare cost data for different farms. In order to express the costs for all methods and farms on the basis of a common denominator they have been presented on a per cow per 30 day month basis. This method takes into account differences in variable costs. However, a bias remains from the allocation of fixed costs. Those farms with larger herds and longer pasture seasons have the fixed costs allocated over a larger number of 30 day cow months. This has resulted in a downward bias in costs on these farms.

The costs of harvesting forage are divided into three main categories; variable cash costs, fixed non-cash costs, and labor expressed as hours used, rather than at a dollar cost. These harvesting costs are presented in Table 10 for the alternative methods.

Variable Cash Costs

Fuel and lubricants

Variable cash costs are divided into two sections: fuel and lubrication expense and repairs expense.

Table 10. Summary of costs and labor hours used per cow per 30 day month under alternative forage harvesting methods 1957

Item of cost	Method of harvesting forage							
	All-silage		Green chop		Daily ration		Rotational	
	Cost	% of total	Cost	% of total	cost	% of total	Cost	% of total
	$	%	$	%	$	%	$	%
Variable cash costs								
Fuel and lubricants	.32	17	.83	33	.04	10	.10	18
Repairs								
Machinery	.15	8	.32	13	.03	8	.05	9
Fence	—	—	—	—	.09	23	.20	36
Total cash costs	.47	25	1.15	46	.16	41	.35	63
Fixed non-cash costs								
Depreciation								
Machinery	1.09	58	1.08	43	.05	14	.12	21
Fence	—	—	—	—	.12	31	.04	7
Interest on investment								
Machinery	.32	17	.27	11	.01	3	.02	5
Fence	—	—	—	—	.04	11	.02	4
Total non-cash costs	1.41	75	1.35	54	.23	59	.21	37
Total variable and fixed costs	1.88	100	2.50	100	.39	100	.56	100
Labor in hours	1.42		1.52		.26		.44	

Fuel costs are based on the actual hours which each machine was operated in the harvesting process. During the survey an attempt was made to secure fuel consumption data from farmers. However, in most instances the farmers were unable to furnish what they considered reasonably accurate fuel consumption data. Therefore, fuel consumption for tractors under rated load capacity has been taken from the, "Nebraska Tractor Tests". (26) The horsepower rating of each tractor and hours of operation were secured from the farmers.

Lubrication charges also are based on hours of use and horsepower rating. Consumption figures were taken from the laboratory manual and workbook, "Farm Power and Machinery Management." (18, p.14)

Prices were applied to these consumption figures to arrive at the fuel and lubrication costs. Gasoline was priced at 21.3 cents per gallon and oil at 95 cents per gallon. On those farms where a truck was used to transport forage, fuel costs were based on data in the publication, "Machinery Costs and Related Data." (28, p.1) Fuel costs per hour of operation in this study were adjusted to 1957 price levels by use of an index of prices paid by farmers for motor supplies.

Table 10 indicates that fuel and lubrication costs were highest for green chopping. The average was 83 cents per 30 day cow month as compared with 32, 10, and four cents for all-silage, rotational grazing, and daily ration grazing, respectively. This item represented one-third of the cost of green chopping. The high charge may be partially attributed to the amount of time spent driving to and from the field relative to actual cutting time. Fuel expenses for green chop were increased by the use of trucks for transporting forage on three of the six farms. Fuel costs on green chop farms ranged from a high of \$1.51 to a low of 26 cents. The high cost farm used a truck for hauling forage. The farm with the lowest cost used a one man operation with an automatic unloader in the chopper wagon.

Fuel and lubrication cost differed significantly between the two grazing methods. Daily ration farms had only 40 percent as great a fuel and lubricants cost. This can be partially attributed to the use of less forage acreage per cow under daily ration grazing.

Repairs

Repair charges for machinery were based on hours of actual operation. Total annual hours of use for each machine were secured from the farmers along with hours of use for harvesting forage. Assuming that machinery repairs are a function of use, hours of operation was considered the most appropriate method for allocating this cost.

Green chopping had the highest machinery repair charge at 32 cents per 30 day cow month. There was a range in repair costs among farms of from 14 to 60 cents. All-silage, the other mechanical harvesting method, had the second highest machinery repair cost at 15 cents. Machinery repairs for the grazing methods were considerably less, since the only repairs were on a tractor and mower used for clipping pastures.

Fence repairs were charged only on those farms classified under a grazing program. Each dairyman using daily ration or rotational grazing was asked to estimate the average annual cost of materials for fence repairs. The percent that 30 days was of the individual farms grazing season was used to determine the fence repair charge. Labor involved in repairing fence was not included since the time would have been difficult to determine and all labor was either unpaid family or operator labor.

Fence repairs were over twice as great for rotational as for daily ration grazing. Thirty six percent of the total cost of harvesting under rotational grazing was represented by fence repairs. This is contrasted to only 23 percent for farms under daily ration.

Fixed Non-Cash Costs

Depreciation

The depreciation schedule used for determining the annual charge on machinery appears in Table 1 of the Appendix. A straight line depreciation schedule was used and the charge was made against each method according to the percent of total hours of operation under that method.

Depreciation on fencing was charged on the basis of current replacement costs because of the lack of information on original cost of fencing.

Depreciation was a major item of cost under all harvesting methods. It was approximately the same for both mechanical methods - $1.09 for all-silage and $1.08 for green chop. Table 10 shows that

58 percent of the cost of the all-silage program was depreciation, whereas, it was only 43 percent of the cost of green chopping. This may be explained by the need for a larger equipment inventory, such as wagons and a blower under all-silage. No depreciation was charged on the silos of all-silage farms since neither built additional storage when changing to the method. Silo depreciation was considered a function of time rather than use.

Machinery depreciation under daily ration grazing was 42 percent of that under rotational grazing. However, fence depreciation was three times greater. Fence depreciation was the largest single item of cost under daily ration grazing, representing 31 percent of the total cost. This resulted from the need for large amounts of fencing material to construct the many cross fences.

Interest on investment

Computation of the charge for interest on investment presented two problems. The first was determination of a method for allocating the cost and second was determination of an applicable interest rate. Allocation of the charge was based on the percent of annual hours of operation that machines were used for harvesting under each method. Opportunity costs would have been the optimum rate to charge. However, since this was not determined an arbitrary rate of six percent was used.

Interest on investment charged for machinery was computed on its depreciated value. One-half the replacement cost for materials was used as the basis for charging interest on investment in fencing. The only fencing considered in this study was that used to cross-fence normal fields. Line and field boundary fencing were not included because, in most cases, this fencing would be present regardless of forage harvesting method.

The type and total length of cross fencing were determined on each farm. This information was used to compute materials cost for a similar amount and type of fencing. No labor charge was included in the replacement cost of fencing.

The all-silage method, using the largest inventory of harvesting equipment, had the highest interest on investment charge. This charge represented 17 percent of the total harvesting costs. Green chop farms averaged five cents less per 30 day cow month, the charge representing only 11 percent of the total harvesting costs. Interest on investment was five cents per 30 day cow month for both grazing methods. Eighty percent of the charge was for fencing under daily ration grazing but only 40 percent under rotational grazing. The total interest on investment charge for daily ration farms was 14 percent of the harvesting costs as compared with nine percent on rotational grazing farms.

Miscellaneous fixed costs

No charge was made for taxes, insurance, or shelter. These expenses vary according to county tax rate, insurance rates, and facilities available on the farm for equipment storage.

Labor Costs

No value was placed on the man hours of labor used due to the difficulty of determining an applicable rate to charge in each case. Labor on the farms was of five classes: operator, other unpaid family, full time hired, seasonally hired, and exchange labor. Thus, labor has been presented as man hours per cow per 30 day month. No further elaboration on labor was made since the preceding chapter was devoted to this subject.

Summary of Costs Per Cow Per 30 Day Month

Daily ration grazing resulted in the lowest harvesting cost and labor hours used. The cost per 30 day cow month was 39 cents compared with 56 cents for rotational grazing, the next lowest. Economies of larger herd size and longer pasture season have caused some bias in favor of the daily ration method.

The two mechanical removal methods resulted in the highest harvesting costs. Green chopping was the most expensive method costing $2.50 per cow per month. This is $2.11 greater than under daily ration grazing, the least cost method, and 62 cents more than the all-silage method.

As indicated in Table 10, non-cash items represented 75, 54, 59, and 37 percent of the harvesting costs under all-silage, green chop, daily ration, and rotational grazing methods respectively. Removal of non-cash items results in placing the all-silage method in a relatively more favorable position since it had the largest percentage of non-cash costs.

The large inventory of machinery used under the all-silage program resulted in its costs being dominated by depreciation and interest on investment in machinery. Rotational grazing was at the other extreme being the only method with over 50 percent of its harvesting costs represented by variable cash items.

Ranges in Costs Among Farms

Table 11 was designed to indicate how the costs on individual farms varied within the methods.

Table 11. Distribution of harvesting costs per cow per 30 day month for individual farms under the alternative harvesting methods

Cost per cow per 30 day month	Number of farms within cost range			
	All-silage	Green chop	Daily ration	Rotational grazing
$				
.00 - .20	-	-	-	-
.21 - .40	-	-	4	4
.41 - .60	-	-	2	2
.61 - .80	-	-	1	2
.81 - 1.00	-	-	-	2
1.01 - 1.20	-	-	-	-
1.21 - 1.40	-	-	-	1
1.41 - 1.60	1	1	-	-
1.61 - 1.80	-	-	-	-
1.81 - 2.00	1	1	-	-
2.01 - 2.20	-	-	-	-
2.21 - 2.40	-	1	-	-
2.41 - 2.60	-	1	-	-
Over 2.60	-	2 /1	-	-
No. of farms surveyed	2	6	7	11

/1 Costs were $3.15 and $4.16

Use of averages in presenting the costs for each method fails to disclose some important variations within the methods. This distribution of costs indicates that although averages may be presented to show harvesting costs under alternative methods they may not be representative of those encountered on an individual farm.

Costs of Cutting and Ensiling Forage

Determination of the economic feasibility of an all-silage method of forage harvesting was limited by the fact that there were only two farms under this method. Additional information on the cost of harvesting silage was needed to facilitate a more thorough analysis of the method. It was for this purpose that silage harvesting costs were determined on an additional 23 farms.

Costs of harvesting both grass and corn silage were determined. The corn silage figures were included even though neither all-silage farm used this feed in 1957. It may be desirable on some farms to produce a late season ensiling crop to use in filling the silo for winter feed. Corn is one of the more popular crops for this purpose.

Allocation and method of presenting costs

Costs of harvesting silage were allocated in a manner similar to that used earlier in this chapter. Variable cash costs and fixed non-cash costs are the two major categories. Fuel and lubricants are charged at the same rates as under the four harvesting methods already presented. Equipment repairs, depreciation, and interest on investment were charged on a percent of total annual usage basis. Labor for harvesting is presented in physical units rather than in value terms. Feeding labor for the silage was not included. The costs are presented in terms of cost per ton of silage placed in the silo.

Cost of harvesting grass silage

Records on the cost of harvesting grass silage were taken from 25 farms. The records from two farms which hired silage put up by custom operators were not used in compiling the table.

Non-cash expenses accounted for 60 percent of the total cost of harvesting grass silage. Depreciation on harvesting equipment was the largest item accounting for 49 percent of the total expense.

Table 12. Cost and hours of labor used per ton in the harvesting of grass silage 1957

Item of cost	Cost per ton	Percent of total
	$	%
Variable cash costs		
Fuel and lubricants	.54	28
Repairs on machinery	.23	12
Total cash costs	.77	40
Fixed non-cash costs		
Depreciation on machinery	.95	49
Int. on investment in machinery	.22	11
Total non-cash costs	1.17	60
Total variable and fixed costs	1.94	100
Labor in hours	.93	

There was a wide range in harvesting costs among farms. The lowest cost was $1.06 per ton on a farm putting up 916 tons of grass silage. Highest cost was $4.32 per ton on a farm putting up 252 tons. The correlation between tonnage of grass silage put up per farm and harvesting cost per ton indicated that 37 percent of the variation in harvesting cost among farms was explained by the number of tons ensiled.

All classes of labor were grouped together in determining the hours of labor used per ton of silage. This included operator labor, unpaid family labor, and hired labor. The largest portion was hired labor accounting for 56 percent of the total. Operator labor was next in importance accounting for 33 percent of the labor, and unpaid family labor the remaining 11 percent.

Cost of harvesting corn silage

A total of 11 records on the cost of harvesting corn silage were taken from farmers. Two of these farms had their corn custom ensiled and their records were not used in compiling this table.

The cost per ton for harvesting corn silage was 54 percent of that for harvesting grass silage. The distribution of costs was similar to that for grass silage with non-cash costs amounting to 62 percent of the total, and depreciation accounting for one-half of the total costs. Lowest cost of harvesting was 68 cents per ton on a farm which ensiled 1,700 tons. The highest cost was $2.54 per ton on a farm harvesting 68 tons.

Table 13. Cost and hours of labor used per ton in the harvesting of corn silage 1957

Item of cost	Cost per ton	Percent of total
	$	%
Variable cash costs		
Fuel and lubricants	.25	24
Repairs on machinery	.15	14
Total cash costs	.40	38
Fixed non-cash costs		
Depreciation on machinery	.52	50
Int. on investment in machinery	.13	12
Total non-cash costs	.65	62
Total variable and fixed costs	1.05	100
Labor in hours	.41	

Labor used per ton was 44 percent of that used for grass silage. Hired labor was the most important class accounting for 59 percent of the total. Operator labor was next with 35 percent, the remaining six percent being unpaid family labor.

One farm produced 59 percent of the total corn silage in this study. If this farm were excluded, cost of harvesting on the remaining farms averaged $1.58 per ton. Labor used on the remaining farms averaged .66 hour per ton.

Due to the small number of farms and the dominance of one large producer no correlation was computed between tonnage per farm and harvesting cost per ton.

EFFECT OF THE ALL-SILAGE HARVESTING METHOD ON THE TOTAL FARM ORGANIZATION

Land Use Under Alternative Harvesting Methods

Size of dairy herds ranged from 30 to 122 cows on the farms surveyed. However, in all cases dairying was an important enterprise and in most cases the major enterprise on the farm. Seventy seven percent of the farms devoted over one-half of their improved cropland to forage production.

The improved acreage not devoted to forage production was used for grain, cannery crops, seed crops, and other cash crops. Table 14 gives the major use of land on the farms.

Table 14. Size of farm and land use by method of harvesting - 1957

Method of Harvesting	Average acres in farm	Percent of farm acreage producing			
		Forage crops	Unimproved pasture	Cash crops/1	Farm-lot & waste
		%	%	%	%
All-silage	107	44	--	36	20
Green chop	146	45	15	33	7
Daily ration	170	58	5	25	12
Rotational	190	42	9	38	11

/1 Includes grain fed on the farm

Seventy percent of the cash crop acreage was used for production of grain. Some or all of this grain was fed on the farm. Thus, including unimproved pasture, 78 percent of the farm acreage was devoted to production of feed usable by the dairy herd.

An exact breakdown of the acres used for hay, silage, green chop, or pasture was not determinable since more than one method of harvesting was practiced on most fields during the season. Surplus forage production over immediate herd requirements during certain portions of the growing season necessitated removal and storage of that feed. A common practice was harvesting part of this early season growth for silage. After the first cutting little feed was produced in excess of immediate herd requirements.

Table 15 presents the percentage of improved cropland devoted to forage crops under the alternative harvesting methods.

Table 15. Percent of improved cropland devoted to forage production under alternative harvesting methods

Method of Harvesting	Percent improved land in forage crops		
		Range among farms	
	Average	Low	High
	%	%	%
All-silage	49.2	30.7	100.0
Green chop	57.7	31.6	100.0
Daily ration grazing	69.4	39.8	100.0
Rotational grazing	52.7	14.8	100.0

Dairymen using the daily ration method devoted the largest percent of their improved cropland to forage production. The small figure for all-silage may be partially explained by the fact that there are only two farms in this group.

Two farms under rotational grazing and green chop and one farm each under all-silage and the daily ration method devoted all their improved cropland to forage crops. The two farms under green chop had the smallest cow herds and also the least acreage of improved land of the farms using this method. The farms under rotational grazing each had 60 cow herds. One of these farms had the least and the other third from the least acreage of improved cropland. The daily ration farm had the least acreage and third from the largest herd for the method. Both all-silage farms had similar size herds, however, the farm that devoted all its land to forage crops had only 60 acres of improved cropland compared with 144 acres on the other farm.

The low ranges were similar except for one farm under rotational grazing which was well below that for the alternative methods. This farm did extensive grain and grass seed farming.

Acres of Forage Crops Per Cow

All-silage farms devoted 1.3 acres per cow to forage production. This compared with green chop using 1.2, daily ration 1.5, and rotational grazing farms 1.8 acres per cow. Table 16 presents the average and ranges of acres of forage crops per cow under the alternative harvesting methods.

Table 16. Acres of forage crops per cow under alternative harvesting methods - 1957

Method of Harvesting	Acres of forage crops per cow		
		Range	
	Average	Low	High
All-silage	1.32	1.23	1.42
Green chop	1.19	1.06	1.42
Daily ration	1.46	.77	2.22
Rotational	1.76	.91	2.98

These acreage figures are those found on the farm, they do not indicate that all forage consumed by the herd was produced on this acreage.

The range among farms in the acres of forage crops per cow under the mechanical harvesting methods was rather narrow relative to the range under grazing methods. The grazing methods had both the lowest and highest acreage per cow devoted to forage production. Three of the 18 farms using grazing methods had less than one acre of forage crops per cow. These farms purchased extensive amounts of silage and hay. Only four of the 18 farms devoted in excess of two acres per cow to forage production. Three of these farms produced all their own forage. The other pastured several acres of volunteer grass seed land which in most years would have been cash cropped.

Type of Forage Crops Grown

The most commonly encountered forage crop was a mixture of ladino clover and grasses. This pasture mix accounted for 37 percent of the land in forage production. Other legume and grass mixtures accounted for an additional 14 percent of the forage land. Straight legumes, straight grasses, and corn for silage represented approximately equal proportions of an additional 40 percent of the forage crops. Legume and cereal grain mixtures, used primarily for hay, represented the remaining nine percent.

Table 17 presents a broad classification of the types of crops grown under the alternative methods. A more complete breakdown of crops produced on each farm appears in Table 3 of the Appendix.

Seventy three percent of the legume and grass classification was ladino clover and various grass mixtures. The other legumes were alfalfa, alsike clover, New Zealand clover, and subterranean clover. Perennial ryegrass, alta fescue, meadow foxtail, and orchardgrass were the primary grasses combined with the legumes. Red clover represented 64 percent of the straight legumes, alfalfa 31 percent, the remaining five percent being lotus. Ryegrass, sudan grass, and various native grasses were the major grasses composing the classification of straight grasses. The legume and grain classification was primarily oats and vetch or oats and austrian peas.

Table 17. Type forage crops grown under alternative forage harvesting methods - 1957

Method of Harvest	Percent of total forage crop acreage				
	Legume & grass	Straight legume	Straight grass	Corn silage	Legume & grain
	%	%	%	%	%
All-silage	77.7	—	14.9	—	7.4
Green chop	50.0	9.5	20.4	9.7	10.5
Daily ration	48.8	14.8	12.9	18.8	4.7
Rotational	49.4	16.5	11.5	10.5	12.1

The high percentage of legume and grass mixture under all-silage farms needs to be interpreted with the understanding that only two farms were under this program. High corn production associated with the daily ration method is primarily attributable to one farm having grown 110 acres.

Many different types of crops were grown for silage on the farms surveyed in determining the cost of harvesting silage. The major portion of the grass silage was from legume and grass pasture mixes.

Next most important type was straight legume, the major portion being red clover with a lesser amount of alfalfa and lotus. Straight grasses and legume and cereal grain mixtures were harvested for silage to a limited extent.

Ensiling affords an outlet for all forage plants if they are harvested at their proper stage of growth. Thus, ensiling may serve as a method of harvesting and storing surplus or seasonal crops. Surplus pasture growth, first cutting of red clover produced for seed, and sudan grass are typical examples of seasonal crops adapted to harvesting for silage. If a future shortage of succulent feed is anticipated, crops such as cereal grains or legume and cereal grain mixtures may be ensiled while still green to meet this need.

The time of harvest is a major consideration in determining the crops to be grown under an all-silage program. On those farms where silo storage is a limiting factor it may prove more profitable to produce both an early and a late season crop rather than building additional silos.

Field corn is one of the most popular late season ensiling crops in the Willamette Valley. In some instances it is possible to double-crop short season annuals. Although double cropping was practiced on only one farm, it offers possibilities in areas with irrigation and a growing season of sufficient length.

Influence on Labor

Data on hours of labor used under alternative harvesting methods were presented earlier in the section on labor. This section considers the effect of the distribution of labor requirements during the season and within the day.

Distribution of labor use under the all-silage method falls into two categories. Feeding labor which is distributed evenly throughout the season, and labor used for the ensiling process which is concentrated into one or a group of short periods. This concentration may necessitate the hiring or exchanging of labor rather than relying on operator or family labor. Revision of cropping and harvesting schedules may aid in distributing the ensiling process over time.

Green chopping distributes labor use evenly throughout the season. However, it requires the tying up of a tractor and one or two men either once or twice a day. This was considered a disadvantage of the method by many farmers since it may interfere with other farming operations on those farms not specializing in dairy. The labor problem may be partially resolved on those farms where a supply of family labor is available during the green chop season.

All the farms using green chop also put up silage during the year. Thus, they had a period of concentrated labor use during the ensiling process.

Labor use under grazing programs is evenly distributed throughout the grazing season, except for clipping and harrowing of pastures. Scheduling of these operations is not so critical as to cause conflicts with labor requirements of other enterprises on the farm. All farms using a grazing program except one, ensiled forage for winter feed. The ensiling operation resulted in a period of concentration of labor use similar to that encountered under the alternative harvesting methods.

Affect on Quantity of Forage Produced

Mechanical harvesting methods may increase forage production by various means. These means include: complete removal of all forage from the field and prevention of losses due to selective grazing, trampling, and fecal contamination. In addition the all-silage method permits cutting of all forage at the maximum nutrient stage of growth. This is more difficult under green chop since plant recovery rates differ throughout the season, which often results in cutting some forage plants before reaching proper maturity and some after passing the optimum nutrient stage.

The all-silage method is subject to nutrient losses not encountered under the alternative methods. These losses occur in the silo through top spoilage, seepage, and fermentation loss.

Detailed data concerning seepage and fermentation losses were presented in the literature review. Seepage losses reported for untreated grass silage ranged from 1.1 percent to 15.0 percent of the dry matter ensiled. An average loss of 7.2 percent was found for all trials reviewed. Fermentation losses averaged 8.1 percent and ranged from 5.5 to 11.5 percent of the total dry matter ensiled.

Effect of top spoilage on the quantity of edible silage was estimated by the dairymen surveyed in this study. Four types of silos were encountered; conventional upright, wooden bunker, concrete lined trench, and stack silos. There were only two concrete lined trench silos and one stack silo, consequently the sample was too small to present top spoilage losses for these types of silos.

Estimated top spoilage in upright silos was 2.5 percent for 8,035 tons of silage. The loss in wooden bunker silos averaged 5.0 percent for 3,422 tons. Average loss for all farms in the study was 3.3 percent on 12,218 tons of grass and corn silage. Top spoilage varied among farms due to many factors - condition of forage entering the silo, condition of the silo, degree of compaction, and exposed surface area were some of the more important considerations.

Losses also occur from wastage in the feeding of silage. Wastage of edible silage in feeding was estimated by the farmers to average 1.4 percent of the total tonnage placed in the silo. Losses varied with the method of feeding silage. Three farms that practiced self-feeding from bunker silos estimated an average loss of 5.4 percent. The remaining farms that physically removed the feed from the silo estimated an average loss of 1.0 percent due to wastage.

The increase in forage production from changing to an all-silage program must be known to fully determine the profitability of the method. It was impractical to determine yields per acre under the alternative harvesting methods in this study, since all farms used at least two harvesting methods and in many instances two or more methods were used on the same field.

Data on nutrient yields under the various harvesting methods needs to come from controlled experiments designed for this purpose.

Yield data from farm surveys where management and cultural practices may vary considerably among farms does not afford figures of a comparable nature.

Affect on Quality of Forage Produced

One advantage of silage as a dairy feed is that it affords a constant feed supply of a uniform quality. This assumes adequate management in the ensiling process so a uniform quality of silage is produced. There should be no fluctuations in feed supply or quality due to the vagaries of weather or other similar uncontrollable conditions as may occur under alternative methods.

Various types of preservatives have been used by farmers in an attempt to improve the quality of silage both by increasing palatability and lessening the loss of nutrients. The cost of preservatives must be returned at feeding time either in added feed value or in conserved nutrients if their use is to be economically practical.

Digestibility of forage is changed little if proper care is taken in the making of silage. The digestion coefficient for crude protein will be lowered if excessive heating occurs, but in silos where little heating occurs it is only slightly affected. Although there are certain changes in the chemical composition of forage during the ensiling process, digestibility is little affected in properly preserved silage.

INCREASED FORAGE PRODUCTION NECESSARY TO COVER DIFFERENCES IN HARVESTING COSTS AMONG ALTERNATIVE FORAGE HARVESTING METHODS UNDER A SYNTHESIZED FARM SITUATION

This section will differ from those presented earlier in this paper in that a synthetic farm situation is used rather than presenting actual data from the various farms. The use of actual farms would not allow analysis of the full impact of the different harvesting methods because there are many other variables between farms.

Synthesizing cost data for a farm will permit holding management, herd size, and length of pasture season constant under all harvesting methods. The use of a synthesized farm situation will eliminate variation between farms and will consider the entire forage harvesting picture. Only those costs incident to harvesting forage for summer feeding were included in the previous sections. This did not consider the influence of harvesting methods used for handling feed stored for use in the non-pasture season.

This chapter is designed to present differences in harvesting cost per acre among the alternative methods. Only those costs which vary when changing from one method to another are considered. Thus, these cost figures should not be construed as total harvesting cost per acre, but are merely designed to determine differences among methods.

The differences in harvesting cost per acre under alternative methods are used to compute the increase in forage production required to offset these cost differences. A schedule of hay and silage prices is used to indicate the necessary increase under various price conditions.

Description of Farm

The forage crop acreage, milk production, and supplemental feed inputs were taken from an actual farm situation. These portions of an actual farm were needed to facilitate calculations under the all-silage program. All other cost data are synthesized to fit this otherwise hypothetical farm situation. The farm is somewhat typical of dairies in this region with 60 or more cows. Cropland is more limited than on the average dairy farm. However, the information presented in this chapter will not be affected by this condition.

The farm selected for budgeting under the alternative methods is now under a rotational grazing program. Dairying is the only enterprise on the farm. An irrigated grass and legume pasture is the only source of forage on the farm. There are 55 acres of a mixture of ladino clover, meadow foxtail, alta fescue, perennial ryegrass, and orchardgrass pasture on the 71 acre farm. Farmlot and brush occupy the acreage not in pasture.

An average growing season of 180 days may be expected on this farm. The present operator maintains a 60 cow herd of predominately holstein breeding.

Certain assumptions must be made concerning this farm and its general method of operation before budgeting the costs under alternative methods. There are some further assumptions made for individual methods but they will be stated in the section explaining the method of computing differences in harvesting costs per acre. The assumptions concerning all methods of harvesting are as follows:

1. A constant 180 day pasture season. Each method of harvesting will produce sufficient forage throughout the 180 day season to supply the herds forage requirements when the same amount of supplemental feed is furnished.
2. Herd size is constant at 60 cows under all methods. This would not be unrealistic on farms where the cow herd is now at barn or milking parlor capacity.
3. Milk production is the same under all methods. There may be some question as to whether milk flow can be maintained under an all-silage program. However, lacking empirical data it is assumed that milk production will be equal when the same amount of digestible nutrients are supplied under each method.
4. The cost of producing an acre of forage is the same under all methods. There may be some reason to consider that production costs would be less under methods where no cross fences are present to interfere with field operations.
5. All surplus forage above immediate requirements is harvested and stored as hay or silage.
6. The amount of forage required for the winter feeding period is identical under all methods.
7. An inventory of ensiling equipment is placed on the farm under each method. Lacking sufficient information to charge

depreciation as a function of use it is charged in accordance with a straight line schedule. Thus, fixed costs for machinery are the same under all methods.

8. The same harvesting equipment will suffice under all methods. There may be some question as to whether the same quality field chopper would suffice on green chop farms. However, the survey indicated the age of chopper was similar on daily ration, green chop, and all-silage farms.
9. All labor, regardless of type, is charged at $1.00 per hour.
10. The farm has adequate silo storage space for an all-silage program without additional silo construction.

Differences in Harvesting Costs Per Acre

Table 18 presents the items of cost which will vary when changing harvesting methods. These figures are not total harvesting costs, but merely facilitate calculation of differences in harvesting cost per acre.

Rotational grazing was the least costly per acre with daily ration grazing costing only one dollar more. The two mechanical harvesting methods were the most expensive. Green chop harvesting costs were $6.47 and all-silage $7.26 more per acre than rotational grazing.

Labor is the largest item in the table. There was some question as to whether labor should not be considered a fixed cost to the farm. Except under all-silage, nearly all harvest labor was operator or unpaid family labor. In many instances the opportunity costs of this labor would be negligible. If labor were removed the least cost order would be; rotational grazing, daily ration grazing, all-silage, and green chop.

Table 18. Harvesting costs per acre that vary with changes in forage harvesting methods

Item of Cost	Harvesting cost per acre			
	Rotational grazing	Daily ration	Green chop	All-silage
	$	$	$	$
Fencing				
Depreciation	.48	1.44	—	—
Int. on investment	.14	.43	—	—
Fuel and lubricants	.58	.58	3.14	2.38 /1
Labor	2.39	2.36	6.05	8.26
Repairs				
Fencing	.91	.69	—	—
Machinery	.24	.24	2.02	1.36
Total	4.74	5.74	11.21	12.00
Cost per acre greater than rotational grazing		1.00	6.47	7.26

/1 Includes two cents power charge for silage feeding conveyor

Method of Computing Differences in Harvesting Costs Per Acre

The first problem was to determine which costs would vary with changes in harvesting method and thus would need to be included in the calculations. Variable costs of fuel and lubricants, repairs, and labor fall into this group. Determination of which fixed cost items to include presented a more difficult problem.

Fixed costs on machinery were not included. This results from the assumption that the farm had an identical equipment inventory under all methods and depreciation was charged on a straight line basis. Thus, the annual depreciation and interest on investment charges would be identical under all methods.

Depreciation and interest on investment were charged on fencing. Depreciation was charged on a straight line basis with a 10 year expected life. Interest on investment in fencing was charged at six percent on one-half the replacement cost. Fencing investments for each grazing method were based on the average investment per acre found in the survey.

Fuel and lubrication rates of consumption and prices are the same as those used in the earlier section on cost of harvesting forage. Rotational and daily ration methods were charged for the tractor hours required to clip pastures twice during the season. Green chop fuel costs were based on the average hours of tractor and chopper operation. The hours used to chop forage for a 60 cow herd were computed from survey data.

Determining fuel cost for the all-silage method required computing the tons of silage that would be fed during a 180 day period. This was necessary since fuel and lubricants are charged on a per ton basis in the section on costs of harvesting grass silage. The tons of silage required were computed by the residual TDN method. The TDN supplied this herd from sources other than pasture for the 180 day grazing season was subtracted from the calculated TDN required to maintain the cow herd and its production of milk during this period. This residual amount of TDN was supplied by the pasture. Assuming an equal supply of TDN to be supplied under an all-silage program this figure was converted to tons of silage. The fuel and lubricants cost from the survey was then applied to this tonnage.

Labor under the grazing programs was for moving cows and clipping pastures. The time used to move cows was based on the average number of minutes used on farms under each grazing method. A farm average was used since there was no apparent correlation between size of cow herd and time spent per day in moving cows. An equal amount of labor was used under both methods for clipping pastures.

Green chop labor was based on a one man chopping crew. The hours of labor used per day on each green chop farm were adjusted to a 60 cow herd basis. An average of these adjusted labor hours was used in the table. Ensiling labor under the all-silage program was computed from the labor used per ton of silage found in the survey on cost of harvesting grass silage. Feeding labor was based on survey data for hand unloading from upright silos with an automatic feeding conveyor.

Fence repairs under the grazing methods were based on farm averages from the survey. Machinery repairs were identical under the grazing methods since both used machines the same number of hours. Machinery repairs for green chop were computed on a per hour basis using the average repair costs found in the survey of green chop farms. Repairs under all-silage were based on a per ton charge determined in the survey on cost of harvesting grass silage.

Increased Forage Production Necessary to Cover Additional Harvesting Costs

Profitability of the all-silage method could be determined if data were available on the increase in nutrient production per acre to be expected under the program. Yield data for the all-silage program are not available. An alternative is to present the increase in forage production per acre necessary to cover the added harvesting costs of the program. This requires the farmer who uses these tables to estimate the production that could be obtained on his farm under the alternative harvesting methods.

The figures for increased production are presented as tons of silage or tons of hay, terms most familiar to the dairyman.

Assuming that all forage produced in excess of that under a rotational grazing program is harvested as hay or silage, the production increase necessary to cover the additional harvesting costs depends upon the price of hay and silage.

Table 19 gives the tons per acre that silage production needs to be increased, above that yielded under rotational grazing, to offset the added harvesting costs of the alternative methods. As the cost of forage rises, the increase in production necessary to offset the added costs of harvesting declines.

In order to avoid introducing harvesting costs, which will vary among farms, forage prices were based on the cost of an amount of standing forage needed to produce one ton of grass silage. In the case of the first figure in the cost of forage column of Table 19; (i.e. $1.00) one dollar would purchase an amount of standing forage needed to produce one ton of silage.

Most standing forage in the Willamette Valley is sold on a per acre basis. When these conditions are encountered it will be necessary to estimate the yield per acre in tons of silage. To determine the cost of standing forage required to produce a ton of silage, divide the estimated yield into the purchase price per acre. The first step in using the table is to find this figure in the left-hand column. Then read in the same row the tonnage that silage production would need to be increased if the harvesting method were changed from rotational grazing to daily ration, green chop, or all-silage. These figures are the number of tons per acre that silage production must be increased over the production normally maintained under rotational grazing. All tonnage figures are rounded to the nearest tenth of a ton.

Table 19. Tons increase in silage production per acre required to offset additional harvesting costs under daily ration grazing, green chopping, and an all-silage program

Cost of standing forage needed to produce one ton of grass silage	Tons increase in silage production per acre		
	Daily ration	Green chop	All-silage
$	tons	tons	tons
1.00	1.0	6.5	7.3
1.25	.8	5.2	5.8
1.50	.7	4.3	4.8
1.75	.6	3.7	4.1
2.00	.5	3.2	3.6
2.25	.4	2.9	3.2
2.50	.4	2.6	2.9
2.75	.4	2.3	2.6
3.00	.3	2.2	2.4
3.25	.3	2.0	2.2
3.50	.3	1.8	2.1
3.75	.3	1.7	1.9
4.00	.2	1.6	1.8
4.25	.2	1.5	1.7
4.50	.2	1.4	1.6
4.75	.2	1.4	1.5
5.00	.2	1.3	1.5
5.25	.2	1.2	1.4
5.50	.2	1.2	1.3
5.75	.2	1.1	1.3
6.00	.2	1.1	1.2

Following is an example of the use of this table on a farm under rotational grazing. Assume the farmer can either purchase or raise forage for \$30 per acre and the forage will yield 10 tons of silage per acre. This results in a cost of \$3.00 for an amount of standing forage needed to produce one ton of silage. Three dollars is found in the left-hand column, the figures to the right in this row indicate the number of tons per acre that silage production needs to be increased to offset the added harvesting costs under the alternative methods. This example results in a needed increase of 0.3 ton when changing from rotational to daily ration grazing, 2.2 tons when changing to green chop, and 2.4 tons when changing to an all-silage program.

Seven farms reported purchasing forage in 1957. The purchase prices ranged from \$10 to \$40 per acre. The corresponding silage yields for these fields made the cost of forage range from a low of \$1.20 to a high of \$4.65 for an amount needed to produce one ton of silage. The average cost of standing forage needed for one ton of silage was \$2.80 on these farms.

Applying this price to Table 19 indicates that, to cover the added harvesting costs of the daily ration method, silage production must be increased at least 0.4 ton per acre above that obtained under rotational grazing. Green chop would require an increased production of 2.3 tons and all-silage 2.6 tons of silage per acre.

The table also permits determination of the increase in production necessary when changing from daily ration grazing to green chop or all-silage. This is done by subtracting the tonnage in the daily ration column from that in the same row under green chop or all-silage. The same method may be used to find the increase in production necessary when using an all-silage program rather than green chop.

Table 20 presents the same type of information except hay production is considered rather than silage. The tables could have been combined, but to avoid confusing hay and silage yields they are presented separately. Tonnage figures are rounded to the nearest tenth of a ton.

Table 20. Tons increase in hay production per acre required to offset additional harvesting costs under daily ration grazing, green chopping, and an all-silage program

Cost of standing forage needed to produce one ton of hay	Tons increase in hay production per acre		
	Daily ration	Green chop	All-silage
$	tons	tons	tons
5.00	.2	1.3	1.5
5.25	.2	1.2	1.4
5.50	.2	1.2	1.3
5.75	.2	1.1	1.3
6.00	.2	1.1	1.2
6.25	.2	1.0	1.2
6.50	.2	1.0	1.1
6.75	.1	1.0	1.1
7.00	.1	.9	1.0
7.25	.1	.9	1.0
7.50	.1	.9	1.0
7.75	.1	.8	.9
8.00	.1	.8	.9
8.25	.1	.8	.9
8.50	.1	.8	.9
8.75	.1	.7	.8
9.00	.1	.7	.8
9.25	.1	.7	.8
9.50	.1	.7	.8
9.75	.1	.7	.7
10.00	.1	.6	.7
10.25	.1	.6	.7
10.50	.1	.6	.7
10.75	.1	.6	.7
11.00	.1	.6	.7

The costs for standing forage needed to make one ton of hay are higher than in the silage table. This is due to the lower moisture content of hay relative to silage, thus requiring a greater amount of standing forage to produce a ton of hay.

Harvesting costs for the daily ration method were only one dollar more per acre than rotational grazing. Thus, tonnage figures in the daily ration column are so small that they do not change appreciably even with large changes in the price of standing forage.

No survey data were obtained on the purchase price of standing forage to be used for hay production. However, by using the "rule of thumb" that one ton of hay equals three tons of silage it is possible to use purchase prices from the silage study. This would have resulted in an average cost of $8.43 for an amount of standing forage needed to produce one ton of hay. This price requires an increase in hay production, above the production normally maintained under rotational grazing, of 0.1, 0.8, and 0.9 ton per acre for daily ration, green chop, and all-silage respectively.

Applying Trial Results to Tables

There have been trials conducted at Oregon State College comparing the yields of pastures under various harvesting methods. Yields from these trials were reported in terms of TDN per acre.

The differences in TDN yields may then be converted to an equivalent in tons of silage or hay. Using these tonnage figures and the tables in this chapter enables determination of relationships under which it would be profitable to use a more intensive harvesting method. The tables indicate the price of forage where additional harvesting costs of more intensive methods are just offset by the value of the increased forage production. If the cost of purchasing or raising forage is greater than this amount, the intensive harvesting method will be more profitable.

The only recent yield data under Willamette Valley conditions are from a 1954 study comparing rotational with daily ration grazing. (8, p.14-17) Daily ration grazing yielded 585 pounds more TDN per acre. Assuming a 16.2 percent TDN value for grass silage this is equivalent to 1.8 tons of silage. This increase will make daily ration grazing more profitable than rotational grazing even when the cost of an amount of standing forage needed to produce a ton of silage drops to one dollar, the lowest cost presented in Table 19. The cost could drop to 55 cents before rotational grazing would be more profitable.

Complete results of other trials conducted in the Willamette Valley on other harvesting methods are not yet available. However, an assumed increase in yield under all-silage and green chop will be used to illustrate the use of this data when it becomes available.

All-silage and green chopping both permit removal of all forage from the field. There are certain nutrient losses in the silo under the all-silage program. However, this may be offset by the ability to cut all forage at its maximum nutrient stage. For illustrative purposes it is assumed that both methods will increase nutrient production by an equal amount above that secured under rotational grazing.

If it were further assumed that an all-silage program would increase TDN production, over rotational grazing, by an equal amount as daily ration grazing, the increase would be 585 pounds TDN per acre. This is equivalent to 1.8 tons of 16.2 percent TDN grass silage.

Locate 1.8 tons in the all-silage column in Table 19. The figure $4.00 appears in the same row under the cost of forage column. This is the minimum cost for an amount of standing forage needed to produce one ton of silage at which it would be profitable to change from rotational grazing to an all-silage program.

Assuming an equal production under green chop, a forage cost of $3.50 would be the break-even point between rotational grazing and green chopping. At any forage cost above $3.50 it would be more profitable to use green chop than rotational grazing.

The same procedure would be used for Table 20 except that TDN yields would have to be converted to equivalent tons of hay rather than silage.

If results of trials compare all-silage yields with a method other than rotational grazing a different procedure is required in using the tables. The following hypothetical situation comparing yields under green chop with an all-silage program illustrates this procedure. Assume all-silage gave an increased yield of 150 pounds TDN per acre over green chop. Converting this into 16.2 percent TDN silage results in an equivalent of approximately 0.5 ton of silage.

In Table 19 locate the row where there is 0.5 ton difference between green chop and all-silage. This occurs in the third row from the top where 4.3 is found under green chop and 4.8 under all-silage. The cost of forage column in this row contains the figure one dollar and fifty cents. Thus, with this increase in yield and the cost of an amount of standing forage needed to produce one ton of silage is $1.50, the value of the increased yield would just offset the added harvesting costs. If the cost of forage were greater than $1.50 it would pay to change to an all-silage program.

The same procedure could be used with Table 20, except that TDN values would be converted to equivalent tons of hay rather than tons of silage.

Least Cost Harvesting Method Under Assumed Yield Increases and Average Price Paid for Forage in 1957

A thorough analysis of the experiments conducted on yields under the alternative harvesting methods indicates that, on an average, nutrient production may be expected to increase approximately 25 percent when changing from rotational grazing to daily ration grazing or green chop. It is believed that the increased production under an all-silage program would be some greater. However, the nutrient losses occurring in the silo will reduce the amount of nutrients available for feeding. Thus, in this section it is assumed that the all-silage method will yield an amount of TDN equal to the production under daily ration grazing and green chopping.

The trial conducted in 1954 at Oregon State College has been used to establish a base yield under rotational grazing. (8, p.14-17) According to this trial rotational grazing yielded 3,560 pounds of TDN per acre.

A 25 percent increase from this yield would be 890 pounds more TDN per acre or approximately 2.7 ton equivalents of 16.2 percent TDN value silage. The average price paid by the seven farms surveyed in this study that purchased standing forage in 1957 was $2.80 for an amount of standing forage needed to produce one ton of silage.

Assuming an increased yield by the alternative methods, over that obtained under rotational grazing, of 2.7 tons of silage per acre and a cost of $2.80 for an amount of standing forage needed to produce one ton of grass silage, daily ration grazing is the least cost harvesting method. Using this price of forage, production under the all-silage method would need to be increased 2.2 tons per acre, over that normally maintained under daily ration grazing before the dairymen would be indifferent between using daily ration grazing or the all-silage method.

SUMMARY AND CONCLUSIONS

The cost-price squeeze of todays' agriculture is forcing dairymen of the Willamette Valley to make an increased effort to attain maximum utilization of their available resources. One of the major problems is the determination of which harvesting method or combination of methods will prove most profitable on their forage acreage. The dairymen may choose from among five alternatives in deciding upon the harvesting method for the pasture season. There are three animal removal methods; continuous grazing, rotational grazing, and daily ration grazing. The mechanical removal methods of green chopping and all-silage are alternatives to grazing.

This paper has been designed to present available information for use in determining the profitability of an all-silage program. To be profitable the cost of handling forage must be lower than costs under alternative methods without lowering revenue a comparable amount. If handling costs are not lower, there must be an increase in nutrient production per acre sufficient to offset the higher harvesting costs. If neither of these conditions is met then other advantages must be great enough to offset the additional harvesting costs.

A survey of dairy farms in the Willamette Valley supplied most of the data for this study. Only three farms were found to be using the all-silage method. A review of the literature on forage harvesting yielded no information directly concerned with an all-silage program. The studies comparing grazing methods with green chop gave a wide range in results. There was general agreement that daily ration grazing and green chopping would increase forage production over that obtained under rotational grazing.

Nutrient losses occur in the silo under the all-silage method. Top spoilage loss data were obtained from the survey. This loss averaged 2.5 percent for upright silos and 5.0 percent for wooden bunker silos. The literature reviewed on various trials gave an average seepage loss of 7.2 percent and an average loss of 8.1 percent from fermentation or unaccountable losses. Although there are certain nutrient losses in the ensiling process, the literature indicated that palatability and digestibility are little affected in properly preserved silage.

Average investment per farm in forage production and harvesting machinery on farms studied varied little among methods. The low investment per farm was $7,231 under the all-silage method. However, due to smaller herds this method had an average investment per cow of $204, highest of the alternative methods. Highest per farm investment was $8,779 under the daily ration method. However, because of larger herds it had an investment of $132 per cow - lowest of the alternative methods.

Survey data on silo storage space provided per cow indicated that most farms would not need to build additional storage if they changed to the all-silage method.

Green chop and all-silage, the mechanical removal methods, used the largest amount of labor per cow during the pasture season. Daily ration farms used only 59 percent as much labor per cow as farms under rotational grazing. This indicates the economies of larger herd size. Daily ration farms averaged 66.5 cows as compared with 46 cows on rotational farms.

Harvesting cost per cow for forage consumed during the pasture season was least under daily ration grazing, costing 39 cents per 30 day cow month. Rotational grazing was next in order at a cost of 56 cents. The all-silage method cost $1.88 and green chop $2.50, indicating that when pasture season alone is considered, mechanical harvesting methods are considerably more expensive.

Harvesting cost for grass silage was $1.94 per ton plus .93 hour of labor. Sixty percent of the costs of harvesting grass silage were represented by the non-cash items of depreciation and interest on investment. Harvesting cost for corn silage was $1.05 per ton plus .41 hour of labor. If the one farm which produced 59 percent of the total corn silage were excluded, average harvesting costs on the remaining farms would be $1.58 plus .66 hour of labor per ton.

Green chop farms devoted 1.2 acres of cropland per cow to forage production. This was the least amount of the alternative methods. All-silage farms devoted 1.3 acres, daily ration farms 1.5 acres, and rotational grazing farms 1.8 acres per cow.

Legume and grass mixtures were the most popular forage grown under the all-silage program. Seventy eight percent of the cropland devoted to forage production on all-silage farms was in a legume and grass mixture. Ladino clover and grass represented over 60 percent of this pasture acreage. This leads to the conclusion that farmers under the all-silage method consider ladino clover and grass mixes suitable for mechanical harvesting.

The use of a synthesized farm situation in Chapter 8 permitted holding constant many otherwise variable factors. This facilitated determination of differences in harvesting costs per acre for this given farm situation. The differences in cost were then used to determine increases in forage production needed to offset the added harvesting costs of the more intensive methods.

Harvesting costs per acre for this farm with an average milking herd of 60 cows were least under the rotational grazing method. Daily ration grazing cost $1.00, green chop $6.47, and all-silage $7.26 more per acre than rotational grazing.

Tables 19 and 20 indicate the number of tons that silage and hay production would need to be increased at various forage prices in order to offset the added harvesting costs of the more intensive harvesting methods. The average price of purchased forage in 1957 was $2.80 for an amount needed to produce one ton of silage. Under these price conditions, silage production would need to be increased 0.4 ton per acre to offset the added costs of the daily ration method as compared with rotational grazing. It would require an increase of 2.3 tons per acre under green chop and 2.6 tons per acre under all-silage to cover the added harvesting costs over rotational grazing.

Some dairy farms in the Willamette Valley are located on soils poorly adapted to producing forage to be harvested under a grazing program. If these soils are better adapted to production of annual forage crops such as cereal grain and legume mixtures, red clover, or sudan grass, an all-silage program may be feasible in order to furnish a source of succulent feed the year round. The availability of unpaid family labor for the ensiling operation may influence the harvesting method used on such farms. A large supply of this type of labor is suited to a labor intensive harvesting method such as the all-silage program. On the basis of information now available, it is on this type of farm that the all-silage method is most likely to be economically feasible.

Results have been received on only one recent trial conducted in the Willamette Valley comparing pasture yields under alternative forage harvesting methods. The trial resulted in a 585 pound greater TDN yield per acre under daily ration than rotational grazing. These results indicate that when the cost of an amount of standing forage needed to produce one ton of silage is greater than 55 cents it is more profitable to use daily ration grazing.

Daily ration grazing was the least cost method as presently practiced on the farms surveyed. When adjustments are made for herd size and acres of forage the additional harvesting cost of daily ration grazing, over rotational grazing, of one dollar per acre would be offset with only a small increase in forage production. Thus, from the information available it appears that daily ration grazing in most instances should prove the most profitable harvesting method.

A final economic evaluation of the all-silage program awaits determination of expected forage yields and substitution rates between silage and green forage. Information now available is not sufficient to definitely conclude whether the program will be profitable on Willamette Valley dairy farms. Forage handling costs are greater under the all-silage program than either grazing methods. The economic feasibility of the program will depend upon the increase in nutrient yields per acre and other considerations dependent upon conditions existing on the individual farm.

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APPENDIX

Appendix table 1. Depreciation schedule used in computing inventory investments

Item of Equipment	Rate of annual depreciation charge
	%
Bale elevator	6.7
Baler	10.0
Blower	8.3
Chopper wagon	10.0
Cultivator	6.7
Disc	10.0
Drill	6.7
Fence - permanent	5.0
Fence - temporary	10.0
Fertilizer spreader	12.5
Forage harvester	12.5
Harrow	6.7
Irrigation system	
Electric connections	5.0
Electric pump	6.7
Portable equipment	6.7
Well	2.9
Manure spreader	8.3
Mower	10.0
Plow	10.0
Roller	6.7
Side delivery rake	10.0
Tractor	10.0
Trailer	10.0
Truck	10.0

Appendix table 2. Inventory of equipment found on farms under alternative harvesting methods 1957

Item of Equipment	Pieces of item on farm	No. of farms having this equipment: All-silage	Green chop	Daily ration	Rotational grazing
Number of farms under the method		2	6	7	11
Bale elevator	1	1	4	4	5
Baler	1	-	2	3	5
Blower	1	2	3	4	7
Chopper wagon	1	-	2	1	5
	2	1	2	2	3
	3	1	-	-	-
Cultivator	1	1	3	3	6
Disc	1	2	6	3	9
	2	-	-	2	1
Drill	1	2	4	5	7
Fertilizer spreader	1	2	6	6	7
Forage harvester	1	2	6	7	10
Harrow	1	1	4	4	9
	2	-	1	3	2
Irrigation system	1	2	5	7	9
Manure spreader	1	2	6	7	10
Mower	1	2	6	7	10
Plow	1	-	3	5	9
	2	1	2	1	2
Roller	1	1	6	4	8
S. D. rake	1	1	4	3	9
Tractor	1	-	1	-	2
	2	2	5	5	7
	3	-	-	1	1
	4	-	-	1	1
Trailer	1	1	2	2	6
Truck	1	2	6	6	7
	2	-	-	1	2
Other Cult. Equip.	-	-	2	2	6
Other Harvest Equip.	-	-	2	7	11

Appendix table 3. Acres of principle crops grown on farms under alternative methods 1957

Harvesting method and survey number	Acres in farm	Acres of Crop on Farm: Ladino & grass mixture	Other legume & grass mixture	Stra-ight legume	/1 Stra-ight grass	Cereal grain and legume	/2 Field corn	Cereal grain	/3 Cash crop	Idle and farm lot	Unim-proved land
All-silage											
III	60	28	16	—	—	7	—	—	—	9	—
XI	153	16	13	—	14	—	—	54	23	24	9
Green chop											
IV	123	49	7	—	—	—	—	—	—	3	64
VIII	200	33	—	—	23	—	—	41	80	7	16
XIII	192	—	—	35	50	—	—	53	—	10	44
XIV	90	11	29	3	—	—	29	—	—	9	9
XVIII	89	32	6	—	2	17	—	—	—	2	30
XXIV	183	34	—	—	—	25	10	108	—	1	5
Daily ration											
II	57	32	—	—	—	21	—	—	—	3	1
VI	98	14	22	20	6	—	9	21	—	2	4
IX	105	—	45	—	52	—	—	—	—	8	—
XVI	320	70	—	40	9	—	—	180	—	11	10
XIX	89	53	13	—	8	—	—	—	9	4	2
XXVI	222	16	6	25	14	—	10	17	—	4	130
XXVII	300	63	—	16	—	11	110	54	17	14	15
Rotational											
I	83	56	—	23	—	—	—	—	—	1	3
V	100	22	—	20	—	10	10	24	—	4	10

Appendix table 3. (con't)

Harvesting method and survey number	Acres in farm	Acres of Crop on Farm: Ladino & grass mixture	Other legume & grass mixture	Stra-ight legume	/1 Stra-ight grass	Cereal grass and legume	/2 Field corn	Cereal grain	/3 Cash crop	Idle and farm lot	Unim-proved land
Rotational (con't)											
VII	546	21	40	—	17	—	—	175	215	68	10
X	127	39	—	5	6	15	10	5	10	1	36
XII	104	—	34	10	5	6	—	35	10	4	—
XV	200	45	15	—	—	—	—	—	15	5	120
XVII	71	55	—	—	—	—	—	—	—	8	8
XXI	199	20	—	16	—	—	23	76	27	16	21
XXII	73	10	14	14	—	—	9	24	—	2	—
XXIII	447	21	—	48	55	40	15	114 /4	—	7	147
XXV	137	24	17	7	8	34	25	13	—	7	2

/1 Includes sudan grass
/2 Harvested either as silage or grain
/3 Excluding feed grains
/4 15 acres ensiled