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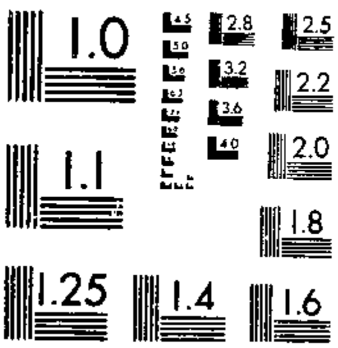

MICROCOPY RESOLUTION TEST CHART
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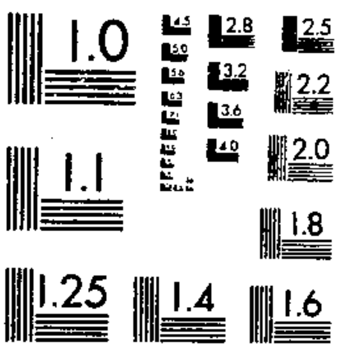

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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Permanent Pasture *Compared with a* 5-Year Crop-and-Pasture Rotation for Dairy Cattle Feed[1]

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INTRODUCTION

Pastures that provide an abundance of good grazing are a necessity on most dairy farms. Properly managed pastures provide in the best form the feed best suited for dairy cattle. The exercise of grazing and the beneficial effect of sunshine help to keep the cattle healthy and functioning normally. The type of land used for pasture and the kind of pasture vary considerably with the locality and the individual farm.

Most farms have some land which, because of its topography or its closeness to barns or streams, or because it is stony or wet, can be used more advantageously for permanent pasture than for tillage.

On land that is suitable for tillage as well as for pasture, the farmer's problem is to determine whether he should have part of the land in permanent pasture and raise harvested crops on the remainder or whether he should farm all the tillable land and depend for pasture on grass-legume crops grown in rotation with other crops.

There is some evidence that pasture crops of grasses and legumes grown in rotation with other crops will outyield well-managed permanent pastures of Kentucky bluegrass and white clover. On the other hand, in regions where Kentucky bluegrass is well adapted, no other crop is surer during favorable growing seasons and no other will better withstand tramping and adverse weather conditions. Furthermore, there is less likelihood of bloat in pasturing bluegrass.

REVIEW OF LITERATURE

Relatively few studies have been conducted to compare directly the production of crop-and-pasture rotations and permanent pastures. Ahlgren (1)[4] has recently prepared a review of studies pertaining to this subject. Only the more pertinent literature will be cited here.

Some of the first and most extensive comparisons of crop-and-pasture rotations and permanent pastures have been made in Great Britain. In presenting a strong case for ley farming in Great

[1] Submitted for publication December 2, 1955.
[2] Retired May 31, 1953.
[3] Now with Office of Experiment Stations.
[4] Italics numbers in parentheses refer to Literature Cited, p. 32.

Britain, Stapledon (26), in 1938, stated that even the best permanent grass has a shorter growing season than a sequence of good leys. He also pointed out that leys are much better adapted to hay and silage making than are permanent pastures.

Roberts and Williams (*22*) compared a pasture seeded to a mixture of ryegrasses (*Lolium* spp.), orchardgrass (*Dactylis glomerata*), timothy (*Phleum pratense*), roughstalk bluegrass (*Poa trivialis*), and red clover (*Trifolium pratense*) with a 70-year-old permanent pasture consisting primarily of bentgrass (*Agrostis* spp.) and velvetgrass (*Holcus lanatus*). These pastures were grazed by cattle and sheep. Gain in live weight per acre over a 9-year period was 35.6 percent higher on the seeded pasture than on the permanent pasture. The superiority of the seeded pasture did not appear to be diminishing toward the end of the period, and it was found that lambs failed to thrive some years on the permanent pasture after about the middle of August.

Heddle (*14*) reported that total gain in live weight by sheep was 5 times greater on a reseeded pasture than on an old permanent pasture over a 5-year period. The difference was attributed to the larger gains made in the early part of the season on the reseeded land and also to the longer growing season.

On the basis of studies conducted in various locations in England, Davies and Williams (*11*) stated that it would appear that the output of four-fifths of their permanent pastures would be increased by well over 50 percent by plowing and reseeding. Ellison (*12*) made a 3-year comparison between gains of yearling wether lambs grazing on reseeded areas and on natural pasture on open hill land. The gain per head during the period was 50 to 60 percent greater on the reseeded land than on the natural, unimproved grassland herbage, and the gain per acre was 10 times greater.

Dallas and Bullen (*9*) found that over a 5-year period leys carried 80 percent more stock than permanent pasture and produced 55 percent more gain. From a consideration of various studies conducted in England, Davies (*10*) concluded that, at least during the first three seasons, leys will yield more than well-managed old grassland. He pointed out that the gain from the ley is about 18 percent more than from first-class old grasslands but is over 50 percent more than from average or moderate grasslands.

Pollitt (*21*) studied the effect of age on the yielding capacity of seeded pasture. He reported a decrease in yield of dry matter, albuminoids, and carotene as a sward grows older. This deterioration appears to be at its maximum rate in about the fourth year. His results show that yield appears to approach a more or less constant level by the seventh year, at a point about two-thirds that of the first 3 years.

Bates (*6*) conducted studies to determine the cause of deterioration in leys and also the reasons why a new ley usually is more productive than the permanent pasture that preceded it. Of the several factors responsible for reduction in yields, Bates lists the primary cause as the accumulation of a mat of dead root material below the soil surface and an increase in the number of tillers. He stated that the sward becomes choked, and the condition resembles that of a potbound plant.

Gorton (*13*) reported that, on irrigated land in eastern Oregon, permanent bluegrass (*Poa pratensis*) pasture produced 152 animal-unit days of grazing per acre as compared with 240 for pasture seeded to tame grasses. High yields were associated with low costs per unit day of grazing.

L'Hote (*16*), from data collected in Missouri, concluded that pastures in a crop-and-pasture rotation are substantially more productive than permanent pastures.

Bechdel and others (*7*) reported that, in studies at Montrose, Pa., pastures in a crop-and-pasture rotation produced far more grazing than permanent pastures under favorable fertilization and management. Of particular significance was the fact that the pastures in the rotation produced from 2 to 3 times as much grazing as the permanent pastures after July, a time when the extra feed was most needed. During a 3-year period, the field in the rotation that was grazed all season by dairy cows produced 51 percent more total digestible nutrients before July 15 than the permanent pasture produced; after that date it produced 113 percent more. The field that was cut for hay in June and grazed until September 1 produced 85 percent more total digestible nutrients in the form of hay before July 15 and 156 percent more grazing after that date. Another point in favor of the Ladino clover (*Trifolium repens* "Var. Ladino")-orchardgrass combination over the improved permanent pasture was that the crop harvested from the former contained 13.5 to 17 percent of crude protein as compared with 11 to 13 percent for the latter.

In Ohio (*20*), bluegrass-white clover (*Trifolium repens*) permanent pasture provided an average of 41 days of grazing annually over the 3-year period 1940–42 as compared with over 100 days for a clover-alfalfa (*Medicago sativa*)-timothy pasture in a crop-and-pasture rotation. Both were limed and fertilized.

Moran (*18*) found that abundant grazing of high quality can be obtained from bluegrass-white clover pastures in the spring and fall, but little growth is obtained during midsummer. Ladino clover-grass mixtures responded exceptionally well to fertilizer and, in addition, maintained higher productivity than bluegrass-white clover during the hot, dry period of July and August.

Studies conducted by Van Horn and Dawson (*29*) from 1943 to 1946, inclusive, showed that unfertilized bluegrass pasture produced an average of 1,049 pounds per acre of total digestible nutrients as compared with 1,478 pounds for fertilized bluegrass and 1,783 pounds where bluegrass sod was plowed, fertilized, and seeded to orchardgrass, bluegrass, and clover. On land that had been in field crops for several years, an orchardgrass-Ladino clover pasture furnished an average of 3,160 pounds of total digestible nutrients per acre.

One of the most comprehensive studies in the United States comparing pastures in a crop-and-pasture rotation with permanent pastures was conducted by Ahlgren and others (*2*) at Wisconsin during the period 1944–49, inclusive. Comparisons were made of (a) permanent bluegrass pasture, (b) renovated bluegrass pasture, (c) bluegrass pasture in rotation with corn and oats, and (d) a mixture of smooth bromegrass (*Bromus inermis*) and alfalfa in rotation with corn and oats. The rotations consisted of a year of corn, a year of oats, and 4 years of grazing. The bromegrass-alfalfa pasture in the rotation was most productive. It produced substantially more pasturage during the 4-year period 1946–49, inclusive, than the permanent pasture produced during the entire 6-year period of grazing. The bluegrass pasture in the rotation and the renovated bluegrass pasture produced about as much grazing in 4 years as the permanent bluegrass pasture produced in 6 years. In addition to the pasturage, the rotations produced an average of 17.4 tons of corn silage and 64.2 bushels of oats per acre in 1944 and 1945, respectively.

OBJECTIVES AND SCOPE OF THE BELTSVILLE EXPERIMENT

The objectives of this experiment were (a) to measure the nature, quantity, and distribution of the nutrients provided for dairy-cattle feed by an improved Kentucky bluegrass-white clover pasture as compared with a 5-year crop-and-pasture rotation consisting of 1 year of corn, 1 year of wheat, and 3 years of a seeded mixture of orchardgrass, Ladino clover, and red clover; and (b) to determine the relative cost of producing nutrients by the 2 systems.

The experiment was started in 1944. Beginning in 1946, the 5-year rotation was in full operation. At this time the experiment was expanded to include a comparison of smooth bromegrass with orchardgrass by seeding the former instead of the latter in the grass-legume mixture on one-half of each field.

Six 4-acre fields were used. They were each approximately 700 feet long and 250 feet wide, located side by side in one continuous tract. The arrangement of the fields and the sequence of crops in the rotation are shown in table 1.

The permanent pasture (check) was used only for grazing. The corn crop (first year of the rotation) was made into silage. The wheat (second year of the rotation) was used as grain for feed and straw for bedding. The seeded grass-legume mixture provided fall grazing following the wheat harvest in the second year of the rotation, grazing only the third year, two crops of hay and fall grazing the fourth year, and early spring grazing followed by one hay crop and grazing to a late date the fifth year. The results reported here are for the 5-year period 1946–50, inclusive.

The fields were on level to slightly sloping land. The soil was principally Sassafras silt loam of only medium natural fertility. There were some slight differences between plots in topography, soil types, and natural soil fertility. Soil fertility was highest in field A, decreasing slightly but progressively in the order of fields B, C, D, E, and F. Previous grazing experience indicated that field C, used for the permanent pasture, was about equal in fertility to the average of the other five fields.

All the fields were in permanent Kentucky bluegrass-white clover pasture during the 14-year period, 1929–43. Before 1929 they were cropped with a corn-oats-alfalfa rotation. The soil had been limed as needed for alfalfa and the grass crops. Barnyard manure and commercial fertilizers had been used in moderate quantities.

TABLE 1.—*Arrangement of the experimental fields and sequence of crops in the crop-and-pasture rotation, Beltsville, Md., 1946–50*

Year	Field A	Field B	Field C (check)	Field D	Field E	Field F
1946	Wheat, fall pasture.	Pasture only	Permanent pasture.	Hay, hay, pasture	Pasture, hay, pasture.	Corn.
1947	Pasture only	Hay, hay, pasture	do	Pasture, hay, pasture.	Corn	Wheat, fall pasture.
1948	Hay, hay, pasture	Pasture, hay, pasture.	do	Corn	Wheat, fall pasture.	Pasture only.
1949	Pasture, hay, pasture.	Corn	do	Wheat, fall pasture.	Pasture only	Hay, hay, pasture.
1950	Corn	Wheat, fall pasture.	do	Pasture only	Hay, hay, pasture	Pasture, hay, pasture.

EXPERIMENTAL METHODS

Tillage, Seeding, and Fertilizing

The pasture sod was plowed in late fall or early winter for corn. The corn was spaced 10 to 14 inches in rows 42 inches apart. The corn ground was disked for winter wheat. The wheat was seeded with a grain drill. Grass seed was broadcast in the wheat shortly after it was seeded, and then cultipacked. The legumes were broadcast in the wheat the following spring, usually in late February or early March, while the ground was still freezing and thawing.

The seeding rates per acre were: Hybrid corn (U. S. No. 13), 8 to 10 pounds; wheat (Leapland), 60 pounds; orchardgrass, 6 pounds; smooth bromegrass, 10 pounds; Ladino clover, 2 pounds; and medium red clover (Kenland), 3 pounds.

The pH of the soil was determined, and all fields had a pH sufficiently high for grasses and legumes (6.3 to 6.6) except field F. Ground limestone was applied to this field at the rate of 1 ton per acre.

Well-rotted barnyard manure was applied to the permanent pasture at the rate of 10 tons per acre in the winter of 1947–48. It was applied at the same rate to pasture sod in the crop-and-pasture rotation shortly before it was plowed for corn.

Commercial fertilizer, 0–14–14, or 0–14–7, was applied to the permanent pasture at the rate of 400 pounds per acre in the fall of 1945 and again in the fall of 1949. It was applied at the same rate to the corn ground just before the ground was disked for wheat. Another 400 pounds per acre was applied to the grass-legume sod in the fall prior to the fifth year of the crop-and-pasture rotation.

Harvesting, Grazing, and Pasture Management

The corn grown was rich in grain. It was cut for silage when the kernels were at a "dough to glazing" stage. A field forage chopper, dump trucks, and a stationary forage blower were used. The silage was stored in a conventional tower silo.

The wheat was cut with a 6-foot grain binder and threshed from the shock. The straw was baled at threshing time.

The grass-legumes in the crop-and-pasture rotation were cut for hay when the grass was at an early to medium hay stage. The hay was either field cured and field baled or partly field cured and then field baled and barn dried with forced air.

The permanent pasture was divided into two 2-acre fields. They were grazed alternately in April and May to make better use of the lush early season growth. The division gate was then left open and both fields were grazed continuously the remainder of the season. Grazing was started in the spring when the bluegrass had attained a height of 4 inches, and it was continued in the fall as late as practical, depending on the season.

The grass-legumes in the crop-and-pasture rotation were grazed rotationally. Grazing was not started in the spring until the herbage had attained a minimum height of 8 to 10 inches. Enough dairy cows were used to graze this herbage down to a height of 2 to 4 inches in

10 days to 2 weeks. The pastures in the fifth year of the rotation were grazed ahead of the pastures in the third year of the rotation, and those in the fifth year were also saved for grazing as late in the fall as possible.

All pastures were clipped following grazing, when necessary to cut off uneaten grass clumps, with a 7-foot power mower with the cutter bar set high. The permanent pasture was harrowed once each fall with a spike-tooth harrow to scatter cow droppings.

The Grazing Cows and Supplemental Feeding

Jersey, Holstein, and crossbred cows of pure dairy breeds were used for grazing. During the peak season of grass growth it was necessary to use cows in various stages of lactation and also some dry cows. No cows were used within 30 days after freshening or within 60 days of calving. The cows were grouped to obtain as good a balance as possible between the permanent pasture and the pastures in the crop-and-pasture rotation with regard to breed, live weight, stage of lactation, stage of gestation, and milk production. The cows were not switched from one type of pasture to another.

The cows were fed all the medium quality grass-legume hay or U. S. No. 2 alfalfa hay they would eat in the barn at milking time. This helped to prevent bloat, and also helped to prevent overgrazing of pastures and an undue milk slump when grazing was not too abundant.

A low-protein grain mixture was fed at the rate of 1 pound daily for each 3.5 pounds of 4-percent fat-corrected milk produced in order to maintain a high level of summer milk production and keep the cows producing sufficiently for fall and winter feeding experiments.

Evaluating the Grazed and Harvested Forages

The relative abundance and proximate analysis of the forage available for grazing was determined on the permanent pasture with forage clipped by hand at intervals throughout the summer from small areas (4′ x 4′ x 18″) protected by wire cages, and on the grass-legumes in the crop-and-pasture rotation with forage from measured (36″ x 30′) randomly located strips cut with a small sicklebar power mower just prior to each grazing.

Samples of the forage from five cages or strips from each field were used for each determination. All the forage cut from each cage or strip was weighed, and representative samples were taken for determination of dry matter and proximate chemical analysis. These samples were dried down to an air-dry condition in 4 hours and to a moisture-free condition in 20 to 28 hours, using forced air heated to 160° F.

The harvested crops were sampled as stored. The samples were weighed and dried as indicated above for dry-matter determination and proximate chemical analysis.

The proximate chemical analyses of the forages were made according to methods published by the Association of Official Agricultural Chemists (*5*).

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The botanical composition and density of the sward of the pastures was determined each fall after grazing was completed. Plant population counts were made on replicated, randomly selected areas with a 10-point quadrat.

Calculating Yields of Total Digestible Nutrients

The yields of total digestible nutrients (TDN), as measured by grazing, were determined by (1) calculating the TDN requirements of the grazing cows, (2) subtracting the TDN consumed in supplemental feed, and (3) crediting the difference to the pasture. This is substantially the method recommended by the Joint Pasture Committee (*4*).

The average live weight of each cow was determined from weights obtained on 3 consecutive days at the beginning of each experimental period on the pastures in the crop-and-pasture rotation, and her gain or loss in weight was determined from weights obtained on 3 consecutive days at the end of each period. Cows grazing continuously on the permanent pasture were weighed on 3 consecutive days at the beginning of each month.

The milk produced was weighed at each milking. Every 10 days a composite of aliquot samples of milk from 4 consecutive milkings was tested for butterfat content by the Babcock test.

All supplemental feeds fed and any refusals were weighed. The dry-matter content and the proximate chemical analysis of the feeds fed and of the weighbacks were determined from samples taken periodically.

The TDN content of the supplemental feeds was based on their proximate chemical analysis and on Morrison's estimates of the digestibility of similar feeds (*19*). The TDN requirements of the grazing animals for maintenance and for milk production were based on the average of Morrison's standards for dairy cows (*19*). The TDN requirements for change in live weight recommended by Knott, Hodgson, and Ellington (*15*) were used—namely, +3.53 pounds for each pound of gain and −2.73 pounds for each pound of loss.

The TDN content of the green corn harvested for silage and that of the wheat grain were calculated from their dry-matter content and their proximate chemical analysis compared with the proximate analyses of similar feeds and their digestibility for cattle as shown by Schneider (*23*), using the regression coefficients for cattle proposed by Schneider and others (*25*).

The TDN content of the grass-legume hay and that of the green herbage cut from cages and mower strips were calculated from their proximate chemical analysis, using the regression coefficients for cattle proposed by Schneider and others (*24*) for feeds on which digestion trial data are limited or nonexistent.

The TDN content of the harvested forage was calculated on the basis of the crops as stored and also on the basis of the crops as fed, using an arbitrary deduction as a minimum storage loss. The deductions made as storage loss were 15 percent for corn silage fed out the same season it was stored, and 5 percent for hay.

WEATHER CONDITIONS DURING THE EXPERIMENT

Monthly mean temperature and rainfall at Beltsville for the period 1946–50 as compared with the 20-year average are shown in table 2. For the entire 5-year period, temperature and rainfall and general conditions for crop production were perhaps as near average for the locality as could be expected. However, there was considerable variation in these conditions from year to year.

TABLE 2.—*Mean temperature and rainfall, by months, Beltsville, Md., 1946–50, as compared with the 20-year average*

MEAN TEMPERATURE

Month	1946	1947	1948	1949	1950	20-year average[1]
	° F.	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*
January	33. 1	37. 7	25. 2	39. 5	42. 9	34. 3
February	36. 5	27. 8	31. 3	39. 3	34. 9	34. 0
March	48. 9	36. 3	43. 5	43. 4	37. 8	42. 6
April	51. 8	52. 3	63. 3	50. 2	48. 6	51. 6
May	62. 1	62. 1	62. 8	62. 7	61. 0	62. 8
June	69. 1	68. 7	69. 9	69. 8	69. 1	70. 9
July	72. 7	72. 5	75. 2	78. 3	72. 8	75. 0
August	69. 2	75. 2	72. 8	74. 4	72. 0	73. 4
September	67. 1	66. 9	61. 0	63. 3	63. 6	66. 5
October	57. 6	60. 3	52. 6	60. 0	57. 0	56. 4
November	47. 2	41. 9	47. 9	43. 5	43. 7	45. 3
December	37. 2	31. 7	35. 8	37. 8	31. 4	35. 2
Yearly average	54. 4	52. 9	53. 6	55. 2	52. 9	54. 0

PRECIPITATION

Month	1946	1947	1948	1949	1950	20-year average[1]
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
January	1. 56	3. 74	4. 57	4. 96	2. 19	3. 31
February	2. 69	. 88	1. 59	3. 70	2. 72	2. 42
March	1. 82	1. 08	4. 35	3. 02	3. 46	3. 45
April	1. 75	3. 97	2. 26	1. 95	1. 58	3. 10
May	6. 37	4. 91	8. 10	4. 81	4. 59	4. 08
June	2. 04	7. 34	6. 67	2. 79	4. 32	3. 35
July	3. 35	3. 72	4. 78	3. 68	5. 42	4. 40
August	4. 11	5. 91	5. 29	3. 75	6. 36	4. 82
September	4. 32	3. 13	2. 67	3. 54	7. 07	3. 96
October	2. 86	1. 69	3. 73	3. 09	3. 16	3. 35
November	1. 21	5. 56	5. 54	1. 26	3. 58	2. 99
December	2. 01	1. 48	5. 07	2. 14	3. 44	2. 86
Yearly total	34. 09	43. 41	54. 62	38. 69	47. 91	42. 09

[1] 1931–50, inclusive.

The 1946 growing season was considerably drier than average in April and May and again in June and July. It was unfavorable for forage-crop production. In 1947, February and March were extremely dry and colder than normal, and the growing season started late. However, there was plenty of rain throughout the growing season with favorable conditions for forage-crop production. In 1948, there was again an abundance of rain throughout the growing season, and cropping conditions were generally good.

The 1949 growing season was again on the dry side and warmer than usual. Rainfall was below average in April, June, July, and August, and temperatures were higher than average in June, July, and August. Crop yields of corn and wheat were reduced by the weather conditions, and some pastures were rotationally grazed once less than usual.

The 1950 growing season was generally favorable for forage crops. However, April was very dry, and a period of very hot, dry weather occurred the last half of July and the first half of August. Forage growth was adversely affected on the permanent pasture and the second year of the crop-and-pasture rotation (fall grazing following winter wheat).

RESULTS OF THE COMPARISON BETWEEN THE PERMANENT PASTURE AND THE 5-YEAR CROP-AND-PASTURE ROTATION

Botanical Composition of the Ground Cover

The kinds and percentage of forage plants growing on the pastures are summarized in table 3.

TABLE 3.—*Average botanical composition of the ground cover on a Kentucky bluegrass-white clover permanent pasture and on orchardgrass-Ladino clover pastures in a 5-year crop-and-pasture rotation, Beltsville, Md., 1946–50* [1]

Ground cover	Permanent pasture	Year of the rotation			
		Second	Third	Fourth	Fifth
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
Kentucky bluegrass	48.8±2.5	0.2±0.2	0.4±0.4	0.6±0.5	7.0±3.0
Orchardgrass	1.2± .7	30.8±4.4	38.8±2.8	43.4±2.4	40.4±3.1
Total grass	50.0±2.7	31.0±4.3	39.2±2.9	44.0±2.4	47.4±2.4
Ladino clover	0	33.0±4.7	46.2±4.0	39.4±1.3	39.4±2.5
Red clover	0	15.4±5.5	.6± .2	1.0± .6	.2± .2
White clover	17.4±3.7	0	0	0	0
Total legumes	17.4±3.7	48.4±8.4	46.8±4.1	40.4±1.1	39.6±2.4
Weeds	30.4±5.7	15.2±4.5	9.4±2.6	11.0±3.4	7.8±2.8
Bare ground	2.2± .9	5.4±1.2	5.0±1.4	4.6±1.1	5.2±1.5

[1] Plant population counts made with a point quadrat each fall after the end of the grazing season.

The percentage of bare ground was low for all pastures. The permanent pasture was weedier than the pastures in the crop-and-pasture rotation. Both kinds of pasture were weedier in 1949 and 1950 than in previous years. The weeds on the permanent pasture consisted largely of dandelions.

The pastures in the rotation had 2.3 to 2.8 times as many legumes in the ground cover as did the permanent pasture. At the end of the second year of the rotation, the young stand was about one-third orchardgrass, one-third Ladino clover, one-sixth red clover, and one-sixth weeds. There were considerably fewer weeds and practically no red clover by the end of the third year.

Ladino clover reached a peak of 46 percent of the ground cover at the end of the third year of the crop-and-pasture rotation, and orchardgrass reached a peak of 43 percent the fourth year. Kentucky bluegrass was present as a trace at the end of the second year of the rotation and as less than 1 percent up to the end of the fourth year, but had extended its area to 7 percent of the ground cover at the end of the fifth year. Total grass gradually increased from 31 to 47 percent. Total legumes gradually decreased from 48 to 40 percent. The stand contained more legumes than grass at the end of the second and third years of the rotation and more grass than legumes at the end of the fourth and fifth years.

The standard errors shown in table 3 and subsequent tables include variation caused by yearly climatic differences. The standard errors for each of the means of the various items by years in the crop-and-pasture rotation also include variation caused by differences in the natural soil fertility of the five fields used. However, differences between means of a particular item between years in the crop-and-pasture rotation do not include year-to-year variation or differences caused by field differences, as each year of the rotation was equally represented in each calendar year and in each of the five fields.

Yield and Composition of the Green Pasture Herbage as Grazed

Data on the amount of green pasture herbage available for grazing (dry-matter basis) and its chemical composition and estimated total digestible nutrient content are summarized by years in table 4, and by seasons in appendix table 24. Only the data for the permanent pasture and for the third year of the crop-and-pasture rotation are for the entire growing season. The data for the second year of the rotation include the wheat stubble in the young grass-legume seedings.

The yield of dry matter in clipped herbage for the third year of the rotation averaged 16 percent higher than for the permanent pasture and exceeded the permanent pasture 4 years out of 5, but the permanent pasture was higher in 1948 when rainfall was abundant and well distributed. Dry-matter yields for the fourth and fifth years of the rotation, with the hay crops included, were lower than for the third year and exceeded the permanent pasture by only 3 and 4 percent, respectively.

All herbage was relatively high in protein and calcium, relatively low in crude fiber, and contained ample phosphorus. The bluegrass-white clover herbage from the permanent pasture was slightly lower in

TABLE 4.—*Average yield and composition of the green pasture herbage as grazed, Kentucky bluegrass-white clover permanent pasture compared with orchardgrass-Ladino clover pastures in a 5-year crop-and-pasture rotation, Beltsvile, Md., 1946–50* [1]

Item	Dry matter per acre	Composition of the dry matter							Estimated total digestible nutrients [2]	
		Protein	Ether extract	Crude fiber	Nitrogen-free extract	Total ash	Calcium	Phosphorus		
	Pounds	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Pounds*
Permanent pasture [3]	5, 550±553. 0	17. 6±1. 6	3. 8±0. 1	23. 1±0. 5	47. 2±0. 5	8. 3±0. 1	0. 86±0. 05	0. 38±0. 01	70. 3±0. 6	3, 905±383. 7
Year of the rotation:										
Second [4]	2, 620±111. 7	13. 9±1. 2	2. 9± . 1	20. 6± . 9	45. 3± . 8	8. 3± . 4	. 83± . 1	. 28± . 5	69. 1±1. 1	1, 812± 87. 6
Third [5]	6, 444±235. 8	18. 8± . 5	3. 3± . 1	24. 6± . 8	44. 8± . 3	8. 5± . 1	1. 02± . 05	. 32± . 01	72. 7± . 6	4, 682±164. 3
Fourth [6]	1, 754±240. 2	19. 0±1. 0	4. 0± . 1	25. 6± . 9	43. 0± . 7	8. 4± . 1	. 84± . 05	. 36± . 01	72. 0± . 9	1, 264±171. 3
Fifth [7]	4, 096±359. 7	20. 3± . 6	3. 9± . 1	23. 9± . 6	42. 9± . 5	9. 0± . 2	. 84± . 04	. 35± .004	72. 5± . 9	2, 969±268. 1

[1] Cut from cages and strips just prior to each grazing; samples dried with heated forced air.
[2] Estimated for cattle by the method of Schneider and others (*25*).
[3] Cages clipped 4 or 5 times each season.
[4] Mower strips cut twice each fall except in 1949; cut only once in 1949. Includes wheat stubble.
[5] Mower strips cut 4 times each season, except cut 3 times in 1949. No hay harvested.
[6] Mower strips cut twice each season in 1946 and 1947; once only in 1948, 1949, and 1950. Two crops of hay were harvested each year.
[7] Mower strips cut 4 times each season. One crop of hay was harvested each year.

protein, particularly in the spring, than the orchardgrass-Ladino clover herbage from the crop-and-pasture rotation (except the second year, with wheat stubble included); and it compared favorably with the latter in crude fiber, calcium, and phosphorus content.

The estimated total digestible nutrient content of the dry matter of the clipped herbage (based on digestibility for cattle) averaged above 70 pecent for all the grazed forages except the fall grazing with wheat stubble included (second year of the rotation). It was slightly higher for the rotation as a whole than for the permanent pasture, however.

In actual grazing, it is probable that the cows selected herbage with more protein and less crude fiber than the chemical analyses indicate. This would be true particularly for the second year of the rotation, when there was wheat stubble in the fall grazing.

In studying these data, the reader should keep in mind that they represent only the herbage above the clipping level. Small differences cannot be considered of significance from a grazing standpoint because: (1) There often is more herbage below the clipping level on permanent bluegrass-white clover pastures than on pastures with tall-growing mixtures such as orchardgrass-Ladino clover; (2) bluegrass-white clover pastures usually are grazed off closer to the ground than tall-growing combinations; (3) cows practice selective grazing and may leave more of the tall-growing forages; and (4) more herbage is trampled and more is left uneaten when forage yields are high than when forage yields are low.

Yield and Composition of the Harvested Crops

Data on the average yield of dry matter of the harvested crops as stored and the chemical composition and estimated total digestible nutrient content of the dry matter are summarized in table 5.

The corn was heavily eared. It yielded as much dry matter as the grass-legumes in the third year of the rotation and 16 percent more than the Kentucky bluegrass-white clover permanent pasture.

The wheat, seeded lightly as a nurse crop, averaged 28 bushels of grain (with 12 percent of moisture) per acre. Two-thirds of the total dry matter produced by the wheat crop was in the straw.

The two orchardgrass-Ladino clover hay crops harvested the fourth year of the rotation produced a total yield of nearly 2 tons of dry matter per acre. The second cutting yielded less dry matter than the first cutting. The dry matter of the second cutting was a little lower in crude fiber than that of the first cutting, and it was considerably higher in crude protein and a little higher in TDN.

The hay crop harvested the fifth year of the rotation was preceded by a very early grazing period. The yield was light, and it was similar in composition to the second cutting of the fourth year.

Grazing Conditions and Results

Information on the time and extent of grazing, live weight of the cows, supplemental feed consumed, milk produced, and total digestible nutrients yielded by grazing on the permanent pasture and on the pastures in the crop-and-pasture rotation is summarized in tables 6 and 7.

TABLE 5.—*Average yield and composition of the harvested crops as stored, 5-year crop-and-pasture rotation, Beltsville, Md., 1946–50* [1]

Year of the rotation and crop harvested [2]	Dry matter per acre	Composition of the dry matter					Estimated total digestible nutrients [3]	
		Protein	Ether extract	Crude fiber	Nitrogen-free extract	Ash		
	Pounds	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Pounds*
First year: Corn (silage)	6, 468±753. 1	8. 8±0. 3	2. 1±0. 2	22. 5±1. 1	61. 9±1. 6	4. 4±0. 3	70. 5±0. 3	4, 557±529. 0
Second year:								
Wheat (grain)	1, 480± 96. 6	13. 2± . 6	1. 8± . 1	2. 7± . 1	80. 2± . 4	2. 1±. 03	88. 0± . 1	1, 302± 92. 6
Wheat (straw)	2, 763±146. 2	2. 7± . 1	1. 0± . 1	47. 8± . 5	42. 4±1. 5	6. 1±1. 1		
Fourth year:								
Hay (first cutting)	2, 238±148. 0	12. 4± . 8	2. 4± . 2	32. 9± . 9	46. 0± . 5	6. 3± . 4	55. 3±1. 2	1, 237± 73. 8
Hay (second cutting)	1, 734±221. 8	16. 0± . 6	3. 4± . 1	29. 4±1. 3	43. 0±1. 2	8. 2± . 2	58. 4± . 7	1, 012±122. 9
Fifth year: Hay (cut after early grazing)	1, 261±123. 0	15. 3± . 7	2. 9± . 2	30. 5±1. 3	43. 6±1. 2	7. 7± . 5	57. 6±1. 0	726± 72. 1

[1] Corn as stored in the silo, wheat grain as stored in the mow, and wheat straw and hay as stored in the mow.

[2] Average date of harvest: Corn for silage, Sept. 4±9 days; wheat, June 25±4 days; fourth year of rotation, first cutting hay, May 23±5 days; fourth year of rotation, second cutting hay, July 18±9 days; and fifth year of rotation, hay cut after early grazing, June 1±11 days.

[3] Estimated for cattle according to Schneider and others (corn and wheat, *24;* hay, *25*).

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TABLE 6.—*Average time and extent of grazing and supplemental feed consumed per acre by cows on a Kentucky bluegrass-white clover permanent pasture and by cows on orchardgrass-Ladino clover pastures in a 5-year crop-and-pasture rotation, Beltsville, Md., 1946–50*

Item	Calendar-days grazed	Grazing per acre		Feed consumed per acre	
		Total grazing days	Total milking days	Hay	Grain
	Number	*Number*	*Number*	*Pounds*	*Pounds*
Permanent pasture [1]	186.0± 6.1	241.1± 9.7	171.8±34.6	671±205.6	1,633±278.2
Year of the rotation:					
Second [2]	16.6± 1.3	74.1±10.3	44.3± 6.6	163± 40.5	399± 58.6
Third [3]	39.4± 2.1	232.6±14.9	174.4±15.6	660± 95.9	1,428±164.0
Fourth [4]	14.0± 2.1	71.2±13.2	32.9±10.6	117± 48.9	329± 88.9
Fifth [5]	51.0± 3.4	205.0±10.2	138.1±17.3	844±132.9	1,314±128.6

[1] Grazing began Apr. 23±3.0 and ended Oct. 27±3.4; grazed rotationally in April and May and continuously thereafter.

[2] Grazing began Aug. 15±6.0 and ended Sept. 30±7.2; grazed rotationally twice each fall except in 1949 when it was grazed only once.

[3] Grazing began May 17±2.5 and ended Oct. 15±7.0; grazed rotationally 4 times each season except in 1949 when it was grazed only 3 times.

[4] Grazing began Sept. 3±6.3 and ended Oct. 5±9.0; grazed rotationally twice each fall in 1946 and 1947; once in the fall of 1948, 1949, and 1950.

[5] Grazing began Apr. 20±2.7 and ended Nov. 4±3.4; grazed rotationally 4 times each season with 1 light hay cutting between the first and second grazings.

TABLE 7.—*Average live weight per cow, and average net gain in weight, milk produced, and total digestible nutrients produced per acre from grazing a Kentucky bluegrass-white clover permanent pasture and orchardgrass-Ladino clover pastures in a 5-year crop-and-pasture rotation, Beltsville, Md., 1946–50*

Item	Live weight		Milk produced per acre [1]	TDN per acre		
	Average per cow	Net gain per acre		Required by cows	Consumed in feed	Credited to pasture
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Permanent pasture	1, 209±19. 2	56. 0±36. 4	5, 917±1, 231. 4	4, 486±403. 1	1, 644±283. 9	2, 842±217. 5
Year of the rotation:						
Second	1, 232±12. 3	10. 3±20. 7	1, 295± 111. 1	1, 204±164. 6	397± 49. 4	807±112. 7
Third	1, 196±15. 5	67. 6±55. 6	5, 100± 607. 7	4, 174±210. 8	1, 468±163. 6	2, 706± 54. 0
Fourth	1, 220±28. 8	66. 4±33. 0	977± 313. 0	1, 260±230. 1	317± 87. 0	943±166. 2
Fifth	1, 179±10. 4	86. 6±39. 7	4, 328± 755. 5	3, 874±212. 3	1, 474±132. 2	2, 400± 81. 5

[1] 4-percent fat-corrected milk.

From 25 to 50 cows were required at one time for grazing. It was necessary to use most of the cows available, regardless of their level of milk production. Consequently, there were some basic differences in the grazing groups between pastures and from year to year on the same pasture, but these differences tended to average out over the 5-year period.

For the 5-year period as a whole, for the permanent pasture and for all pastures in the crop-and-pasture rotation, the average live weight of the cows was 1,209 pounds and 1,198 pounds, respectively; dry cows comprised 28.8 percent and 33.1 percent, respectively, of the total number; average daily production of 4-percent fat-corrected milk by the milking cows was 34.4 pounds and 30.0 pounds, respectively; and by all cows it was 24.5 pounds and 20.1 pounds, respectively; average hay consumption per cow daily was 2.8 pounds and 3.1 pounds, respectively; the average ratio of grain fed to milk produced was 1:3.62 and 1:3.37, respectively; and the average consumption of TDN in supplemental feeds was 36.7 and 34.8 percent, respectively, of the total nutrient requirement.

Only the permanent pasture and the third year of the rotation were used entirely as grazing. The permanent pasture was grazed earlier in the spring and later in the fall than the third year of the rotation, and it produced slightly more grazing days and total digestible nutrients per acre. However, the third year of the rotation outyielded the permanent pasture by a small margin in 1946 and again in 1950.

Grazing following two hay crops (fourth year of the rotation) produced slightly fewer grazing days and slightly more total digestible nutrients per acre than grazing following the wheat harvest (second year of the rotation). Grazing early in the spring and late in the fall with one light hay crop in between (fifth year of the rotation) extended the grazing season beyond the usual limits and produced only 306 pounds less total digestible nutrients from grazing than the third year of the rotation, and only 442 pounds less than the permanent pasture.

The total digestible nutrients obtained per cow daily from grazing averaged 11.77 pounds for the permanent pasture as compared with an average of 11.64 pounds for the third year of the rotation and 11.76 pounds for all pastures in the rotation.

Live-weight gains per cow daily averaged 0.23 pound for the permanent pasture as compared with an average of 0.29 pound for the third year of the rotation and 0.40 pound for all pastures in the rotation.

Yield of Dry Matter and Total Digestible Nutrients Per Acre

Data on the yield of dry matter and total digestible nutrients per acre from the permanent pasture (grazing) and from the 5-year crop-and-pasture rotation (grazing and harvesting) are summarized in table 8.

The permanent pasture produced an average of 5,550 pounds of dry matter and 2,842 pounds of total digestible nutrients per acre. This yield of TDN is equivalent to 177.5 standard grazing days of 16 pounds TDN each. In other words, this yield of TDN would provide, by

TABLE 8.—*Average yield of dry matter and total digestible nutrients per acre, from grazing a permanent pasture and from grazing and harvesting a 5-year crop-and-pasture rotation, Beltsville, Md., 1946–50*

	Dry matter per acre		TDN per acre			
			Crop as stored		Less minimum storage loss [1]	
	Pounds	*Percent*	*Pounds*	*Percent*	*Pounds*	*Percent*
Permanent pasture (check)	5, 550±553. 1	100. 0	2, 842±217. 5	100. 0	2, 842±217. 5	100. 0
Crop-and-pasture rotation:						
First year (corn for silage)	6, 468±752. 4	116. 5± 7. 4	4, 557±529. 0	160. 3±22. 5	3, 873±449. 4	136. 3±18. 9
Second year (wheat and grazing) [2]	4, 100±166. 8	70. 4± 7. 6	2, 109±156. 1	74. 5± 8. 2	2, 109±156. 1	74. 5± 8. 0
Third year (grazing only)	6, 444±234. 1	116. 1±10. 6	2, 706± 53. 9	95. 2± 6. 9	2, 706± 53. 9	95. 2± 6. 9
Fourth year (hay, hay, grazing)	5, 726±377. 3	103. 2± 6. 7	3, 192±215. 5	112. 3± 6. 0	3, 080±209. 6	108. 4± 5. 9
Fifth year (grazing, hay, grazing)	5, 357±359. 6	96. 5± 6. 4	3, 126±137. 6	110. 0± 7. 2	3, 090±134. 4	108. 7± 7. 7
Average	5, 619±316. 8	101. 2± 5. 7	3, 138±132. 0	110. 4± 8. 9	2, 972±117. 8	104. 6± 6. 8

[1] Deducted as storage loss: 15 percent of corn as stored in the silo; 5 percent of hay as stored in the mow.
[2] Does not include wheat straw.

grazing alone without any supplemental feed, sufficient TDN for a 1,200-pound cow to maintain herself and produce 20 pounds of 4-percent fat-corrected milk daily for 177.5 days, or a total of 3,550 pounds of milk. It is also equal to 5,684 pounds of high-quality, early cut hay with 15 percent of moisture.

The 5-year crop-and-pasture rotation produced an average of 5,619 pounds of dry matter per acre, or only 1.2 percent more than the permanent pasture. The third. fourth, and fifth years of the rotation averaged 16.1 percent more, 3.2 percent more, and 3.5 percent less, respectively, than the permanent pasture. The 3 years combined averaged 5,842 pounds of dry matter, or 5.3 percent more than the permanent pasture.

The 5-year crop-and-pasture rotation produced an average of 2,977 pounds of TDN per acre after storage losses for the silage and hay were deducted, or 4.6 percent more than the permanent pasture. The third, fourth, and fifth years of the rotation averaged 4.8 percent less, 8.4 percent more, and 8.7 percent more, respectively, after storage losses for the hay were deducted, than the permanent pasture. The 3 years combined averaged 2,959 pounds of TDN, or 4.1 percent more than the permanent pasture.

The corn and wheat crops combined (including grazing in the fall following wheat) produced an average of 2,991 pounds of TDN per acre per year after storage losses for the silage were deducted. This was only 1.1 percent more than the grass-legumes in the rotation and only 5.2 percent more than the permanent pasture.

Seasonal Distribution of the Total Digestible Nutrients Produced

Data on the seasonal distribution of the TDN produced per acre per day from grazing the permanent pasture, from grazing the third year of the crop-and-pasture rotation, and from the hay crop and grazing the fourth and fifth years of the rotation are summarized by months in table 9, and by 5-day intervals throughout the season in figure 1 and appendix table 22.

In comparing the seasonal distribution of TDN produced, the dates on which grazing was started on the permanent pasture in the spring were used as a base. The TDN yields obtained from the first rotational grazing of grass-legumes in the crop-and-pasture rotation and from the first hay harvest each season were prorated back to these dates, assuming equal yields for each 5-day period based on calculations from proximate analyses and Schneider's regression coefficients for cattle (*24*). TDN yields obtained from later grazings and hay harvests were prorated back to the date of the preceding grazing or hay harvest. A 5-percent deduction was made from the TDN produced by the hay harvests, as a minimum storage loss.

All fields reached their peak daily production of TDN in May. The average daily production of TDN in May was lower for the third and fifth years of the crop-and-pasture rotation than for the permanent pasture but was considerably higher for the fourth year.

Daily production of TDN dropped sharply in all fields the latter part of May, the rate of decline slowing down and leveling off in June. The average in June was appreciably higher for the fourth and fifth

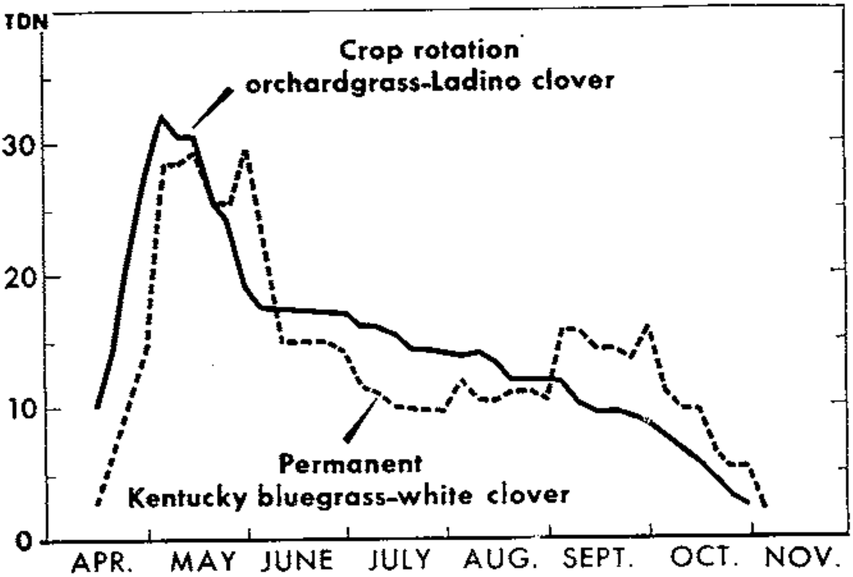

FIGURE 1.—Average production of TDN per acre per day throughout the season from grazing a Kentucky bluegrass-white clover permanent pasture and from the hay crop and grazing orchardgrass-Ladino clover pastures for 3 years of a 5-year crop-and-pasture rotation, Beltsville, Md., 1946–50.

TABLE 9.—*Average production of total digestible nutrients per acre daily, by months, on a Kentucky bluegrass-white clover permanent pasture and on orchardgrass-Ladino clover pastures in a 5-year crop-and-pasture rotation, Beltsville, Md., 1946–50* [1]

Month	Permanent pasture	Year of the rotation			
		Third	Fourth	Fifth	Average
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
May	26.6±5.4	23.9±3.4	36.2±4.2	22.8±1.5	27.6±3.0
June	16.4±2.4	14.2±1.0	18.1±2.5	19.3±1.3	17.2±1.7
July	10.4±2.3	13.1±1.1	16.7±1.3	15.7±2.0	15.2±1.4
August	10.8±2.1	13.9±1.1	12.7±2.6	11.9±1.0	12.8±1.6
September	15.0±2.8	13.8±1.4	8.1±1.8	8.4± .1	10.1±1.3
October	10.7±1.5	7.0±1.1	3.4±1.8	6.2±1.0	5.5±1.3

[1] Complete seasonal distribution shown in figures 1 and 2. The dates on which grazing was started on the permanent pasture in the spring were used as a base. The TDN yields obtained from the first rotational grazing of the pastures in the crop-and-pasture rotation and from the first hay harvest each season were prorated back to these dates; the TDN yields obtained from later grazings and hay harvests were prorated back to the date of the preceding grazing or hay harvest. In these data, 5 percent of the total digestible nutrients was deducted from the hay harvests as a minimum storage loss.

years of the rotation than for the permanent pasture but was lower for the third year. Also, during June, daily production of TDN dropped considerably lower for the permanent pasture than for the pastures in the rotation. Therefore, average daily production of TDN was considerably higher during July and August for the pastures in the rotation than for the permanent pasture.

Production of TDN increased slightly for the permanent pasture in the latter part of August and this increase was maintained during September, whereas production of TDN continued to decline for the crop-and-pasture rotation. As a result, average daily production of TDN was lower for the crop-and-pasture rotation than for the permanent pasture during September and October.

The yearly data indicate that variation in daily yield of TDN was greater from year to year for the permanent pasture than for the crop-and-pasture rotation.

RESULTS OF THE COMPARISON BETWEEN ORCHARDGRASS AND BROMEGRASS IN THE GRASS-LEGUME MIXTURE

Orchardgrass grows well and produces high yields in the Maryland-Virginia area in which Beltsville is located. Small-plot studies by the Field Crops Research Branch show that bromegrass, a well-adapted high-yielding pasture grass in the Corn Belt and the Northeast, apparently is not so well adapted for Maryland and Virginia as orchardgrass. Bromegrass was introduced into this experiment to compare the growing habits and yields of the two grasses when grown with Ladino clover on a larger scale under actual grazing and harvesting conditions.

Beginning in the fall of 1945, therefore, orchardgrass was replaced by bromegrass on 2 of the 4 acres seeded yearly to the orchardgrass-Ladino clover-red clover mixture. At the end of the experiment in 1950, the 2 grasses had been compared 5 times for the second year of the crop-and-pasture rotation, 4 times for the third year, 3 times for the fourth year, and 2 times for the fifth year. Therefore, the data for the orchardgrass-Ladino clover fields in these comparisons differ from those in the previous discussion, which included the years 1946–50, inclusive.

Botanical Composition of the Ground Cover

Plant population counts were made each fall after the end of the grazing season. The data are summarized in table 10.

Bromegrass did not develop in the ground cover as rapidly as orchardgrass nor to as great an extent. Bromegrass reached a peak of 30.5 percent the third year of the rotation, as compared with 41.3 percent for orchardgrass, and they maintained about those same levels the fourth and fifth years. Ladino clover provided more ground cover throughout than bromegrass.

Weeds occupied a larger area on the bromegrass fields than on the orchardgrass fields the second, third, and fourth years of the rotation and about the same on both the fifth year. Kentucky bluegrass was more aggressive on the bromegrass fields than on the orchardgrass

TABLE 10.—*Average botanical composition of the ground cover on comparable orchardgrass-Ladino clover and bromegrass-Ladino clover fields in a 5-year crop-and-pasture rotation, Beltsville, Md.*[1]

Ground cover	Year of the rotation, and field							
	Second [2]		Third [3]		Fourth [4]		Fifth [5]	
	Orchard-grass	Brome-grass	Orchard-grass	Brome-grass	Orchard-grass	Brome-grass	Orchard-grass	Brome-grass
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Kentucky bluegrass	0.2	0.2	0.5	1.8	1.0	3.0	4.0	11.5
Orchardgrass	30.8	.2	41.3	.7	40.0	1.3	39.0	1.5
Bromegrass	0	24.0	0	30.5	0	30.7	0	30.0
Total grasses	31.0	24.4	41.8	33.0	41.0	35.0	43.0	43.0
Ladino clover	33.0	39.4	43.7	45.3	38.3	36.7	36.0	37.5
Red clover	15.4	12.2	.5	2.5	.7	.3	.5	0
Total legumes	48.4	51.6	44.2	47.8	39.0	37.0	36.5	37.5
Weeds	15.2	18.8	10.5	15.7	17.0	25.7	14.5	15.5
Bare ground	5.4	5.2	3.5	3.5	3.0	2.3	6.0	4.0

[1] Plant population counts made each fall with a point quadrat after the end of the grazing season.
[2] 1946–50, inclusive.
[3] 1947–50, inclusive.
[4] 1948–50, inclusive.
[5] 1949 and 1950.

fields beginning the third year of the rotation. By the end of the fifth year, Kentucky bluegrass covered nearly three times as large an area on the bromegrass fields as on the orchardgrass fields.

Yield of Dry Matter and Total Digestible Nutrients Per Acre

Data on the yield of dry matter and total digestible nutrients per acre from grazing and harvesting comparable orchardgrass-Ladino clover fields and bromegrass-Ladino clover fields are summarized in table 11.

TABLE 11.—*Average yield of dry matter and total digestible nutrients per acre from grazing and harvesting comparable orchardgrass-Ladino clover fields and bromegrass-Ladino clover fields in a 5-year crop-and-pasture rotaton, Beltsville, Md.*

Field, and year of rotation	Dry matter per acre	TDN per acre	
		Crop as stored	Less minimum storage loss [1]
	Pounds	*Pounds*	*Pounds*
Orchardgrass:			
Third year [2]	6,551	2,718	2,718
Fourth year [3]	5,668	3,161	3,043
Fifth year [4]	5,289	3,397	3,351
Average	5,836	3,092	3,031
Bromegrass:			
Third year [2]	5,865	2,741	2,741
Fourth year [3]	4,898	2,595	2,495
Fifth year [4]	5,305	3,165	3,132
Average	5,356	2,834	2,789

[1] 5 percent of hay stored in the mow deducted as storage loss.
[2] 1947–50, inclusive; grazing only.
[3] 1948–50, inclusive; hay, hay, grazing.
[4] 1949 and 1950; grazing, hay, grazing.

Both grass-legume mixtures were grazed and harvested under similar conditions. There were only slight differences in the chemical composition of the dry matter of the two mixtures. The orchardgrass-Ladino clover mixture was ready for grazing from 6 to 8 days earlier in the spring than the bromegrass-Ladino clover mixture. On an average, the orchardgrass-Ladino clover mixture produced 9 percent more dry matter and 9 percent more TDN from grazing and harvesting than the bromegrass-Ladino clover mixture.

Seasonal Distribution of the Total Digestible Nutrients Produced

Data on the seasonal distribution of the TDN produced per acre per day by comparable orchardgrass-Ladino clover fields and bromegrass-

Ladino clover fields are summarized by months in table 12, and by 5-day intervals throughout the season in figure 2 and appendix table 23.

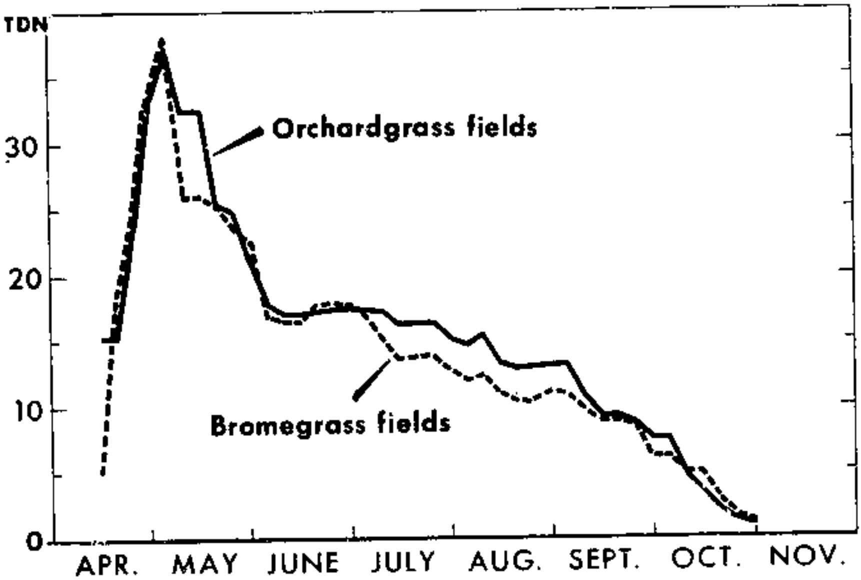

FIGURE 2.—Average production of TDN per acre per day throughout the season by comparable orchardgrass-Ladino clover fields and bromegrass-Ladino clover fields in a 5-year crop-and-pasture rotation, Beltsville, Md.

TABLE 12.—*Average production of total digestible nutrients per acre daily, by months, on comparable orchardgrass-Ladino clover and bromegrass-Ladino clover fields in a 5-year crop-and-pasture rotation, Beltsville, Md.*

Month	Year of the rotation, and field					
	Third [1]		Fourth [2]		Fifth [3]	
	Orchard-grass	Brome-grass	Orchard-grass	Brome-grass	Orchard-grass	Brome-grass
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
May	26.4	32.0	37.3	24.7	24.9	24.4
June	14.3	14.4	17.8	19.8	19.9	18.0
July	12.9	10.8	17.1	15.6	19.7	17.7
August	13.8	10.2	13.1	9.7	14.5	14.0
September	14.4	11.0	7.0	5.6	9.2	10.9
October	6.2	5.2	.5	.4	3.8	3.8

[1] 1947–50, inclusive.
[2] 1948–50, inclusive.
[3] 1949 and 1950.

The bromegrass fields reached a higher peak production of TDN than the orchardgrass fields in late April and early May of the third and fifth years of the rotation, but had a considerably lower peak production the fourth year. For all 3 years, there was little difference in the average daily production of TDN per acre between the bromegrass fields and the orchardgrass fields in May and June. However, production was lower on the bromegrass fields than on the orchardgrass fields during the remainder of the season for the third and fourth years, and also during July and August for the fifth year.

CROP PRODUCTION REQUIREMENTS AND COSTS

Farming operations for the first and second years of the crop-and-pasture rotation were on 4-acre fields. All others, including those on the permanent pasture, were on 2-acre fields.

How Requirements and Costs Were Calculated

The time requirements used for crop production are based on the average actual observed time required to perform the various field operations in this experiment. Hourly charges for labor and machinery at Beltsville are not typical of average farming. Surveys of actual farm costs per hour were used, therefore, to provide cost data that would be typical for an average-size farm.

The hourly rate used for labor was $0.69. This was the average hourly wage without room and board paid to farmworkers in the United States in 1950 (*28*).

The observed operation time per acre for the different types of equipment used and the cost per hour of operating each piece of equipment as determined by farm surveys are given in table 13. The operating costs per hour used for most farm machinery were obtained from a farm survey in Nebraska (*17*) published in 1948. The operating costs per hour used for the manure spreader, power scoop, fertilizer spreader, and cultipacker were calculated from (a) the annual usage figures for such machines in Indiana (*8*), as published in 1939; (b) the 1950 prices of these machines; and (c) the method for calculating hourly costs outlined by the American Society of Agricultural Engineers in 1949 (*3*). All hourly costs of machinery include depreciation, repair, daily maintenance, and fuel. A flat charge of 10 cents per bushel of wheat threshed was made for the use of the threshing machine.

The cost of barnyard manure was placed at $2 per ton, its calculated value for replacing commercial fertilizer. The cost of fertilizer and seed was their actual cost at Beltsville in 1950, as follows: Commercial fertilizer, $36 per ton; hybrid seed corn, $10.30 per bushel; seed wheat, $3 per bushel; orchardgrass seed, $41.30 per hundredweight; red clover seed, $44.30 per hundredweight; and Ladino clover seed, $189 per hundredweight.

The price charged for the use of land was $9.40 per acre. This was the average cost paid as interest or rent by operators of family-size hog-dairy farms in the Corn Belt in 1949 (*27*).

Fencing costs are not included in this study.

TABLE 13.—*Kind of farming equipment used, rate of operation per acre, and cost of operation per hour in a comparison of a Kentucky bluegrass-white clover permanent pasture with orchardgrass-Ladino clover pastures in a 5-year crop-and-pasture rotation, Beltsville, Md., 1946–50* [1]

Kind of equipment	Rate of operation per acre	Cost of operation per hour
	Minutes	*Dollars*
Corn planter, 2-row	28	0.73
Corn cultivator, 2-row	28	.29
Cultipacker, 8-foot	22	.31
Fertilizer spreader, 10-foot	22	.40
Field forage baler	46	2.22
Field forage chopper	87	1.82
Forage blower, stationary	58	.66
Grain binder, 6-foot	48	1.58
Grain drill, 8-foot	22	.43
Harrow, disk, tandem, 8-foot	23	.38
Harrow, spike-tooth, 12-foot	24	.18
Harrow, spring-tooth, 10-foot	25	.14
Manure scoop [2]	24	.20
Manure spreader, 50-bushel capacity [2]	152	.13
Mower, 7-foot, clipping pastures	24	.68
Mower, 7-foot, mowing hay	32	.68
Plow, moldboard, 2 14-inch	74	.25
Rake, side delivery, 10-foot	20	.61
Thresher, stationary	23	[3] .10
Tractor		.80
Truck		.80
Wagon, hauling wheat during threshing	46	.03

[1] See text for source of rates and co...
[2] 8 loads (10 tons) of barnyard manure spread per acre.
[3] Cost per bushel.

Crop Production Requirements and Costs Per Acre

A summary of labor requirements and labor and equipment costs per acre per year for the permanent pasture and for the 5-year crop-and-pasture rotation is given in table 14. Labor requirements and labor and equipment costs for grazing and for harvesting are given separately for the second, fourth, and fifth years of the rotation. All material, labor, and equipment costs for manuring, fertilizing, and seeding are prorated according to their apparent usefulness. This is more equitable than to charge all these costs to the first crop year following application or seeding, as manuring, fertilizing, and seeding all affect crop production beyond the first year.

The costs per acre were prorated as follows:

Barnyard manure (including its application)—

Two-thirds to the first year following application: Manure, $12.33; labor (2 hours) and equipment cost, $5.19; total $18.52.

One-third to the second year following application: Manure, $6.67; labor (1 hour) and equipment cost, $2.59; total, $9.26.

Commercial fertilizer (including its application)—

Charged equally to all years: Fertilizer, $2.92; labor (0.29 hour) and equipment cost, $0.44; total, $3.36.

Grass and legume seed and seeding—

One-tenth to the second year of the rotation: Seed, $0.76; labor (0.20 hour), $0.14; total, $0.90.

Three-tenths to each of the third, fourth, and fifth years of the rotation: Seed, $2.27; labor (0.60 hour), $0.42; total, $2.69.

All costs for the second, fourth, and fifth years of the crop-and-pasture rotation were prorated between the harvested crops and the grazing on the basis of their relative yield of TDN, with storage losses deducted, as follows:

Second year—Wheat (grain), 61.7 percent; fall grazing, 38.3 percent.

Fourth year—Hay (2 cuttings), 69.4 percent; fall grazing, 30.6 percent.

Fifth year—Hay (1 cutting), 22.3 percent; grazing, 77.7 percent.

For the permanent pasture, applying barnyard manure (prorated basis) increased total costs by 109 percent the first year following application, and by 55 percent the second year following application.

Labor and equipment costs were 268 percent higher and total costs were 63 percent higher for the 5-year crop-and-pasture rotation than for the permanent pasture. Production requirements and costs per acre were lowest for the third year of the rotation (grazing only), and they were similar to requirements and costs for the permanent pasture under similar conditions (no manure applied in either case). Harvesting one light hay crop (fifth year of the rotation) doubled labor requirements and increased total costs by 25 percent. Harvesting two light hay crops (fourth year of the rotation) nearly quadrupled labor requirements and increased total costs by over 50 percent.

Labor requirements averaged 184 percent more and total costs averaged 107 percent more for the first and second years of the rotation (corn and wheat; manure applied) than for the last 3 years (grass-legumes; no manure applied). After labor requirements and costs of applying manure were deducted, the first 2 years still averaged 153 percent more labor and 49 percent more total cost per acre per year.

Labor requirements and labor and equipment costs per acre per year for the various farming operations on the permanent pasture are given in detail, by calendar years, for the 5-year period 1946–50 in appendix table 16. Average labor and equipment requirements and costs per acre per year for the permanent pasture and for each of the 5 years of the crop-and-pasture rotation are given in appendix tables 17 to 20, inclusive. Average labor requirements and all costs for labor, equipment, fertilizer, barnyard manure, seed, and land use per acre per year are summarized in appendix table 21. In this table, all costs for manuring, fertilizing, and seeding are charged to the first crop year following application or seeding, rather than being prorated as in table 14.

TABLE 14.—*Labor requirements and all costs per acre per year for a Kentucky bluegrass-white clover permanent pasture and for crops and pastures in a 5-year crop-and-pasture rotation, Beltsville, Md., 1946–50* [1]

PERMANENT PASTURE

Item	Labor required per acre	Costs per acre per year for—					Total cost per acre
		Labor	Equipment	Fertilizer or manure	Seed	Land	
	Hours	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1946	1. 50	1. 04	1. 80	2. 88	----------	9. 40	15. 12
1947	1. 50	1. 04	1. 80	2. 88	----------	9. 40	15. 12
1948	3. 50	2. 42	3. 63	16. 21	----------	9. 40	31. 66
1949	2. 50	1. 73	2. 72	9. 55	----------	9. 40	23. 40
1950	1. 50	1. 04	1. 80	2. 88	----------	9. 40	15. 12
Average	2. 10	1. 45	2. 35	6. 88	----------	9. 40	20. 08

5-YEAR CROP-AND-PASTURE ROTATION

Item	Labor required per acre	Labor	Equipment	Fertilizer or manure	Seed	Land	Total cost per acre
First year: Corn (silage)	13. 87	9. 57	15. 17	16. 21	2. 06	9. 40	52. 51
Second year:							
Wheat (grain)	12. 40	8. 56	10. 03	5. 89	3. 00	5. 80	33. 28
Fall grazing	1. 10	. 76	1. 03	3. 66	. 76	3. 60	9. 81
Total	13. 50	9. 32	11. 06	9. 55	3. 76	9. 40	43. 09
Third year: Grazing	2. 10	1. 45	2. 01	2. 88	2. 28	9. 40	18. 02

Fourth year:							
Hay (2 cuttings)	6. 86	4. 74	7. 28	2. 00	1. 58	6. 52	22. 12
Fall grazing	. 67	. 46	. 66	. 88	. 70	2. 88	5. 58
Total	7. 53	5. 20	7. 94	2. 88	2. 28	9. 40	27. 70
Fifth year:							
Hay (1 cutting)	3. 32	2. 30	3. 50	. 64	. 51	2. 10	9. 05
Grazing	1. 50	1. 03	1. 38	2. 24	1. 77	7. 30	13. 72
Total	4. 82	3. 33	4. 88	2. 88	2. 28	9. 40	22. 77
Average (5 years)	8. 36	5. 76	8. 22	6. 88	2. 53	9. 40	32. 79
Average (first and second years)	13. 68	9. 50	13. 11	12. 88	2. 91	9. 40	47. 30
Average (third, fourth and fifth years)	4. 82	3. 33	4. 94	2. 88	2. 28	9. 40	22. 83

[1] Labor requirements and all costs prorated as indicated in text, p. 25.

Labor Required and Total Cost Per Hundred Pounds of Total Digestible Nutrients Produced

The labor required and total cost per 100 pounds of total digestible nutrients produced by the permanent pasture and by the 5-year crop-and-pasture rotation are shown in table 15. Data are based on prorated labor requirements and costs, as shown in table 14. For har-

TABLE 15.—*Labor required, and total cost, per 100 pounds of total digestible nutrients produced by a Kentucky bluegrass-white clover permanent pasture and by a 5-year crop-and-pasture rotation, Beltsville, Md., 1946–50* [1]

PERMANENT PASTURE

Item	Labor required per acre	Total cost per acre	TDN produced per acre	Labor required per 100 pounds TDN	Total cost per 100 pounds TDN
	Hours	*Dollars*	*Pounds*	*Hours*	*Dollars*
1946	1. 50	15. 12	2, 202	0. 068	0. 69
1947	1. 50	15. 12	3, 388	. 044	. 45
1948	3. 50	31. 66	3, 370	. 104	. 90
1949	2. 50	23. 40	2, 851	. 087	. 82
1950	1. 50	15. 12	2, 401	. 062	. 63
Average	2. 10	20. 08	2, 842	. 074	. 71

5-YEAR CROP-AND-PASTURE ROTATION [2]

Item	Labor required per acre	Total cost per acre	TDN produced per acre	Labor required per 100 pounds TDN	Total cost per 100 pounds TDN
First year: Corn (silage)	13. 87	52. 51	3, 873	0. 358	1. 35
Second year:					
Wheat (grain)	12. 40	33. 28	1, 302	. 952	2. 56
Fall grazing	1. 10	9. 81	807	. 136	1. 22
Total	13. 50	43. 09	2, 109	. 640	2. 04
Third year: Grazing	2. 10	18. 02	2, 706	. 078	. 67
Fourth year:					
Hay (2 cuttings)	6. 86	22. 12	2, 137	. 321	1. 04
Fall grazing	. 67	5. 58	943	. 071	. 59
Total	7. 53	27. 70	3, 080	. 244	. 90
Fifth year:					
Hay (1 cutting)	3. 32	9. 05	690	. 481	1. 31
Grazing	1. 50	13. 72	2, 400	. 063	. 57
Total	4. 82	22. 77	3, 090	. 156	. 74
Average, 5-year crop-and-pasture rotation	8. 36	32. 79	2, 972	. 283	1. 10
All hay				. 360	1. 10
All grazing				. 078	. 69

[1] Labor requirements and all costs prorated as indicated in text, p. 25.
[2] Minimum storage losses deducted: 15 percent for corn silage; 5 percent for hay.

vested crops, the data are based on yields of TDN after storage losses of 15 percent for corn stored in the silo and 5 percent for hay stored in the mow were deducted. Data are given separately for grazing and for harvested crops, where both occur in the same crop year. All hay and all grazing for the crop-and-pasture rotation are also summarized separately.

For the permanent pasture, the labor required per 100 pounds of TDN produced was very low, averaging 0.074 hour. Application of barnyard manure (1948 and 1949) doubled both the labor required and the total cost per 100 pounds of TDN produced.

For the 5-year crop-and-pasture rotation, the labor required per 100 pounds of TDN produced covered a wide range and averaged about 4 times as much as for the permanent pasture. The average for all grazing in the rotation was about the same as for the permanent pasture. The average for all hay in the rotation was about 4½ times as much as for all grazing. The corn crop (first year of the rotation) required about as much labor per 100 pounds of TDN produced as the average for all hay; the wheat crop (grain only, second year of the rotation) required nearly 3 times as much as the corn crop.

For the 5-year crop-and-pasture rotation, total cost per 100 pounds of TDN produced also covered a wide range and averaged about 1½ times as much as for the permanent pasture. The average for all grazing in the rotation was about the same as for the permanent pasture. The average for all hay in the rotation was about 1.4 times as much as for all grazing. Total cost per 100 pounds of TDN produced was about 1.2 times as much for the corn crop (first year of the rotation) as the average for all hay; and it was about twice as much for the wheat crop (grain only, second year of the rotation) as for the corn crop. Both the corn crop and the wheat crop included labor, material, and equipment costs of applying manure, whereas the hay and grazing did not.

SUMMARY

At Beltsville, well-managed improved Kentucky bluegrass-white clover pastures provide high yields of desirable grazing for dairy cattle. The principal faults of these pastures are that yields are greatly reduced during dry periods and dry seasons, and the pastures are sometimes quite weedy.

Seeded orchardgrass-Ladino clover pastures, grown in a 5-year rotation with corn for silage and wheat as a nurse crop, were compared with a Kentucky bluegrass-white clover permanent pasture for the 5-year period 1946–50. The pastures in the rotation were used as pasture or as hay and pasture. Bromegrass was seeded with Ladino clover during part of this period, to compare with orchardgrass.

The ground cover of the orchardgrass-Ladino clover pastures contained more legumes and fewer weeds than the Kentucky bluegrass-white clover pasture. All grazing was relatively high in protein, calcium, and phosphorus and low in crude fiber, but the grazing on the Kentucky bluegrass-white clover pasture was lower in protein early in the season. On both kinds of pasture, the quality of the grazing changed but little throughout the season.

The seasonal production of dry matter and total digestible nutrients followed somewhat the same pattern on both kinds of pasture. They

reached a high peak production during early May and dropped off sharply during late May and early June, with lower production throughout the remainder of the season. Yields were about equal on both kinds of pasture during May and June, somewhat higher on the orchardgrass-Ladino clover pastures during July and August, and slightly higher on the Kentucky bluegrass-white clover pasture during September and October.

The orchardgrass-Ladino clover pastures provided their best late summer grazing the third year of the rotation, and they reached their highest peak of spring productivity the fourth year. They provided very early grazing in the spring of the fifth year and were reserved for very late grazing that fall, thus extending the length of the grazing season appreciably.

As a whole, the orchardgrass-Ladino clover pastures (third, fourth, and fifth years of the rotation) outyielded the Kentucky bluegrass-white clover permanent pasture during dry periods and dry seasons but not during seasons of abundant, well-distributed rainfall. The orchardgrass-Ladino clover pastures yielded only 5.3 percent more dry matter and 4.1 percent more TDN, on an average, than the Kentucky bluegrass-white clover permanent pasture. The first 2 years of the crop-and-pasture rotation (corn the first year; wheat followed by fall grazing the second year) yielded only 5.2 percent more TDN than the Kentucky bluegrass-white clover pasture and only 1.1 percent more than the orchardgrass-Ladino clover pastures.

Bromegrass did not develop in the grass-legume mixture to the same extent as orchardgrass. The bromegrass-Ladino clover combination produced about as much TDN during May and June as the orchardgrass-Ladino clover combination, but produced less from July 1 on, and 9 percent less for the season.

The labor required and total cost per 100 pounds of TDN produced by the Kentucky bluegrass-white clover permanent pasture and by the orchardgrass-Ladino clover pastures in the crop-and-pasture rotation were low and about equal. Compared to grazing the orchardgrass-Ladino clover pastures, making hay required 4.6 times as much labor and cost 1.6 times as much; corn harvested as silage required 4.6 times as much labor and cost 2.0 times as much; and wheat harvested as grain required 12.2 times as much labor and cost 3.7 times as much.

A 5-year crop-and-pasture rotation consisting of corn for silage, small grain used as a nurse crop, and 3 years of seeded grass-legumes provides a good means for utilizing the accumulating fertility reserves in old pasture sods for the production of harvested forage, and then remaking them into high-yielding pastures. Grazing the wheat crop off or cutting it early for silage or hay will reduce the high labor requirements and costs of this crop without decreasing the amount of feed nutrients produced.

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APPENDIX

TABLE 16.—*Labor and equipment requirements and costs per acre for a Kentucky bluegrass-white clover permanent pasture, Beltsville, Md., by calendar years, 1946–50* [1]

Year, and item	Time per acre per year for—					Cost per acre
	Clipping after grazing	Scattering droppings	Fertilizing	Manuring	Total time	
	Minutes	*Minutes*	*Minutes*	*Minutes*	*Hours*	*Dollars*
First year, 1946:						
Labor	48	24	44		1.93	1.33
Mower, 7-foot	48				.80	.54
Harrow, spike-tooth, 12-foot		24			.40	.07
Fertilizer spreader, 10-foot			22		.37	.15
Truck			10		.17	.14
Tractor	48	24	22		1.57	1.26
Total cost						3.49
Second year, 1947:						
Labor	48	24			1.20	.83
Mower, 7-foot	48				.80	.54
Harrow, spike-tooth, 12-foot		24			.40	.07
Tractor	48	24			1.20	.96
Total cost						2.40
Third year, 1948:						
Labor	48	24		180	4.20	2.90
Manure spreader				152	2.53	.33
Manure scoop				24	.40	.08
Mower, 7-foot	48				.80	.54
Harrow, spike-tooth, 12-foot		24			.40	.07
Tractor	48	24		176	4.13	3.30
Total cost						7.22
Fourth year, 1949:						
Labor	48	24			1.20	.83
Mower, 7-foot	48				.80	.54
Harrow, spike-tooth, 12-foot		24			.40	.07
Tractor	48	24			1.20	.96
Total cost						2.40
Fifth year, 1950:						
Labor	48	24	44		1.93	1.33
Mower, 7-foot	48				.80	.54
Harrow, spike-tooth, 12-foot		24			.40	.07
Fertilizer spreader, 10-foot			22		.37	.15
Truck			10		.17	.14
Tractor	48	24	22		1.57	1.26
Total cost						3.49

[1] Pastures clipped twice each year, droppings scattered once each year. All machinery operated by tractor.

TABLE 17.—*Average labor and equipment requirements and costs per acre per year for a Kentucky bluegrass-white clover permanent pasture, Beltsville, Md., 1946–50* [1]

Item	Time per acre per year for—					Cost per acre
	Clipping after grazing	Scattering droppings	Fertilizing	Manuring	Total time	
	Minutes	*Minutes*	*Minutes*	*Minutes*	*Hours*	*Dollars*
Labor	48. 0	24. 0	17. 6	36. 0	2. 09	1. 44
Mower, 7-foot	48. 0				. 80	. 54
Harrow, spike-tooth, 12-foot		24. 0			. 40	. 07
Fertilizer spreader, 10-foot			8. 8		. 15	. 06
Truck			4. 0		. 07	. 06
Manure scoop				4. 8	. 08	. 02
Manure spreader				30. 4	. 51	. 07
Tractor	48. 0	24. 0	8. 8	35. 2	1. 93	1. 54
Total cost						3. 80

[1] Pastures clipped twice each year; droppings scattered once each year. All machinery operated by tractor. Fertilizing and manuring charges prorated evenly over the 5 years.

TABLE 18.—*Average labor and equipment requirements and costs per acre per year for the first year of a 5-year crop-and-pasture rotation, Beltsville, Md., 1946–50* [1]

Items	Time per acre per year for—					Cost per acre
	Spreading manure	Plowing, disking, harrowing	Planting and cultivating	Harvesting for silage	Total time	
	Minutes	*Minutes*	*Minutes*	*Minutes*	*Hours*	*Dollars*
Labor	180	170	84	440	14. 57	10. 05
Manure scoop	24				. 40	. 08
Manure spreader	152				2. 53	. 33
Plow, moldboard, 2 14-inch		74			1. 23	. 31
Harrow, disk, tandem, 8-foot		46			. 77	. 29
Harrow, spring-tooth, 10-foot		50			. 83	. 12
Corn planter, 2-row			28		. 47	. 34
Corn cultivator, 2-row			56		. 93	. 27
Field forage chopper				87	1. 45	2. 64
Stationary forage blower				58	. 97	. 64
Truck				237	3. 95	3. 16
Tractor	176	164	84	146	9. 60	7. 68
Total cost						25. 91

[1] Corn for silage. Disked twice, spring-tooth harrowed twice, cultivated twice; harvested with field forage chopper and dump trucks, averaging 8 loads per acre; all machinery operated by tractor. All manuring costs charged to the corn crop.

TABLE 19.—*Average labor and equipment requirements and costs per acre per year for the second year of a 5-year crop-and-pasture rotation, Beltsville, Md., 1946–50* [1]

Items	Time per acre per year for—						Cost per acre
	Disking, harrowing, fertilizing	Seeding wheat, grass, legumes	Binding and shocking wheat	Hauling, threshing, storing wheat	Clipping after fall grazing	Total time	
	Minutes	*Minutes*	*Minutes*	*Minutes*	*Minutes*	*Hours*	*Dollars*
Labor	140	164	244	312	24	14. 73	10. 16
Harrow, disk, 8-foot	46					. 77	. 20
Harrow, spring-tooth, 10-foot	50					. 83	. 12
Fertilizer spreader	22					. 37	. 15
Grain drill, 8-foot		22				. 37	. 16
Cultipacker, 8-foot		22				. 37	. 11
Grain binder, 6-foot			48			. 80	1. 26
Thresher				23		. 38	2. 90
Mower, 7-foot					24	. 40	. 27
Wagon				46		. 77	. 02
Truck	10			101		1. 85	1. 48
Tractor	118	44	48	46	24	4. 68	3. 74
Total cost							20. 66

[1] Wheat, followed by fall grazing. All machinery operated by tractor; fields were disked twice, springtooth-harrowed twice, cultipacked once; grass and legume seed broadcast by hand; wheat harvested with a grain binder and threshed from shock. All fertilizing costs charged to the second year of the rotation in this table.

TABLE 20.—*Average labor and equipment requirements and costs per acre per year for the third, fourth, and fifth years of a 5-year crop-and-pasture rotation, Beltsville, Md., 1946–50* [1]

Year of the rotation, and item	Time per acre per year for—					Cost per acre
	Clipping and/or mowing	Raking hay	Baling, storing hay	Fertilizing	Total time	
	Minutes	*Minutes*	*Minutes*	*Minutes*	*Hours*	*Dollars*
Third year: [2]						
Labor	72				1.20	0.83
Mower, 7-foot	72				1.20	.82
Tractor	72				1.20	.96
Total cost						2.61
Fourth year: [3]						
Labor	88	80	230		6.63	4.57
Mower, 7-foot	88				1.47	1.00
Rake, side delivery, 10-foot		80			1.33	.81
Field forage baler			46		.77	1.71
Truck			90		1.67	1.34
Tractor	88	80	46		3.57	2.86
Total cost						12.29
Fifth year: [4]						
Labor	80	40	115	44	4.65	3.21
Mower, 7-foot	80				1.33	.90
Rake, side delivery- 10-foot		40			.67	.41
Field forage baler			23		.38	.84
Fertilizer spreader, 10-foot				22	.37	.15
Truck			45	10	.93	.74
Tractor	80	40	23	22	2.75	2.20
Total cost						8.45

[1] All machinery operated by tractor.
[2] Grazing only; clipped 3 times following grazing.
[3] Two hay crops and grazing; each hay cutting raked twice; one load of hay per acre at each cutting. Pasture herbage clipped once following grazing.
[4] Grazing, 1 hay crop, grazing; hay crop raked twice; pasture herbage clipped twice following grazing.

TABLE 21.—*Average labor requirements and all costs per acre per year for a Kentucky bluegrass-white clover permanent pasture and for crops and pastures in a 5-year crop-and-pasture rotation, Beltsville, Md., 1946–50* [1]

PERMANENT PASTURE

Item	Labor required per acre	Costs per acre per year for—					Total cost per acre
		Labor	Equipment	Fertilizer or manure	Seed	Land	
	Hours	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1946	1.93	1.33	2.16	[2] 7.20	------	9.40	20.09
1947	1.20	.83	1.57	-------	------	9.40	11.80
1948	4.20	2.90	4.32	[3] 20.00	------	9.40	36.62
1949	1.20	.83	1.57	-------	------	9.40	11.80
1950	1.93	1.33	2.16	[2] 7.20	------	9.40	20.09
Average	2.09	1.44	2.36	6.88	------	9.40	20.08

5-YEAR CROP-AND-PASTURE ROTATION

Item	Labor required per acre	Labor	Equipment	Fertilizer or manure	Seed	Land	Total cost per acre
First year: Corn (silage)	14.57	10.05	15.86	[3] 20.00	2.06	9.40	57.37
Second year: Wheat, fall grazing	14.73	10.16	10.50	[2] 7.20	10.59	9.40	47.85
Third year: Grazing	1.20	.83	1.78	-------	------	9.40	12.01
Fourth year: Hay, hay, grazing	6.63	4.57	7.72	-------	------	9.40	21.69
Fifth year: Grazing, hay, grazing	4.65	3.21	5.24	[2] 7.20	------	9.40	25.05
Average	8.36	5.76	8.22	6.88	2.53	9.40	32.79

[1] Labor and costs are charged to the year in which they occurred.
[2] Fertilizer, 0–14–14 or 0–14–7.
[3] Barnyard manure, charged at its fertilizing value.

TABLE 22.—*Average yield of TDN per acre per day by 5-day intervals throughout the season, for a Kentucky bluegrass-white clover permanent pasture and for orchardgrass-Ladino clover pastures in a 5-year crop-and-pasture rotation, Beltsville, Md., 1946–50*

Date	Permanent pasture	Year of the rotation			
		Third	Fourth	Fifth	Average
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Apr. 10					
15	2.7	4.6	6.0	18.6	9.7
20	7.1	7.4	11.4	23.0	14.3
25	10.8	13.2	19.8	32.2	21.7
30	14.0	18.3	32.6	33.1	28.0
May 5	28.3	27.3	42.3	26.6	32.1
10	28.3	27.3	42.3	21.5	30.4
15	29.3	27.3	42.3	21.5	30.4
20	25.3	25.5	30.9	20.2	25.5
25	25.3	24.1	27.6	19.9	23.9
30	29.4	14.6	23.2	19.9	19.2
June 5	22.7	14.6	18.1	19.9	17.5
10	14.9	14.6	18.1	18.9	17.2
15	14.9	14.6	18.1	18.9	17.2
20	14.9	14.6	18.1	18.9	17.2
25	14.9	13.3	18.1	19.9	17.1
30	14.1	13.3	18.1	19.9	17.1
July 5	11.6	12.8	18.1	17.2	16.0
10	11.0	12.8	19.0	15.8	15.9
15	10.1	13.2	19.0	14.7	15.5
20	9.8	13.3	15.3	14.7	14.3
25	9.8	13.3	15.3	14.7	14.3
30	9.8	13.3	13.1	14.7	13.9
Aug. 5	12.0	13.3	12.7	14.7	13.8
10	10.4	14.5	12.7	14.7	14.0
15	10.4	14.5	12.7	12.1	13.3
20	11.2	13.5	12.7	9.9	12.0
25	11.2	13.5	12.7	9.6	11.9
30	10.7	14.4	12.7	9.6	12.2
Sept. 5	15.8	14.4	11.6	9.6	11.9
10	15.8	13.6	7.2	9.6	10.1
15	14.5	13.6	7.2	7.9	9.6
20	14.5	13.6	7.2	7.9	9.6
25	13.8	13.6	6.2	7.9	9.2
30	15.6	13.6	6.2	6.3	8.7
Oct. 5	11.2	13.6	3.7	6.3	7.9
10	9.9	10.0	3.7	6.3	6.7
15	9.9	7.4	3.7	6.3	5.8
20	6.7	4.0	3.7	6.3	4.7
25	5.3	2.1	1.0	6.3	3.1
30	5.3	2.1	1.0	5.7	2.9
Nov. 5	2.0	2.1		3.0	1.7
10		2.1		3.0	1.7
15				1.8	.6
20					

Table 23.—*Average yield of TDN per acre per day by 5-day intervals throughout the season for comparable orchardgrass-Ladino clover fields and bromegrass-Ladino clover fields, Beltsville, Md.*

Date	Year of the rotation, and field							
	Third [1]		Fourth [2]		Fifth [3]		Average	
	Orchardgrass	Bromegrass	Orchardgrass	Bromegrass	Orchardgrass	Bromegrass	Orchardgrass	Bromegrass
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Apr. 10								
15	5.8	6.2	9.9	9.1	30.0		15.2	5.1
20	5.8	6.2	9.9	9.1	30.0	39.1	15.2	18.1
25	13.1	13.9	23.9	15.2	30.0	39.1	22.3	22.7
30	19.4	19.3	45.2	26.5	34.1	52.4	32.9	32.7
May 5	30.7	34.3	45.2	26.5	34.1	52.4	36.7	38.4
10	30.7	34.3	45.2	26.5	21.1	17.0	32.3	25.9
15	30.7	34.3	45.2	26.5	21.1	17.0	32.3	25.9
20	28.4	32.3	26.3	26.5	21.1	17.0	25.3	25.3
25	26.7	32.3	26.3	20.8	21.1	17.0	24.7	23.4
30	14.8	29.3	26.3	20.8	21.1	17.0	20.7	22.4
June 5	14.8	12.7	17.8	20.8	21.1	17.0	17.9	16.8
10	14.8	12.7	17.8	20.8	18.8	16.2	17.1	16.6
15	14.8	12.7	17.8	20.8	18.8	16.2	17.1	16.6
20	14.8	12.7	17.8	20.8	18.8	19.5	17.1	17.7
25	13.1	12.7	17.8	20.8	21.4	19.5	17.4	17.7
30	13.1	12.7	17.8	20.8	21.4	19.5	17.4	17.7
July 5	12.6	11.7	17.8	20.8	21.4	19.5	17.3	17.3
10	12.6	11.7	17.5	14.8	21.4	19.5	17.2	15.3
15	13.1	10.1	17.5	14.8	18.6	16.6	16.4	13.8
20	13.1	10.1	17.5	14.8	18.6	16.6	16.4	13.8
25	13.1	10.1	17.5	14.8	18.6	16.6	16.4	13.8
30	13.1	10.1	13.7	11.7	18.6	16.6	15.1	12.8

Aug. 5	13.1	10.1	13.1	9.7	18.6	16.6	14.9	12.1
10	14.5	10.9	13.1	9.7	18.6	16.6	15.4	12.4
15	14.5	10.9	13.1	9.7	12.2	12.6	13.3	11.1
20	13.3	9.2	13.1	9.7	12.2	12.6	12.9	10.5
25	13.3	9.2	13.1	9.7	12.2	12.6	12.9	10.5
30	14.4	11.0	13.1	9.7	12.2	12.6	13.2	11.1
Sept. 5	14.4	11.0	13.1	9.7	12.2	12.6	13.2	11.1
10	14.4	11.0	5.8	5.3	12.2	12.6	10.8	9.6
15	14.4	11.0	5.8	5.3	8.1	10.0	9.4	8.8
20	14.4	11.0	5.8	5.3	8.1	10.0	9.4	8.8
25	14.4	11.0	4.1	3.2	8.1	10.0	8.8	8.1
30	14.4	11.0	4.1	3.2	4.0	4.1	7.5	6.1
Oct. 5	14.4	11.0	4.1	3.2	4.0	4.1	7.5	6.1
10	10.0	7.5	---	---	4.0	4.1	4.7	3.9
15	6.6	7.5	---	---	4.0	4.1	3.5	3.9
20	2.5	4.0	---	---	4.0	4.1	2.2	2.7
25	---	---	---	---	4.0	4.1	1.3	1.4
30	---	---	---	---	2.4	3.2	.8	1.1
Nov. 5	---	---	---	---	---	---	---	---

[1] 1947–50, inclusive.
[2] 1948–50, inclusive.
[3] 1949 and 1950.

Table 24.—*Composition of the green pasture herbage at different times of the year, for a Kentucky bluegrass-white clover permanent pasture and for orchardgrass-Ladino clover pastures in a 5-year crop-and-pasture rotation, Beltsville, Md., 1946–50* [1]

Time of the year, and pasture [2]	Composition of the dry matter							Estimated total digestible nutrients
	Protein	Ether extract	Crude fiber	Nitrogen-free extract	Total ash	Calcium	Phosphorus	
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Spring (first grazing):								
Permanent pasture	16. 4±0. 7	3. 3±0. 2	25. 8±1. 0	47. 3±0. 7	7. 5±0. 2	0. 77±0. 07	0. 34±0. 01	71. 6±0. 4
Third year of the rotation	18. 0± . 7	3. 1± . 1	24. 0±1. 2	46. 8± . 5	8. 1± . 2	. 97± . 09	. 30± . 02	72. 5± . 5
Fifth year of the rotation	23. 6± . 6	4. 1± . 1	19. 9± . 6	43. 3±1. 4	9. 1± . 4	. 67± . 05	. 38± . 02	73. 5± . 6
Early summer (second grazing):								
Permanent pasture	18. 3± . 8	3. 8± . 1	22. 4± . 5	46. 7±1. 0	8. 8± . 1	1. 08± . 08	. 39± . 02	70. 1±1. 2
Third year of the rotation	18. 3± . 3	3. 2± . 1	25. 6± . 7	44. 4± . 8	8. 5± . 2	1. 08± . 05	. 32± . 08	72. 3± . 2
Fifth year of the rotation	19. 2±1. 1	3. 7± . 1	25. 3± . 6	42. 9± . 6	8. 9± . 3	. 94± . 05	. 35± . 01	71. 9±1. 4
Late summer (third grazing):								
Permanent pasture	18. 6± . 8	4. 3±2. 0	21. 9±1. 0	46. 4±1. 5	8. 8± . 3	. 77± . 06	. 45± . 02	70. 1± . 5
Third year of the rotation	20. 1±1. 2	3. 5± . 2	25. 9±1. 0	41. 8± . 4	8. 7± . 1	1. 09± . 05	. 35± . 01	73. 4±1. 2
Fifth year of the rotation	19. 9± . 6	3. 9± . 1	25. 3± . 7	42. 1±1. 0	8. 8± . 3	. 93± . 02	. 34± . 02	72. 5± . 8
Fall (fourth grazing):								
Permanent pasture	18. 3±1. 3	3. 9±. 01	21. 7± . 8	47. 5±1. 1	8. 6± . 3	. 88± . 05	. 37± . 02	70. 1±1. 2
Third year of the rotation	20. 8± . 9	3. 7± . 1	22. 3± . 8	44. 3± . 7	8. 9± . 3	. 96± . 07	. 31± . 01	73. 1± . 6
Fifth year of the rotation	21. 8±1. 1	4. 2± . 2	21. 7± . 8	42. 8± . 4	9. 5± . 4	. 90± . 06	. 32± . 02	72. 6±1. 2

[1] Mean average, not weighted.

[2] The herbage for the permanent pasture was clipped periodically from protected cages, as the pasture was grazed continuously. Time of the 4 grazings for the third and fifth years of the crop-and-pasture rotation: First, May; second, early July; third, late August; fourth, October.

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