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THE UNIVERSITY OF TENNESSEE
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INTRODUCTION

Irrigation studies were initiated in 1951 on a clover-grass pasture sod that was established for this purpose at the Dairy Experiment Station, Lewisburg, Tennessee. Previous studies at this station and other places showed that the productive capacity of pastures is often reduced by drouths of varying periods within the spring, summer, and fall months. Van Horn and Dawson(1) found that rainfall fluctuates widely from year to year at Lewisburg. This variability in rainfall affects amounts of forage production from one year to the next, and from month to month within a year for a given pasture crop. Carreker and Liddel(2) showed that drouths of varying lengths occurred each year during the 25-year period of 1920-44 at six locations in Georgia. Ewing(3) showed that irrigation of summer pasture for dairy cows at the Middle Tennessee Experiment Station, Columbia, Tennessee, gave a profitable return through increased milk production. This work showed also that late summer milk production was maintained by grazing irrigated pasture, where dairymen normally resorted to heavy supplemental feeding because of the limited grazing available during dry weather. Ewing's study showed further that certain pasture species, such as white clover, were maintained longer on irrigated pastures than on unirrigated pastures. The maintenance of white clover with irrigation was observed also by Peterson and Hager(4) in California; McKibbon, et al.(5) in Illinois; Robinson, et al.(6) in Pennsylvania, and others throughout the country. Some farmers in eastern and southern states installed irrigation systems to eliminate drouth hazards on pastures and crops as materials became available after World War II. Many factors affected this development, some of them being: (1) availability of portable irrigation equipment and power units suitable for use on farms in this area; (2) economic conditions making it profitable to obtain higher production per acre on high-value crops (3) a realization of the need to use available water resources to overcome detrimental effects of short drouths during each growing season.

The foregoing developments led to the decision in 1949 to begin the pasture irrigation study reported in this bulletin.

EXPERIMENTAL METHODS AND PROCEDURES

Pasture Area Selected

A pasture area containing 9.2 acres of creek bottom land where water was accessible from a nearby creek was selected for use in this study. About seven acres consist of Huntington silt loam, about two acres consist of Lindside silt loam, and about two-tenths of an acre consists of Emory silt loam. This pasture area had been in permanent pasture for at least 20 years. It was originally bluegrass and white clover on which Bermuda grass had gradually spread until it covered most of the area. It was plowed in April, 1949, and seeded to a forage sorghum with a grain drill. The sorghum was harvested for silage. In September after the sorghum was removed, it was seeded to a mixture of winter barley and crimson clover which was utilized for grazing during the winter months. It was plowed again in April, 1950, and seeded to sudangrass which was harvested for silage. This treatment eliminated practically all of the Bermuda grass.

Tests on soil samples obtained once or twice each year previous to and during the course of the experiment indicated high phosphate, low to medium potash, and a pH of 6.5 or above.

ESTABLISHMENT OF PASTURE AND FERTILITY ADDITIONS

Following the harvesting of the sudangrass, the field was plowed in late August, 1950, and worked down to a good seedbed. Fertility applications were made which included 200 pounds of 6-12-12 fertilizer; 100 pounds of 50 percent muriate of potash, and 25 pounds borax per acre. During each of the succeeding years 200 pounds of 60 percent muriate of potash and 15 to 20 pounds of borax were applied during February with an additional 200 pounds of muriate of potash applied in August. The seeding was made August 28, 1950, using 5 pounds alfalfa, 2 pounds ladino clover, and 12 pounds of orchardgrass per acre. This seeding resulted in a very good stand.

Pasture Layout and Management

The 9.2 acres of pasture was divided into eight grazing areas which were separated by electric fences. Four plots reecived no irrigation, while four plots were irrigated. All areas were treated the same except for the irrigation and grazing. Both irrigated and unirrigated areas were grazed with different numbers of producing dairy cows according to the forage available. Each area was grazed 8 days followed by 24 days with no grazing except the first time over at the beginning of each grazing season. Since grazing could not be started on all areas on the same date at the beginning of the grazing season, each group of cows was allowed to graze 5, 7, 9, and 11 days on the four grazing areas, respectively.

The pasture was clipped with a mower at a height of 6 to 8 inches as needed to remove unpalatable growth and weeds. The mowing of orchardgrass at an approximate height of 8 inches was required to remove unpalatable, stemmy growth, and seed heads following the first or second time each area was grazed. Some mowing was necessary to control weeds later in the season.

Water for the irrigated plots was pumped from the adjacent creek. It was applied with rotating sprinklers mounted on portable aluminum irrigation pipe. A centrifugal pump powered by a 23-horsepower air-cooled gasoline engine forced water through the pipes and sprinklers at the desired pressure. Two-nozzle sprinkler heads were spaced 40 feet apart along the lateral lines, and the lines were moved 60 feet between settings. The amount of water applied on each setting was controlled by the rate of discharge from the sprinklers and the length of the run. The two nozzles on each sprinkler head were $\frac{1}{4}$ x $\frac{7}{32}$ inch in size, giving a discharge rate of 16.2 gallons per minute per sprinkler, or .62 inch per hour for the 40 x 60 spacing when operated at 30 pounds pressure per square inch. These operating conditions required 1 hour and 37 minutes for 1 inch of water on the land. A main line of 4-inch pipe was laid at the end of the plots. From this main line, two laterals were laid. Either 11 or 12 sprinkler heads were used on each lateral. Water was pumped to only one lateral at a time. Seven settings were required to cover the irrigated plots. The time required for one run over these plots varied with the amount of water being applied. A 2-inch application required 15 hours and 45 minutes to cover the irrigated area, consisting of 4.6 acres.

The need for irrigation was determined by field observations in 1951 and most of 1952. Plaster of paris electrical resistance blocks were imbedded at 6 and 12 inch depths in the soil of each plot during the late August, 1952. The available soil moisture was estimated after August 23, 1952, with a Bouyoucos moisture meter. Irrigation water was applied thereafter when the meter reading showed that 50 percent of the available moisture was used out of the top 12 inches of soil. The rainfall, irrigation, and available moisture data for 1953 are given in Figure 1. The use of the moisture meter enabled investigators better to determine when water was needed than was formerly possible from field observations.

Measuring Pasture Yields

Records were kept of the amounts of milk and butterfat produced, the live weights of the cows, and the amounts of grain mixture and hay consumed. From these records and from figures based on Morrison's* feeding standard showing the nutrients required for cows under usual conditions, the yields of total digestible nutrients supplied per acre of pasture were calculated in accordance with the method of Knott and associates(7). By this method, credit is given for feeds supplementing the pasture and adjustments are made for gains or losses in the live weight of the cows.

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*__Feeds and Feeding,__ 21st edition, by F. R. Morrison.

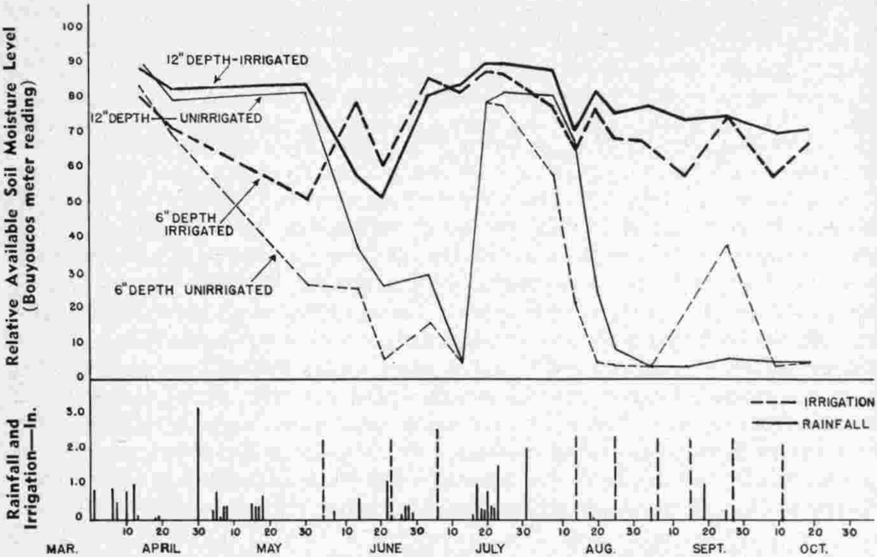

Figure 1.—Rainfall, irrigation, and relative available soil moisture levels in 1953.

RESULTS

Costs of Irrigation

The data on costs of irrigation are given in Table I. The costs reported for labor, gasoline, and motor oil were taken from actual records for these items. The labor charges include the cost of moving the equipment from other locations to the experimental pasture. Cost per man hour varied from 85c during 1951 to 90c during 1954. The costs reported for repairs and depreciation are proportioned according to the amount of time that the equipment was used on the plot areas as compared to the amount of time it was used on other fields. Irrigation was done on approximately 35 acres of other land in addi-

TABLE I

Cost of Irrigation Per Acre

Items of cost	1951	1952	1953	1954	Av. 4 Yrs.
Labor, setting up equipment, moving pipe, etc.	$25.16	$16.74	$22.32	$20.34	$21.14
Gasoline	12.39	7.70	10.25	9.68	10.01
Motor oil	.70	.45	.71	1.26	.78
Repairs	7.38	2.67	8.42	6.57	6.26
Depreciation of equipment*	14.04	10.00	10.00	14.04	12.02
Totals	$59.67	$37.56	$51.70	$51.89	$50.21

*Computed at 10 percent per year.

tion to the experimental plot area. However, the total amount of water applied to these other 35 acres was somewhat smaller per acre than on the experimental land. The original cost of the irrigation equipment is estimated at approximately $2,500.

The average cost of irrigation per acre on the experimental land using the above methods of calculation was $50.21, as shown in Table 1. Costs for applying one acre inch of water were $2.45, $2.54, $2.50, and $2.61 for the years 1951 to 1954, respectively.

Rainfall and Irrigation

As shown in Table II, the rainfall each year was 6 to 8 inches below normal. The available moisture was maintained at 50 percent of capacity or above at 6 to 12 inches depth (Figure 1), during 1953. It dropped slightly below 50 percent at 6 inches depth on one occasion but remained above 50 percent at 12 inches depth during 1954. As data also show in Figure 1, soil moisture in the unirrigated pasture dropped to very low levels and remained low for long periods.

It is also noted (Table II) that total water from rainfall and irrigation for the months of April through October averaged 40.30 inches per year for the four years. This amounted to 12.16 inches above average rainfall. During both 1953 and 1954, applications of about 2.25 inches of water at 10-day intervals were required to hold the available moisture at 50 percent or above to a depth of 12 inches when there was no rainfall. The results for 1953-54 indicate that irrigation could have been less frequent with more water applied at each irrigation during 1951-52 with about the same results as were obtained with the smaller, more frequent irrigations.

The supply of water for irrigation became so low during the first half of July, 1952, that it was impossible to irrigate when wilting of pasture herbage indicated the need for irrigation. Rains during the latter part of the month overcame this situation.

TABLE II

Rainfall and Irrigation Water

Year	No. of Irrigations	Irrigation Water: Each Irrigation Inches (Av.)	Irrigation Water: Total Inches	Rainfall Received April-October* Inches	Total Inches
1951	18	1.35	24.33	20.01	44.34
1952	12	1.23	14.80	21.16	35.96
1953	9	2.30	20.69	19.77	40.46
1954	10	1.99	19.89	20.54	40.43
Average	12	1.72	19.93	20.37	40.30

*50-year average rainfall for April to October, 28.14 inches.

Yields and Income

Grazing was not started in the spring until the pasture herbage had reached a height of 6 to 8 inches. It was started on both the irrigated and unirrigated plots on April 1, 1951; April 14, 1952; March 25, 1953; and April 6, 1954. The differences in starting dates were due to weather conditions affecting the early growth. Grazing was discontinued November 3, 1951; November 1, 1952; November 12, 1953; and November 1, 1954. The average length of grazing season was 207 days on the irrigated plots. The unirrigated plots were grazed throughout the grazing seasons during the four years except for 7 days, September 18-24, 1953; and 78 days, July 27 through October 12, 1954, when there was no available grazing due to drouth.

The returns per acre as indicated by yields of calculated digestible nutrients furnished by grazing, yields of milk and butterfat, value of milk, and net income after deducting the value of grain mixture and hay fed at the barn and the cost of irrigaton of the irrigated plots, are shown in Table III.

The pasture yields per acre as measured by the amounts of calculated digestible nutrients obtained by the cows from grazing the unirrigated plots were 3,178 pounds; 2,243 pounds; 3,025 pounds; and 1,784 pounds for the four years, 1951-54, respectively. The yields obtained from grazing the irrigated plots were 4,677 pounds; 3,392 pounds; 4,252 pounds; and 4,073 pounds of total digestible nutrients per acre for the four years, respectively. The four-year averages were 2,557 pounds for the unirrigated pasture and 4,099 pounds for the irrigated pasture, which indicates that irrigated pasture furnished 61 percent more total digestible nutrients than unirrigated pasture during the four years.

The yield of total digestible nutrients obtained from the irrigated pasture during 1952 was lower than that obtained during any of the other three years. The yield from unirrigated pasture was lower than for 1951 and 1953. Observation of the pastures during March and early April, 1952, indicated that about 50 percent of the ladino clover on the irrigated plots appeared to be dead. Weather conditions, which probably contributed to this condition, were slightly above normal temperatures during October, 1951, which produced a rapid growth of clover. This was followed by a sudden drop to 14 degrees F. on November 2. This drop in temperature caused practically a 100 percent kill of both winter barley and winter oats on other areas which had been seeded and nitrated in September, 1951. The stand of clover thickened again with the coming of warm weather. Weather conditions during the spring of 1952 also delayed growth of both the clover and orchardgrass and grazing was started later (April 14), as previously noted, than during any of the other three years. The shortage of irrigation water during the first half of July, 1952, added to conditions which probably account for the lower yields of grazing from both irrigated and unirrigated pastures during 1952.

As previously indicated, the cows used in grazing the pastures were fed a grain mixture and a small amount of hay. The yields of milk (4% FCM) per acre of unirrigated pasture, and including this supplemental feeding, were 9,137 pounds; 6,725 pounds; 9,096 pounds; and 6,018 pounds for the four years, respectively. The yields per acre of irrigated pasture, including supplemental feed, were 13,975 pounds, 10,491 pounds, 13,094 pounds, and 10,778 pounds, respectively. The four-year averages per acre were 7,744 pounds for the unirrigated pasture, and 12,085 pounds for the irrigated pasture. These milk yields were proportioned according to the source of feed nutrients consumed by the cows, and the results

TABLE III

Yield and Income Per Acre, During Pasture Season 1951-54

Items		1951	1952	1953	1954	Ave.
Calculated TDN from pasture, lbs.	Unirrigated	3,178	2,243	3,025	1,784	2,557
	Irrigated	4,677	3,392	4,252	4,073	4,099
Standard cow days of grazing*	Unirrigated	198	140	189	112	160
	Irrigated	292	212	266	255	256
Milk (4% FCM), lbs.	Unirrigated	9,137	6,725	9,096	6,018	7,744
	Irrigated	13,975	10,491	13,094	10,778	12,085
Butterfat, lbs.	Unirrigated	386	285	392	258	330
	Irrigated	589	436	545	470	510
Value of milk**	Unirrigated	$402.00	$347.00	$342.00	$250.00	$335.00
	Irrigated	625.00	534.00	497.00	434.00	522.00
Feed consumed at barn: grain mixture, lbs.	Unirrigated	2,051	1,799	2,235	1,642	1,932
	Irrigated	3,193	2,731	3,422	2,558	2,976
hay, lbs.	Unirrigated	138	28	111	47	81
	Irrigated	176	28	126	60	98
Value of feed at barn: grain mixture	Unirrigated	$ 74.00	$ 68.00	$ 78.00	$ 54.00	$ 69.00
	Irrigated	115.00	101.00	120.00	84.00	105.00
hay	Unirrigated	$2.08	$0.56	$1.66	$0.71	$1.25
	Irrigated	2.64	.56	1.89	.90	1.50
Income from sale of milk above value of feed consumed at barn and cost of irrigation.	Unirrigated	$327.00	$279.00	$262.00	$195.00	$266.00
	Irrigated	448.00	389.00	324.00	297.00	364.00
Difference in gross income from irrigated and unirrigated pasture after subtracting cost of supplemental feed and irrigation.		$121.00	$110.00	$ 62.00	$102.00	$ 99.00

*One standard cow day = 16 lbs. TDN.
**Valued at price actually received at farm.

are shown in Table IV. It will be noted that the increase in milk production per acre (last column Table IV) due to irrigation was 3,030 pounds; 2,314 pounds; 2,251 pounds; and 3,745 pounds for the four years, respectively. The four-year average increase in milk per acre was 2,835 pounds. The 4-year average cost of the irrigation per acre was $50.21 (Table I). Applying this cost for irrigation ($50.21) to the additional milk produced by irrigation (2,835 lbs.) indicates that the cost for irrigation amounted to $1.77 per 100 pounds of additional milk.

The milk produced by the cows used in grazing the pastures was valued at the prices actually received for milk at the farm. These prices were dependent upon the price of base milk and the proportion of base to surplus, which varied from year to year. As a result, average prices received varied considerably from year to year and are reflected in the income per acre from the sale of milk.

The unirrigated pasture produced a four-year average income of $265.32 per acre from the sale of milk above the value of grain mixture and hay feed at the barn. The irrigated pasture produced a four-year average of $364.25 above the value of feed at the barn and the cost of irrigation.

The differences in gross income from irrigated and unirrigated

TABLE IV

Increase in Milk Production Per Acre by Irrigation as Indicated by Proportioning Total Milk Production According to Source of Feed Consumed by Cows

		Source of Feed (TDN)		Milk (4% FCM) Proportioned according to source of feed		
	Total Milk (4% FCM) Produced Lbs.	Grain Mixture and Hay Percent	Pasture* Percent	Grain Mixture and Hay Milk, lbs.	Pasture Milk, Lbs.	Increase in Milk with Irrigation Lbs.
1951, unirrigated	9,137	34.2	65.8	3,125	6,012	3,030
1951, irrigated	13,975	35.3	64.7	4,933	9,042	
1952, unirrigated	6,725	37.7	62.3	2,555	4,190	
1952, irrigated	10,401	38.0	62.0	3,987	6,504	2,314
1953, unirrigated	9,096	36.5	63.5	3,320	5,776	
1953, irrigated	13,094	38.7	61.3	5,067	8,027	2,251
1954, unirrigated	6,018	41.7	58.3	2,510	3,508	
1954, irrigated	10,778	32.7	67.3	3,525	7,253	3,745
Av. 4 years, unirrigated	7,744	37.1	62.9	2,873	4,871	
Av. 4 years, irrigated	12,085	36.2	63.8	4,379	7,706	2,835

*Calculated.

pasture areas after subtracting costs of supplemental feed and irrigation were as follows: 1951 — $121; $1952 — $110; 1953 — $62; 1954 — $102. The average for the 4-year period is $99. It should be noted that costs in the production of milk other than supplemental feed on both irrigated and unirrigated plots, and the cost of irrigation of the irrigated plots, were not subtracted before estimating the increased income from irrigation. It is recognized that other costs are involved and that the total difference in income would be smaller if these costs were considered. However, it is difficult to make any accurate estimates of these additional costs under the conditions of this experiment. Some of these additional cost factors which have been neglected in estimating the increased returns from irrigation are: (1) labor, for handling of extra cows and extra milk produced under irrigation; (2) additional clipping of irrigated pastures, which had to be gone over more frequently than those not irrigated; (3) interest on investment in extra cows needed to graze the additional forage on irrigated pasture. In order to determine actual net returns from irrigation, costs of all such items should be estimated and deducted from the increased milk sales obtained from the irrigated pastures.

Soil Physical Properties

Physical properties of the soil were measured in October, 1953. The measurements included bulk density, field capacity, wilting point, and available water holding capacity. The values obtained are given in Table V. The available water-holding capacity, the capacity of the soil to hold water in a condition available for plant growth to a

TABLE V

Physical Properties of the Soils

	Soil Depth Inches	Plots (3, 4, 5, & 6)	Plots (1, 2, 7, & 8)
Bulk density—gm/cc	0-3	1.409	1.417
	12-15	1.275	1.364
	24-27	1.534	1.289
Field capacity—percent by weight	0-3	26.36	26.66
	12-15	28.56	27.46
	24-27	23.10	30.01
Wilting point—percent by weight	0-3	10.86	10.41
	12-15	12.07	9.93
	24-27	12.31	13.10
Available water holding capacity—inches per foot	0-3	2.62	2.76
	12-15	2.52	2.88
	24-27	1.98	2.62
	0-36	2.37	2.75

depth of three feet was 7.11 inches for the irrigated plots, and 8.25 inches for those unirrigated. No undue compaction of the soil by grazing animals as a result of the irrigation was observed.

Other Effects of Irrigation

As stated previously, both the irrigated and unirrigated areas were divided into four plots for rotation grazing and, except for the first 32 days at the beginning of each season, each area was grazed eight days followed by 24 days with no grazing. It thus required 32 days to graze all four areas one time. The records kept of feed consumption, milk production, and body weights were therefore kept by 32-day periods which coincided with the 32-day periods required to graze the four areas. The upper portion of Figure 2 shows graphically the distribution of the grazing by 32-day periods and the lower portion shows the distribution and amounts of rainfall and irrigation by days during 1953. Similar records were kept for the other three years.

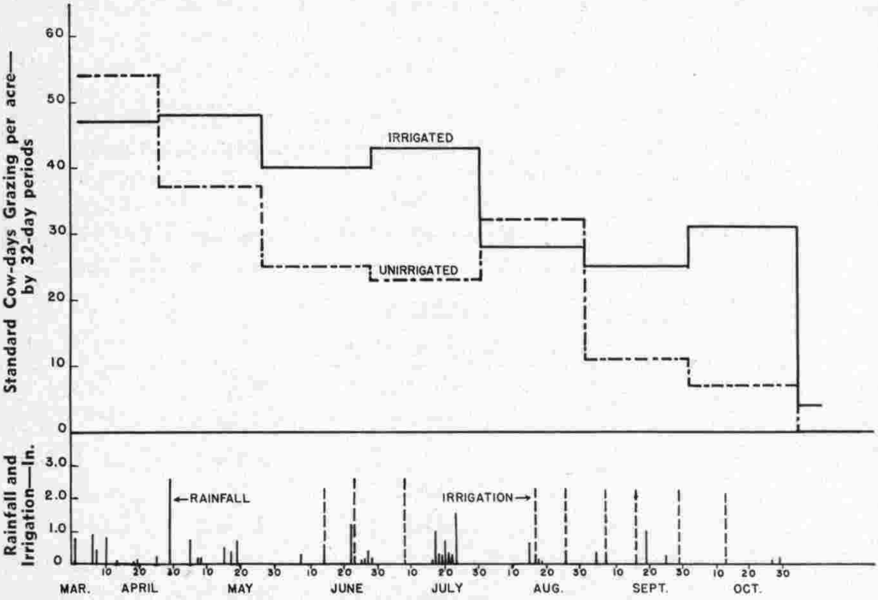

Figure 2.—Rainfall, irrigation, and grazing record in 1953

The rainfall pattern was erratic and amounts of grazing furnished by the unirrigated pasture showed a similar pattern, except that the grazing pattern was a little behind the rainfall. After a period of favorable moisture conditions, it required a period of about two weeks with no effective rainfall to materially affect the amount of grazing. Similarly, it required about two weeks for the pasture to recover so that additional cows could be added when ample rainfall came following a period of drouth.

Both grazing results and observation of growth in the pastures indicated that the unirrigated pasture produced more grazing than the irrigated when rainfall was sufficient to produce favorable moisture conditions. This situation was especially noticeable during the first 32-day grazing period each year except the first year (1951) when none of the plots had been irrigated previously. It was also apparent during the fifth grazing period, August 16 through September 16, of 1953, when the unirrigated pasture furnished 14 percent more grazing than the irrigated. Rainfall received July 15 to 31, 1953, totaled 6.54 inches. This period of heavy rainfall was immediately preceded by a period of drouth with a total of only 3.08 inches of rainfall during a period of 57 days, May 20 through July 15.

Average distribution of grazing for the four years was greatly improved by irrigation as shown by 32-day periods in Figure 3. The

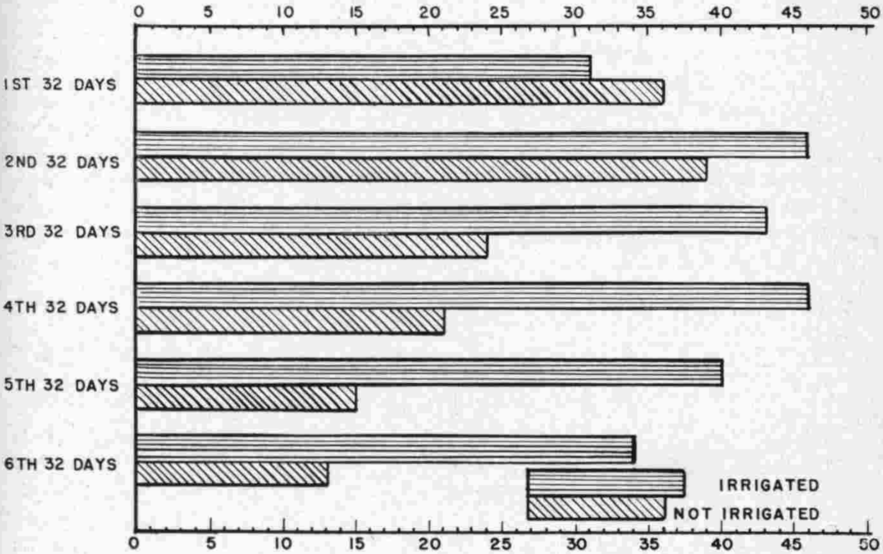

Figure 3.—Average number of standard cow-days of grazing by 32-day periods, 1951-1954.

unirrigated pasture did well during the first 64 days of the grazing season but declined rapidly during the third 32-day period which started in the second week of June. The irrigated pasture did not show a consistent tendency to decline in productivity until the fifth grazing period, which started in the second or third week of August. This improvement in distribution of grazing because of irrigation is one of the major benefits of this practice. Under practical dairy farm operating conditions, it could mean the difference between adequate pasture and barn lot feeding, in which instance the difference could amount to considerably more than the difference in income between irrigated and unirrigated pasture.

As stated previously, the experimental plots were seeded with a mixture of alfalfa, ladino clover, and orchardgrass that produced an excellent stand which survived during the first winter. The alfalfa disappeared from the mixture during the first season of grazing on both the irrigated and unirrigated plots, except on a small portion of plot A which lies at a higher level than the remainder of the area covered by the plots. Ladino clover remained a good stand on the irrigated plots at the end of four years, but it gradually disappeared from the unirrigated plots until there was only a trace of clover at the beginning of the fourth grazing season. The orchardgrass remained a good stand on the unirrigated plots throughout the four years. There was a gradual loss of orchardgrass on the irrigated plots through the first 3 years, and at the end of the third and fourth years, it was estimated that the orchardgrass was one-fourth as thick as on the unirrigated plots.

At the beginning of the 1952 grazing season, scattered plants of tall fescue were observed in all plots. A few more plants were noted each year during the two following years. This fescue could not be accounted for except by overflow from the nearby creek, bringing seed from upstream farms on which there were fields of fescue.

The amount of weeds tended to increase from year to year in the irrigated plots and required clipping with a mower several times each year. The unirrigated plots had few weeds.

Chemical Composition of Pasture Vegetation

The chemical analysis of the pasture vegetation (Table VI) indicated little difference in ash content, organic matter, crude protein, and lignin between the irrigated and unirrigated pasture and between samples obtained during June and October on both.

TABLE VI

Average Chemical Composition of Pasture Vegetation For 1951-54, on a Dry Matter Basis

Date Cut	% Ash	% Crude Protein	% Lignin
6-19-51, unirrigated	11.0	23.5	9.3
6-19-51, irrigated	11.1	23.7	10.9
10-15-51, unirrigated	10.4	31.1	6.0
10-15-51, irrigated	10.4	27.4	7.4
6-14-52, unirrigated	9.8	22.5	6.7
6-14-52, irrigated	12.0	21.9	7.1
10-11-52, unirrigated	10.5	24.9	8.3
10-11-52, irrigated	13.5	20.9	9.1
6- 8-53, unirrigated	11.0	22.5	8.8
6- 8-53, irrigated	11.0	25.2	8.5
10-23-53, unirrigated	11.9	15.2	7.9
10-23-53, irrigated	12.7	23.3	7.6
6- 9-54, unirrigated	11.9	20.2	7.9
6- 9-54, irrigated	11.0	25.8	6.9
10-15-54, unirrigated	10.1	21.1	8.3
10-15-54, irrigated	11.8	21.0	7.9
Average unirrigated, spring	10.9	22.2	8.2
Average irrigated, spring	11.3	24.1	8.3
Average unirrigated, fall	10.7	22.9	7.6
Average irrigated, fall	12.1	23.2	8.0
Average all spring	11.1	23.2	8.2
Average all fall	11.4	23.2	7.8
Average all samples, 4 yrs.	11.3	23.2	8.0

SUMMARY AND CONCLUSION

During a four-year period, an average of 19.39 inches of irrigation water was applied to orchardgrass-ladino clover pasture at an average cost of $50.21 per acre, or $2.52 per acre inch. The largest item in the cost ($21.14) was for setting up irrigation equipment and moving irrigation pipes. During this period, rainfall averaged 7.77 inches below normal during the grazing season (April through October). The irrigation plus rainfall averaged 40.30 inches per grazing season, or 12.16 inches above normal rainfall.

Plaster of paris electrical resistance blocks attached to a Bouyoucos moisture meter were of material assistance in determining when to irrigate. Application of 2.0 to 2.3 inches of irrigation water at approximately 10-day intervals during 1953 and 1954 gave results similar to those obtained from smaller amounts applied at about 7-day intervals during 1951 and 1952.

The average length of the grazing season was 207 days. The unirrigated pasture did not furnish continuous grazing during two years (1953-54) because of the drouth. The irrigated pasture produced 61 percent more grazing as indicated by calculated yields of total digestible nutrients, and 58 percent more milk than the unirrigated pasture. Distribution of grazing was greatly improved by irrigation.

The cows which grazed on the irrigated pasture obtained 63.8 percent of their calculated nutrient requirements from the pasture while those which grazed on unirrigated pasture obtained 62.5 percent.

The income from the sale of milk from the irrigated pasture after deducting cost of supplemental feed and cost of irrigation averaged $99.00 per acre above the income from unirrigated pasture after deducting the cost of supplemental feed.

Irrigation had a marked effect upon the pasture flora. At the end of the four years a good stand of ladino clover remained in the irrigated pasture, but the orchardgrass was about one-fourth as thick as in the unirrigated pasture. Orchardgrass continued a good stand in the unirrigated pasture but only a trace of ladino clover remained at the end of four years. The irrigated pasture tended to become weedy and the unirrigated pasture remained comparatively free of weeds.

Attention is called to the fact that although summer drouths are common in the region where this experiment was conducted, the drouths which occurred while the experiment was in progress were longer and more frequent than would be expected as an average over a long period of years. Differences between irrigation and no irrigation during a series of more favorable years would probably be less than those obtained in this experiment.

It should be recognized that farmers have ways other than through irrigation of maintaining or increasing milk production. For example, money invested in irrigation might be used to provide silos and to produce additional silage for use during the periods when pastures are inadequate or short. Such money also could be used to purchase additional feed rather than to invest it in an irrigation system. The profitableness of the alternative methods of increasing milk production would depend on the particular set of circumstances on each individual farm. It is further recognized that many farmers do not have a source of water available and could not undertake an irrigation program as a means of increasing pasture production.

REFERENCES

1. A. G. Van Horn and J. R. Dawson, "Improvement of Pastures for Dairy Cattle in Middle Tennessee," Circular No. 786, USDA, March, 1948.

2. John R. Carreker and W. J. Liddell, "Results of Irrigation Research in Georgia," **Agricultural Engineering,** Vol. 29, No. 6, June, 1948

3. John A. Ewing, "Irrigated Pasture for Dairy Cows," Bulletin No. 216, The University of Tennessee, April, 1950.

4. Maurice L. Petersen and Robert M. Hagan, "Production and Quality of Irrigated Pasture Mixtures as Influenced by Clipping Frequency," **Agronomy Journal,** Vol. 45, July, 1953.

5. George E. McKibbon, L. E. Gard, C. A. Van Doren, and R. J. Fuellman, "Soil Moisture Availability in Irrigated and Non-irrigated Pastures," **Agronomy Journal,** Vol. 42, November, 1950.

6. R. R. Robinson, V. G. Sprague, and A. C. Lueck, "The Effect of Irrigation, Nitrogen Fertilization and Clipping Treatment on Persistence of Clover and Seasonal Distribution of Yields in a Kentucky Blue Grass Sod," **Agronomy Journal,** Vol. 44, May, 1952.

7. J. C. Knott, R. E. Hodgson, and E. V. Ellington, "Methods of Measuring Pasture Yields with Dairy Cattle," Washington Agric. Exp. Sta. Bul. No. 295, 1934.