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Response of Sheep to Irrigation and Fertilization of Pastures

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SUMMARY

Tests were conducted in 1955 and 1956 to study the effects of irrigation and irrigation plus nitrogen fertilizer on various forages produced alone and in combination. Ewes and their late lambs were used to measure these effects.

During the suckling period in the 1955 trial, there was no significant difference in total pasture days, ewe and lamb gains and/or losses among plots of orchard grass-ladino clover, orchard grass-lespedeza, and orchard grass. No irrigations were made during this period because rainfall was adequate. Lactating ewes did not maintain their weight. Lambs gained approximately 0.3 pounds per day.

After weaning, the carrying capacities of the pastures were increased from one and one-half to three and one-half times through irrigation. Periodic applications of nitrogen during this period did not result in increased forage production as measured by total pasture days. Severe parasite infestation occurred; normal control measures did not prevent death losses and lamb gains were very low.

In 1956, carrying capacity was doubled, approximately, during the suckling period through irrigation of orchard grass-ladino clover mixtures and orchard grass-lespedeza mixtures; however, irrigation of orchard grass alone yielded only 34 percent increase. Adding nitrogen in three applications in addition to the supplemental water further increased the carrying capacity approximately 20 percent in orchard grass-ladino clover mixtures. Average rate of daily gain for the suckling period significantly favored the control pastures.

Rate of gain during the post weaning period showed the same response, but the gains were materially lower. Irrigation increased the carrying capacities of orchard grass-ladino clover 129 percent, orchard grass-lespedeza 66 percent, and orchard grass 47 percent. Adding nitrogen periodically in addition to irrigation brought further increases of 13 percent on orchard grass-ladino clover, 15 percent on orchard grass-lespedeza, and 43 percent on orchard grass alone.

Severe stomach worm infestation occurred in spite of all that was done to prevent it; i.e., drenching of ewes prior to pasturing, constant access to phenothiazine-salt mixture, and bi-weekly treatment of ewes and lambs with drench. Death losses occurred among both ewes and lambs, the latter largely during September. Sheep grazed selectively and killed the Korean lespedeza under all treatments; the stand of ladino clover also was greatly reduced in the control lot which received no additional moisture.

Increases in gains per acre did not pay the extra cost of irrigation.

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INTRODUCTION

One essential for maximum forage production is adequate moisture. Severe drouths pose serious problems for livestock producers who depend heavily upon forage for economical production. Even in a so-called normal season, there are usually periods when rainfall is inadequate for maximum production. In many cases it is possible to provide the needed moisture through irrigation. However, research has not determined fully the results we can expect from irrigation; this applies especially to forages grazed by sheep. Research was initiated at the Missouri Station to obtain some of the answers. Irrigation was compared with no irrigation on three different pastures: orchard grass-ladino clover, orchard grass-lespedeza, and orchard grass alone. Sheep were the test animals. A companion study measured effects on production of adding a high level of nitrogen.

REVIEW OF LITERATURE

Effects of Irrigation

Little conclusive information is available on the effects of irrigating sheep pastures.

Robinson and Sprague (1952) in studies at the Pennsylvania Station, measured orchard grass-ladino clover yields of 5,770 pounds with irrigation and 2,950 pounds per acre without on an air dry basis when no nitrogen fertilizer was used. Addition of nitrogen at the rate of 260 pounds per acre with irrigation and 220 pounds per acre without irrigation increased yields to 8,050 pounds and 6,020 pounds per acre, respectively.

Peterson and Hagen (1952) in California showed that frequent irrigations of ladino clover produced more fresh weight but little more dry matter than plots that received less frequent irrigations but had some available moisture in the soil at all times. They concluded that the most economical point to irrigate was when 75 percent of the available moisture in the effective root zone had been depleted.

Somewhat opposite results were found by Nelson and Robins (1955) at the Washington Station. They found that the highest total yields of ladino clover-

orchard grass were obtained by irrigating when 60 to 70 percent available moisture remained in the 0 to 18-inch soil zone. These authors also report that total yields increased with the application of from 0 to 200 pounds of nitrogen per acre but this reduced the clover yields.

Effects of Fertilizer on Pasture Productivity

The effect of nitrogen fertilizer on pasture production has been studied extensively.

After many years of testing the effects of fertilizers on grass land at the Rothamsted Station (1926) English investigators reported the following conclusions:

(1) Phosphoric acid and lime improved practically all pastures.
(2) Nitrogen carrying fertilizers increased the grass at the expense of the clovers.
(3) Potash is necessary on sandy soils but not on others.
(4) Liming continuously over a period of years may result in decreased production.

Jones (1927) demonstrated that the live weight gain per acre made by lambs deteriorated as the season progressed, but complete manuring, including nitrogen fertilizer, helped to postpone this deterioration.

Enlow and Coleman (1929) found that the protein content of grasses averaged much higher when mowed frequently than when cut only at the end of the season. This was true for both fertilized and unfertilized pastures. They stated that the protein content of a pasture grass in a good grazed condition can be increased and maintained at a somewhat higher level than ordinary by frequent and light applications of a nitrogen fertilizer.

McClure (1929), at the Ohio Station, found that when the same amount of nitrogen was supplied by urea, ammonium nitrate, calcium nitrate or ammonium sulfate to eight year old bluegrass sod, the increase in yield of dry matter and protein was practically the same for all treatments. He showed that increasing the frequency of application gave very little increase in total yield. Increasing the amount of nitrogen gave a corresponding increase in both dry matter and protein. The percentage recovery of the added nitrogen varied from 26 percent when 25 pounds were applied per acre to 31 percent when 400 pounds were applied.

Brown (1933), at the Storrs (Connecticut) Experiment Station, found that applications of nitrogen in addition to super phosphate and lime increased the yield of pasture plants 197 percent over the unfertilized. The percentage of bluegrass increased and the percentage of clover decreased with added nitrogen. It was found that the protein content of forage was increased by 50 percent through the application of super phosphate and nitrogen. This change was due in part to a change in population of plant species.

Mortimer and Rupel (1934), Wisconsin investigators, reported the effects of various treatments on bluegrass pasture: Non-treated bluegrass pasture yielded

147 heifer pasture days; 80 pounds of nitrogen in two separate applications gave 221 heifer pasture days per acre; and a single application of 40 pounds of nitrogen provided 199 heifer pasture days per acre. The average daily gain for the treated pastures was 0.70 pounds per head during the 117-day pasture season. This is not considered a good rate of gain. No average daily gains were reported for the untreated pasture.

Dodd (1935), working at the Ohio Station, reported that nitrogen fertilizer applied early in the spring increased production not only in the spring but throughout the season, as indicated by regular and uniform mechanical harvests. He stated that the increased production during July and August was so little that this could not be considered as a means of meeting the mid-summer pasture shortage; but the fall growth was materially increased by making a second or third application of nitrogen later in the season. The exact time of response in extra growth from nitrogen application appeared to depend upon moisture and temperature conditions.

Noll *et al.* (1944), of the Pennsylvania Station, reported that nitrogen applied at the rate of 24 pounds and 48 pounds per acre of pasture greatly increased the yields in the early part of the season. However, 72 pounds of nitrogen were required per acre to obtain increased production consistently after June.

In pasture studies at the Illinois Station, McKibben *et al.* (1950) applied nitrogen fertilizers to ladino clover pasture mixtures and got only a slight increase in total dry matter. Nitrogen fertilizer also tended to reduce the amount of ladino clover and increase the amount of grass in the stand. Nitrogen increased total yield only slightly.

A Comparison of Irrigated Pastures

Heinemann and VanKeuren (1956), in comparing irrigated alfalfa, alfalfa-orchard grass, ladino clover, ladino clover-orchard grass, and orchard grass pastures, found that alfalfa and alfalfa-orchard grass produced the most pounds of lamb and the greatest gain by ewes. On this basis, they indicated there were three distinct categories into which the five kinds of pastures fit. The first and best category included alfalfa and alfalfa-orchard grass; the second ladino clover and ladino clover-orchard grass; and the third, orchard grass. For lambs, the average season-long carrying capacity per acre varied from 10.9 for ladino clover to 15.2 for alfalfa-orchard grass. Average daily gains by the lambs were 0.47 on alfalfa, 0.38 on alfalfa-orchard grass, 0.46 ladino clover, 0.36 ladino clover-orchard grass, and 0.28 pounds on orchard grass. They indicate that the carrying capacity of the pastures was not directly related to average daily gains or pounds of lamb produced per acre.

Parasite Control.

When forage is irrigated, the incidence of worm infestation is increased, ac-

cording to research findings. Several control methods have been reported.

Wright (1931) found that weekly treatments for more than a year with 100 c.c. of a 1 percent copper sulfate solution, 5 c.c. of carbon tetrachloride, or 5 c.c. of tetrachlorethylene failed to remove all parasites present in sheep kept in small enclosures.

Investigators at the Oregon Station, Besse (1937), found that irrigated pasture provided the best sources of succulent feed during summer months, but the principal draw-back of irrigated pasture for sheep was internal parasite infestation.

Although several species of parasites are found in Missouri sheep, Elder and Rodabaugh (1949) state that the most serious seem to be the stomach worm *(Haemonchus contortus),* the nodular worm *(Oesophogostomun columbianum),* the tape worm *(Moniezia expansa and Moniezia benedeni),* and the small stomach worm *(Ostertagia circumcinita).*

Gordon (1939), Boughton and Hardy (1941), Habermann and Shorb (1942), Thorp and Keith (1943) reported good results in worm control from the use of phenothiazine as a drench or when supplied in the salt.

Shaw and Muth (1946) in summarizing six years' results with ewes and lambs on irrigated ladino clover pastures in Oregon reported a 12 percent death loss in lambs due to internal parasites. They found that phenothiazine and salt (1 part phenothiazine and 15 parts salt or 1 part phenothiazine and 10 parts salt by weight) did not prevent parasite infestation in the lambs. Even though the lambs were supplemented with grain, only a small percent of the experimental lambs had enough finish to be marketed after about 108 days on the irrigated pastures.

Elder *et al.* (1946) at the Missouri Station found that nodular worms in ewes were not controlled when the ewes were drenched with phenothiazine in December and in March and every 28 days thereafter with a 1½ percent solution of copper sulphate until the following December. However, in sheep that were drenched every four weeks with phenothiazine from December until April and then allowed access to phenothiazine-salt mixture (1 part phenothiazine and 10 parts salt) nodular worms were controlled.

In summarizing results of an experiment to compare the merits of a 1:10 phenothiazine salt mixture with standard monthly doses of phenothiazine for the control of helminthiasis in lambs, Pollard *et al.* (1949) found that monthly doses of 20 gm. phenothiazine were more effective than the phenothiazine-salt mixture in reducing the mean egg count, the proportion of clinical cases, and the total worm burden. The average daily intake of phenothiazine was slightly less than 0.2 gm. per head.

Foster (1953) stated that after 11 years of free choice administration of phenothiazine in salt (1:9) to experimental flocks, there were no ill effects attributable to the drug. On the other hand, parasites had been controlled but not eradicated, as evidenced by periodic egg-counts.

Whitlock and Cox (1940) reported that the number of worm eggs per gram of feces was reduced to a harmless level in all cases when phenothiazine was given at the rate of 0.5 gm. per pound body weight in single dose trials. This was also confirmed by clinical improvement of the infected sheep. In some cases copper and nicotine sulfate solution failed to reduce the egg count to a non-significant level. It was postulated that the reason for the lowered efficiency of phenothiazine in some heavily parasitized animals was because the esophageal groove reflex was weakened; likewise, rumination was retarded. It was believed that after the administration of phenothiazine to heavily parasitized sheep, the drug was partially immobilized in the rumen and prevented from reaching its most effective concentration in the abomasum and intestine. A pre-treatment with a copper sulfate mouth spray caused the passage of the anthelmintic directly to the abomasum.

PURPOSE OF INVESTIGATION

The purpose of this investigation was to study the effects of irrigation and irrigation plus nitrogen fertilizer on various forages produced alone or in combination with one another, as measured by ewes and their "late" lambs.

The criteria for measuring the results were:

A. Carrying capacity of pasture.
B. Daily rate of gain.
C. Total gain per acre.
D. Condition and thrift of ewes and lambs.
E. Parasite infestation.
F. Economic considerations.

Part I: 1955 Trial

METHODS

Sheep: Two trials were conducted, one in 1955 and the other in 1956. Sheep used in the first trial were mature western ewes and their "April" lambs. Lambs were sired by Hampshire rams.

Nine one-half acre pasture plots were used in this test. Three produced orchard grass-ladino mixture; three, orchard grass-Korean lespedeza; and three, orchard grass alone. Prior to seeding, all plots were brought to the same approximate levels of calcium, phosphorus, potassium, and nitrogen as recommended by the Department of Soils.

Seeding was made in the spring of 1954 in accordance with recommendations made by the Department of Field Crops. One pasture in each trio was used as a control; one was irrigated; and one received nitrogen in addition to irrigation. The arrangement was as follows:

PASTURE SPECIES AND TREATMENTS USED IN EXPERIMENTS

Pasture Species	Lot Number	Pasture Treatment
Orchard Grass	1	Control (no treatment)
and	2	Irrigation
Ladino Clover	3	Irrigation & Nitrogen
Orchard Grass	4	Irrigation
and	5	Irrigation & Nitrogen
Korean Lespedeza	6	Control (no treatment)
Orchard Grass	7	Control (no treatment)
(no legume)	8	Irrigation
	9	Irrigation & Nitrogen

Fence, Shed, Water: Because the sheep were kept on the pastures continuously, the area was fenced with a dog-proof fence. Shade was provided by open sheds in each plot. Water was available constantly.

Fertilizer Treatment: Plots that received nitrogen fertilizer (3, 5, and 9) were top dressed in the fall of 1954 and in July and August of 1955 with 53 pounds of nitrogen per acre at each application.

Irrigation: The irrigation water was supplied by a rotary sprinkler system and in accordance with recommendations from the Agricultural Engineering Department. Approximately 2 inches of water were applied per application; a total of 14 inches was applied during the 1955 season. It was not deemed necessary to irrigate until the last of June. (About two-thirds of the total amount of water was applied during July and August.)

Division of Ewes and Lambs: Sixty-three ewes and their lambs, which were dropped in April, were divided into nine lots on the basis of lamb birth weights and the weight of the ewes. Each lot weighed approximately the same and each lot had the same number of twin lambs.

Grazing Season: The grazing season began June 4, 1955, and lasted until October 8. An attempt was made to keep all pastures grazed to approximately the same height. To accomplish this, some of the sheep had to be removed from the non-irrigated plots during hot, dry periods of the summer.

Weaning of the Lambs: All lambs were weaned on the sixth of August, and the ewes were removed from the test.

Weights: Individual weights of the ewes and lambs were recorded weekly.

Parasite Control: All ewes were drenched with phenothiazine prior to being placed on the experiments and fecal egg counts were taken to determine the worm load.

In an attempt to control stomach worms in the ewes and lambs, fecal egg counts were made periodically and when counts indicated an increasing worm burden, the sheep were drenched with standard doses of phenothiazine.

RESULTS

Responses of Sheep to Various Pastures During Suckling Period Before Irrigation (June 4 to August 6).

Responses of sheep to the various pastures were evaluated by the following criteria:

1. Rate of gain by lambs.
2. Lamb pasture days per acre.
3. Total gains per acre by lambs.
4. Average loss in weight by ewes.

Suckling period results will be discussed first, then the post weaning period results. During the suckling period, enough rain fell to eliminate the need for supplemental irrigation.

Response of Lambs: Tables 1, 2, and 3 show that there was no marked difference in average daily gains, lamb pasture days, or total lamb gain per acre. This may be explained in part by the fact that one of the variables of the test was eliminated (irrigation) because of adequate rainfall.

TABLE 1--AVERAGE DAILY GAIN BY LAMBS, SUCKLING PERIOD BEFORE FREQUENT IRRIGATION*
June 4 to August 6 (62 days)

	Daily Gain per Lamb from:		
Pasture Species	Control	Irrigation	Irrigation plus Nitrogen
Orchard Grass Ladino Clover	0.32 lb.	0.35 lb.	0.34 lb.
Orchard Grass Lespedeza	0.33	0.32	0.32
Orchard Grass	0.30	0.32	0.33

TABLE 2--LAMB PASTURE DAYS PER ACRE, SUCKLING PERIOD BEFORE FREQUENT IRRIGATION*
June 4 to August 6 (62 days)

	Pasture Days per Acre from:		
Pasture Species	Control	Irrigation	Irrigation plus Nitrogen
Orchard Grass Ladino Clover	880	954	818
Orchard Grass Lespedeza	868	906	844
Orchard Grass	906	906	906

*One irrigation required the latter part of June and two in July.

TABLE 3--TOTAL LAMB GAINS PER ACRE, SUCKLING PERIOD BEFORE FREQUENT IRRIGATION*
June 4 to August 6 (62 days)

	Pounds Gain per Acre from:		
Pasture Species	Control	Irrigation	Irrigation plus Nitrogen
Orchard Grass Ladino Clover	282	334	278
Orchard Grass Lespedeza	286	290	260
Orchard Grass	275	290	299

*One irrigation required the latter part of June and two in July.

Average Loss in Weight by Ewes: Average losses in weight by ewes during the suckling period ranged from 8.7 pounds in control orchard grass-ladino clover to 21.7 pounds per head in orchard grass-ladino clover pasture. Table 4 shows that in the other pastures, losses in weight were about the same.

TABLE 4--AVERAGE WEIGHT LOSS PER EWE
June 4 to August 6 (62 days)

	Pounds Lost per Ewe on:		
Pasture Species	Control	Irrigation	Irrigation plus Nitrogen
Orchard Grass Ladino Clover	8.7	21.7	21.0
Orchard Grass Lespedeza	20.5	19.8	19.8
Orchard Grass	18.6	19.8	20.5

Effects of Irrigation and Fertilization During the Post Weaning Period (August 6 to October 8).

Responses of lambs to fertilized and frequently irrigated pastures were evaluated by the following criteria:

1. Rate of gain by lambs.
2. Lamb pasture days per acre.
3. Total gain per acre by lambs.
4. Lamb deaths from parasites

Rates of Gain by Lambs: The rates of gain made by weaned lambs during the second 62-day period, when frequent irrigations were made, are listed in Table 5.

TABLE 5--AVERAGE DAILY GAIN OF WEANED LAMBS DURING FREQUENT IRRIGATION
August 6 to October 8 (62 days)

	Daily Gain per Lamb from:		
Pasture Species	Control	Irrigation	Irrigation plus Nitrogen
Orchard Grass Ladino Clover	0.21 lb.	0.22 lb.	0.14 lb.
Orchard Grass Lespedeza	0.24	0.01	0.04
Orchard Grass	0.16	0.13	0.19

Lambs that grazed irrigated forage gained more slowly than controls in two cases out of three. However, adding nitrogen to irrigation increased daily gains slightly on orchard grass-lespedeza and on orchard grass.

Lamb Pasture Days per Acre: Table 6 shows the effect of irrigation and irrigation plus nitrogen on carrying capacities of the various pastures. Irrigation increased lamb pasture days in all pastures. However, the addition of nitrogen gave a decrease over irrigation alone in lamb pasture days per acre of orchard grass-lespedeza and orchard grass. This may be explained partly by the moderate infestation of weeds in the orchard grass pasture.

TABLE 6--TOTAL LAMB PASTURE DAYS PER ACRE AFTER WEANING DURING FREQUENT IRRIGATION
August 6 to October 8 (62 days)

	Pasture Days per Acre from:		
Pasture Species	Control	Irrigation	Irrigation plus Nitrogen
Orchard Grass Ladino Clover	372	824	1074
Orchard Grass Lespedeza	288	1320	1240
Orchard Grass	440	812	584

Total Lamb Gains Per Acre: Total lamb gains per acre are shown in Table 7. Irrigation increased markedly the total gains per acre from orchard grass-ladino clover and orchard grass alone. In contrast, orchard grass-lespedeza produced less. Adding nitrogen to irrigation did not give returns of consequence except with orchard grass-lespedeza. Parasite infestation, no doubt, is an underlying cause for some of these occurrences.

TABLE 7--TOTAL GAIN PER ACRE DURING FREQUENT IRRIGATION (AFTER WEANING)
August 6 to October 8 (62 days)

Pasture Species	Pounds Gain per Acre from: Control	Irrigation	Irrigation plus Nitrogen
Orchard Grass Ladino Clover	78	181	150
Orchard Grass Lespedeza	69	13	50
Orchard Grass	70	105	111

Lamb Deaths from Parasites: Severe parasite infestation developed in lambs. Rigid control measures were not effective. All lots were heavily infested and made very poor individual gains. Death loss occurred in four lots (see Table 8); the deaths did not follow a particular pasture treatment.

The heaviest death loss occurred in an orchard grass-ladino clover lot receiving both irrigation and nitrogen fertilizer. This lot had an abundance of forage and a stocking rate of 20 lambs per acre.

TABLE 8--LAMB DEATHS DUE TO PARASITES DURING FREQUENT IRRIGATION
August 6 to October 8 (62 days)

Pasture Species	Treatments Control	Irrigation	Irrigation plus Nitrogen
Orchard Grass Ladino Clover	0	0	3
Orchard Grass Lespedeza	1	1	1
Orchard Grass	0	0	0

Part II: 1956 Trial

METHODS

Sheep: In the second trial, the ewes were two year old Colorados that dropped lambs in April sired by Hampshire rams.

Division of Ewes and Lambs: On April 25, 1956, fifty-four head of two-year old Colorado ewes and their 64 lambs were divided into nine comparable lots based on birth weights. Each lot contained one set of twins.

The factors which contribute to greater birth weights also contribute to greater milk yields, according to Guyer and Dyer (1954). Milk yield affects rate of gain more than any other factor. Each group of ewes and lambs was kept on the same pasture throughout the experiment to determine the rate of gain it would produce. However, to consume all pastures equally, additional ewes and lambs were used from time to time in the faster growing pastures. The total gain per lot was obtained by multiplying the average daily gain of the "tester" group by the number of pasture days.

Pastures: The pasture plots used in Trial I were used in Trial II. The control pastures, however, had a smaller population of legumes than the irrigated pastures.

Fertilizer Treatment: The pasture plots receiving additional nitrogen fertilizer (3, 5, and 9) had been top dressed with ammonium nitrate in the fall of the previous year, again in mid-July and again in late August. Each nitrogen application was made at the rate of 53.6 pounds per acre.

Irrigation: Irrigation water was supplied by a rotary sprinkler system at the rate of 0.2 inch per hour for 10 hours. Ten applications were made during the growing season, at intervals of 2 weeks even though infrequent light showers occurred during this period.

Treatment for Parasites: On April 15, 1956, all ewes were drenched for stomach worms with 2 ounces of a phenothiazine suspension. The ewes and lambs were again drenched on June 7 and bi-weekly thereafter with 2 ounces of phenothiazine. A salt-phenothiazine mixture (10 parts stock salt by weight to one part phenothiazine) was kept before the flock at all times.

Minerals: From the tenth of July until the end of the grazing season, the lambs had free access to steamed bone meal.

Grazing Season: The grazing season began on April 25, 1956, at which time the forage was about 6 to 8 inches high and it ended October 1. An attempt was made to graze all plots to the same height; to do this some of the sheep had to be removed occasionally from their pastures for short periods of time.

Weaning: All lambs were weaned on July 7, 1956, and the ewes were then removed from the test.

Weights: Individual weights of the ewes and lambs were taken weekly at approximately the same time of day.

Fecal Egg Counts: The Department of Veterinary Bacteriology and Parasitology collected fecal samples from representative lambs that grazed various pastures to determine the extent of parasitism.

Nematode Larvae Counts: Larvae counts were made by placing one kilogram of grass clippings (taken early in the morning while heavy dew was present) in a large Baermann Apparatus (Rohrbacher). The grass was covered with warm water and allowed to settle for 1½ hours. Five hundred to 800 c.c. of fluid were withdrawn and the number of larvae was calculated. Three count aliquots (10 c.c.-25 c.c.) were made, and the means were considered as a representative factor for calculating the total. Counts were made using a Steroscopic microscope. The total larvae in an aliquot sample were counted. Representative samples were removed from each collection and examined under higher magnifications to determine the proportion of nematode larvae present which were parasitic species. In each instance a high percentage was found to be larval stages of *Haemonchus Contortus.*

RESULTS

Effects of Irrigation and Fertilization During the Suckling period (April 25 to July 7).

Responses of sheep to irrigated and fertilized pastures were evaluated by the following criteria:

1. Rate of gain by lambs.
2. Lamb pasture days per acre.
3. Total gains per acre by lambs.
4. Condition and thrift of lambs.
5. Ewe pasture days per acre.
6. Loss or gain made by ewes.

Rate of Gain by Lambs: The daily gains are shown in Table 9. Irrigation of grass-legume mixtures decreased significantly ($P<.01$) the rate of gain by suck-

TABLE 9--AVERAGE DAILY GAINS MADE BY LAMBS, SUCKLING PERIOD
April 25 to July 7 (73 days)

	Daily Gain per Lamb from:		
Pasture Species	Control	Irrigation	Irrigation plus Nitrogen
Orchard Grass Ladino Clover	0.78 lb.	0.46 lb.	0.42 lb.
Orchard Grass Lespedeza	0.80	0.43	0.44
Orchard Grass	0.49	0.52	0.56

ling lambs. It increased the rate of gain made on orchard grass alone, but only slightly (statistically insignificant).

Using daily gain as a criterion, there was no significant difference in daily gains due to pasture species alone, as determined by analysis of variance, and no significant difference in daily gains due to pasture treatment alone. There was a significant difference with regard to interaction, i.e., the various pastures responded differently to treatments.

Lamb Pasture Days per Acre: Table 10 shows the effect of irrigation and irrigation plus nitrogen on carrying capacity of the various pastures. Irrigation increased lamb pasture days 74 percent on orchard grass-ladino clover, 147 percent on orchard grass-lespedeza, and 34 percent on orchard grass alone. Adding nitrogen gave further increases of 22 percent with orchard grass-ladino clover and 6 percent with orchard grass alone; but with orchard grass-lespedeza, the lamb pasture days per acre were reduced 27 percent by the addition of nitrogen fertilizer. No suitable explanation has been found for this occurrence.

TABLE 10--LAMB PASTURE DAYS PER ACRE, SUCKLING PERIOD
April 25 to July 7 (73 days)

	Pasture Days per Acre from:		
Pasture Species	Control	Irrigation	Irrigation plus Nitrogen
Orchard Grass Ladino Clover	512	892	1088
Orchard Grass Lespedeza	418	1034	756
Orchard Grass	562	756	798

Total Gains per Acre by Lambs: Irrigation increased the carrying capacities of pastures, it has been noted, but it reduced rate of gain. Thus, the total gains per acre were not greatly increased. The total lamb gains per acre are shown in Table 11. The increased gain per acre from treatments was obviously insufficient to pay for the added expense.

TABLE 11--TOTAL LAMB GAINS PER ACRE, SUCKLING PERIOD
April 25 to July 7 (73 days)

	Pounds Gain per Acre from:		
Pasture Species	Control	Irrigation	Irrigation plus Nitrogen
Orchard Grass Ladino Clover	399	410	457
Orchard Grass Lespedeza	334	445	333
Orchard Grass	275	393	447

Condition and Thrift of Lambs: By June 1, most of the lambs on irrigated pastures had begun to lose their bloom even though the pastures were lush and

the ewes appeared to be milking well; several cases of scours and foot rot developed. Lambs on control pastures were in a healthier condition, as indicated by luster of the fleece, gains in weight, and freedom from scours. On June 5, a lamb from Lot 4 (irrigated orchard grass-lespedeza) died. Post mortem examination revealed a severe infestation of stomach worms. A drench of phenothiazine was given immediately and at bi-weekly intervals thereafter to all lambs. No additional death losses occurred during the suckling period. The unthrifty appearance of the lambs continued.

Ewe Pasture Days per Acre: The ewe pasture days followed about the same pattern as that of the lambs. Results are in Table 12. Irrigated pastures supported more sheep than the controls, and irrigation plus nitrogen gave additional increases with the exception of orchard grass-lespedeza. In this case irrigation plus nitrogen produced about one-third fewer ewe pasture days per acre than irrigation alone. No reasonable explanation could be found for this occurrence.

TABLE 12--EWE PASTURE DAYS PER ACRE, SUCKLING PERIOD
April 25 to July 7 (73 days)

	Treatments		
Pasture Species	Control	Irrigation	Irrigation plus Nitrogen
Orchard Grass Ladino Clover	468	850	894
Orchard Grass Lespedeza	374	934	624
Orchard Grass	508	336	684

Weight Loss or Gain by Ewes: All lots of ewes lost weight while suckling lambs. (See Table 13.) Loss of weight is normal, but the amount of loss varied from 1.8 pounds per ewe on the non-irrigated orchard grass-ladino clover pasture to 20 pounds per ewe on the irrigated and nitrogen fertilized orchard grass-lespedeza pasture. In all cases, the losses followed a definite pattern; i.e. as each pasture treatment was applied, the losses in weight increased.

On June 27, a ewe in the irrigated orchard grass-lespedeza pasture (Lot 4) died. Cause of death was heavy infestation of stomach worms. On July 3 and 5, two ewes died on the orchard grass-lespedeza pasture (Lot 5) that received both

TABLE 13--AVERAGE WEIGHT LOSS PER EWE DURING SUCKLING PERIOD
April 25 to July 7 (73 days)

	Pounds Lost per Ewe on:		
Pasture Species	Control	Irrigation	Irrigation plus Nitrogen
Orchard Grass Ladino Clover	1.8	5.3	14.8
Orchard Grass Lespedeza	10.0	14.8	20.0
Orchard Grass	3.8	6.18	11.5

supplemental irrigation and nitrogen fertilizer. These death losses occurred in spite of the fact that the ewes had been drenched every two weeks since June 7 and had constant access to a phenothiazine-salt mixture.

The inability to control stomach worms under such conditions was evident.

Effects of Irrigation and Fertilization During the Post Weaning Period (July 7 to October 1)

Responses of lambs to irrigated and fertilized pastures during the post weaning period were evaluated using the following criteria:

1. Average daily gains.
2. Pasture days per acre.
3. Total gain per acre.
4. Condition and thrift of the lambs.
5. Parasite infestation.

Average Daily Gains: The daily gains were materially lower in all pastures during the post weaning period (Table 14). When irrigation was practiced, lamb gains were reduced. Adding nitrogen to irrigation resulted in further reduction of lamb gains.

Using daily gains as a criterion, orchard grass-ladino clover produced a significant increase over orchard grass-lespedeza ($P<.05$). During this period, however, lespedeza was practically extinct. There was no significant difference in daily gains due to pasture species between orchard grass-ladino clover and orchard grass, alone, or between orchard grass-lespedeza and orchard grass alone. Irrigation plus nitrogen decreased rate of gain significantly ($P<.05$); irrigation alone decreased rate of gain but not significantly.

TABLE 14--AVERAGE DAILY GAIN BY LAMBS, POST WEANING PERIOD
July 7 to October 1 (86 days)

	Pounds Gain per Day from:		
Pasture Species	Control	Irrigation	Irrigation plus Nitrogen
Orchard Grass Ladino Clover	0.24	0.17	0.08
Orchard Grass Lespedeza	0.14	0.06	0.01
Orchard Grass	0.18	0.16	0.09

Pasture Days per Acre: Carrying capacities were increased in all cases as treatments were applied—irrigation and irrigation plus nitrogen fertilizer as shown in Table 15.

Irrigation gave the following percentage increases over controls: 129 with orchard grass-ladino clover; 66 with orchard grass-lespedeza; and 47 with orchard grass alone. Adding nitrogen gave further increases of: 13 percent with orchard grass-ladino clover; 15 percent with orchard grass-lespedeza; and 43 percent with orchard grass alone.

TABLE 15--LAMB PASTURE DAYS PER ACRE, POST WEANING PERIOD
July 7 to October 1 (86 days)

Pasture Species	Pasture Days per Acre from: Control	Irrigation	Irrigation plus Nitrogen
Orchard Grass Ladino Clover	670	1536	1732
Orchard Grass Lespedeza	870	1446	1664
Orchard Grass	840	1204	1724

Total Gain per Acre: Total gains per acre made by weaned lambs were considerably below those made during the suckling period, as indicated in Table 16. Total gains per acre were increased in two cases out of three by irrigation. Nitrogen addition gave a negative response in all cases, i.e., the total gain was less than for the controls or those grazing irrigated pastures.

TABLE 16--TOTAL LAMB GAINS PER ACRE, POST WEANING PERIOD
July 7 to October 1 (86 days)

Pasture Species	Pounds Gain per Acre from: Control	Irrigation	Irrigation plus Nitrogen
Orchard Grass Ladino Clover	161	261	138
Orchard Grass Lespedeza	122	87	22
Orchard Grass	151	193	155

Condition and Thrift of the Lambs: During the post weaning period the lambs on irrigated pastures were generally unthrifty. Most of the lambs had lost their bloom and gained very little—in fact, some lambs lost weight during this period. A number of cases of foot rot developed in all irrigated pastures and occasionally on the non-irrigated pastures.

Death losses in the lambs was relatively light until September. However, the effects of heavy parasite infection were demonstrated by marked anemia, edema, weakness, anorexia, and frequent scouring. Symptoms were much more severe in lambs on irrigated plots. The greatest losses occurred in September when it became evident that the worm burden was breaking the resistance of practically all animals on the irrigated plots.

Autopsy findings—The pathological findings appeared to be essentially pure *Haemonchus contortus* infection; although, in most lambs considerable numbers of *Nematodirus spp.* were found. The lambs were extremely anemic. Usually about 30 to 40 percent of the normal hemoglobin level was noted just prior to death. Edema (Bottle Jaw) was observed in all lambs, and excessive accumulations of straw colored fluid were present in the abdominal cavity.

Parasite Infestation: During the early months of the study, worm egg output was relatively light. Counts, as determined by the Stoll dilution method, varied from 400 to 1000 eggs-per-gram of feces in most lambs. However, beginning in July the counts began to rise. During July and August, the counts varied from 3000 to 10,000 eggs-per-gram of feces. Usually a marked rise in egg count could be observed at the end of the second week following treatment.

Ecological studies were made of the immature parasite larvae present on the irrigated pastures. Grass clippings were cut at random over similar areas of three different pastures (Lots 3, 4, and 5). A detailed examination of representative samples of larvae concentrated in this manner indicated that a high percent were immature stages of *Haemonchus contortus.* Even though there is a probability of considerable error, the counts shown by Table 17 give a good estimate of the immature parasite population on these irrigated pastures.

TABLE 17--NEMATODE LARVAE COUNTS MADE FROM IRRIGATED SHEEP PASTURES

	Larvae Recovered from a Kilogram of Grass		
Date	Plot 3	Plot 4	Plot 5
July 6	51,000	16,000	11,750
August 24	3,000	2,250	1,450
September 19	5,000	1,850	2,100

CONCLUSIONS

Each of the various treatments had its advantages and disadvantages. Compared with non-irrigated pasture, irrigated pastures had the following advantages:

1. Carrying capacity was increased.
2. Total lamb gain per acre was increased.
3. Continuous grazing was provided.
4. Legumes were more easily maintained in mixtures.

The disadvantages of irrigation were:

1. Daily gains per head were reduced.
2. Parasitic infestation was much more severe.
3. Costs of irrigating were greater than the value of the greater total gain per acre; thus, irrigation did not pay.

Adding nitrogen to irrigated pastures had the following effects:

1. Rate of gain was generally lowered compared with the irrigated and the control pastures.
2. Carrying capacity was greater, with one exception, than when only the irrigation was used.
3. Lamb mortality from parasitic infestation was increased.
4. Added returns did not pay the greater costs.

Comparison of pasture species indicated the following:

1. There was no significant difference in pasture species, using daily gain as the criterion.
2. Orchard grass responded to treatments more than grass legume mixtures, using gains made by the lambs as a criterion.
3. Sheep are selective grazers; they tend to over-graze legumes in mixtures. This would suggest that a single species might be best for sheep under conditions similar to those in the tests.
4. There was probably a lowered percentage of dry matter in the irrigated forages. Sheep apparently did not ingest enough to secure the necessary nutrients for most rapid gains.

To avoid parasitic infestation, rotational grazing might seem desirable; however, under the conditions of this test, rotational grazing would probably be of little help. If the irrigated plots were not grazed for a period of two weeks, the forage would be too tall for optimum grazing by sheep; and, according to the parasitologist who was in close contact with this experiment, a period of at least 28 days without grazing would be necessary before any reduction in stomach worm larvae on the grass could be expected. Soiling might work well under such conditions. There is need for research within this area.

Different species might prove better than those used in the tests. Additional research on species also seems desirable.

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