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New Mexico College of Agriculture And Mechanic Arts

AGRICULTURAL EXPERIMENT STATION
STATE COLLEGE, N. M.

Covering the Vines After Plowing.

Winter Protection of the Vinifera Grape

By Fabian Garcia and J. W. Rigney

RIO GRANDE PUBLISHING CO.
LAS CRUCES, N. M.
1916

New Mexico Agricultural Experiment Station

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Winter Protection of the Vinifera* Grape

INTRODUCTION.

The results of the first experiments with European grapes are given in Station Bulletin No. 58. The discussions deal mostly with the question of propagation, cultivation and varieties, and slight mention is made of the resistability of the European grape to the winter temperatures.

The bulletin also makes some reference to the early history of grape growing in the Rio Grande Valley and it shows that varieties of the European grape, principally the old Mission or El Paso grape, were grown in parts of the Rio Grande Valley for many years before New Mexico became part of the United States.

It has been ascertained that the range of adaptability of the European grape, as far as the winter temperature is concerned, is not as great as that of the native grapes. In other words, the European grapes are not as hardy to cold as the native varieties, such as the Concord, Delaware, etc. For that reason the best European grape growing districts of the State may be found in the warmer and lower agricultural districts. On the other hand, wherever the European grape will grow it produces better and larger crops and is at the present time the commercial grape for New Mexico.

The early Mexican farmers, who were the first grape growers in New Mexico, ascertained, through experience mostly, that it was good practice to protect their vines during the winter. Later vineyardists doubted the necessity of this practice

*The Vinifera grape is the European or so-called "California" grape

and discontinued the use of it, with more or less unsatisfactory results. In view of this and the lack of definite knowledge on the subject, the Experiment Station planned an experiment to ascertain, among other things, the effect of winter protection upon the vines and yield.

PLAN.

In order to carry out this experiment, a small vineyard was planted between the 14th and the 20th of March, 1906, on the new horticultural farm in a very sandy soil. In this vineyard 400 Flame Tokay, 400 Black Cornichon, 300 Emperor, 730 Muscat of Alexandria, and 600 Mission cuttings were planted. All of the plants of the Flame Tokay, Black Cornichon and Emperor were rooted cuttings obtained from California. The Mission and Muscat of Alexandria were unrooted cuttings obtained from local vineyards. A very good stand was secured. The Mission and Muscat of Alexandria cuttings rooted remarkably well and the vines made almost as good growth the first year as the rooted cuttings. In starting this vineyard some of the Mission and Muscat cuttings were taken in the fall and heeled-in during the winter. These rooted somewhat better than those taken in the spring.

All of the cuttings were planted in the field in squares eight feet apart and immediately irrigated. The sandy soil in which they were planted held the moisture well, and therefore required little irrigation. As a matter of fact, the irrigation was stopped about the last of July the first season. From that time on the vineyard was simply surface-cultivated. The small vines were banked late in the winter.

The pruning in the spring of 1907 was done the first week in April and by the 21st of the month a growth of from six to ten inches had been made by some of the vines. All of this growth was killed on the 21st of April by a late frost. The killing back of this new growth caused the plants to start from the base, producing a number of sprouts during the summer which had to be removed, leaving one or two to form the stump.

The growth made during the summer of 1907 was remarkably large. The shoots kept on growing until late in the fall, when the first frost occurred. The vines were banked up early in the fall of 1907. The pruning was done from the first to the sixth of April, 1908, two weeks after the uncovering of the vines. Immediately after pruning, the vines were tied to stakes which were driven by the side of the plant. The stakes used for this purpose were made of material not more than an inch to two inches in diameter and from one to two feet in length. The object of this operation was to strengthen the stump so that it would grow up straight. Most of the Mission, Muscat of Alexandria, Flame Tokay and Black Cornichon set a fair crop in 1908. The Emperor did not produce any fruit.

Figure 1. Tying the canes up in the fall. First operation.

The vine growth during 1908 was very rank and due to a number of vegetables being planted in the vineyard it was necessary to keep irrigating until late in the fall. This late irrigation undoubtedly kept the vines growing too late and prevented the canes from properly maturing before the freezing weather started. In December, 1908, quite a drop in temperature oc-

curred and the more succulent and tender canes were materially injured. The vines were not protected during the winter of 1908-'09. In the spring when the vines were pruned, April 1 to 4, it was observed that about ninety per cent of the canes were dead. On most of the injured vines the main stump was killed back to the ground. The grape vines, having the main stump killed, again sprouted from the base in the spring of 1909. This made it necessary during the summer to remove most of the sprouts and start a new stump. The canes produced from such buds are generally classed as renewal canes which do not, as a rule, bear fruit the current season. On account of such a large percentage of renewals the grape crop was very small in 1909.

In the fall and early winter of 1909 part of the vineyard was pruned. The vines were covered from the 15th to the 22nd of November. In the fall or winter pruning of the vines the canes were cut back to about six buds, leaving from six- to eight-inch stubs. In the spring these stubs were again cut back to two or three buds, the usual number of buds to be left after pruning. In the spring of 1910 after the pruning was done no material difference could be seen between the winter and spring pruned vines. Since there seemed to be no material advantage in the winter pruning the practice was not continued. The vines were uncovered March 15 to 20 and pruned from the 1st to the 5th of April.

On April 17, 1910, a frost injured some of the young sprouts which had started to grow and this reduced the grape crop during that year. During the ripening season the honey bees did a great deal of damage to the berries, by sucking all of the grape juice out and leaving nothing but the hulls.

Experiments.

In the fall of 1910 the vineyard was divided into nine plats, in order to test different ways of winter protection and to get more reliable data on the effect of winter irrigation with no protection; irrigation and covering the vines with moist soil; covering the vines with dry soil and immediately irrigating them; covering the vines with dry soil and not irrigating them; no protection and no irrigation; and also to study the effect of the early and late treatment of the vines.

WINTER PROTECTION OF THE VINIFERA GRAPE.

WINTER TREATMENT OF GRAPES 1910-1911									
PLAT 1		PLAT 2		PLAT 3		PLAT 4		PLAT 5	
PLAT 6		PLAT 7		PLAT 8		PLAT 9		PLAT 10	
MUSCAT OF ALEXANDRIA		MISSION		BLACK CORNICHON		EMPEROR		FLAME TOKAY	
IRRIGATED NOT COVERED	14 ROWS	IRRIGATED AND COVERED	9 ROWS	COVERED AND IRRIGATED	9 ROWS	COVERED NOT IRRIGATED	9 ROWS	NOT COVERED IRRIGATED	7 ROWS
TREATED EARLY		CHECK		TREATED LATE		TREATED LATE		TREATED LATE	

Plats 1 and 6 were irrigated and not covered. Plats 2 and 7 were irrigated first, plowed and covered just as soon as possible after the irrigation; usually, on the sandy soil in which the vineyard grew, from three to four days after irrigation. Plats 3 and 8 were covered with dry soil and immediately irrigated. Plats 4 and 9 were covered with dry soil but not irrigated. Plat 5 was not treated at all. Plats 1, 2, 3 and 4 were in the series treated early in the season, usually from the 1st to the 15th of November. Plats 6, 7, 8 and 9 were in the series treated about two weeks later, usually from the 20th to the 27th of November.

In 1910, plats 1, 2, 3 and 4 were treated during the first week in November according to the outline in the plan. Plat 1 was irrigated but not covered; plat 2 irrigated and covered; plat 3 covered and irrigated; plat 4 covered and not irrigated. About two weeks later, from the 18th to the 24th of November, the second series of plats was treated. Plat 6 was irrigated but not covered; plat 7 irrigated and covered; plat 8 covered and irrigated; plat 9 covered, not irrigated.

While the winter of 1910-'11 was very cold, the canes on the protected vines were not killed. The uncovered vines, however, were badly winter killed. The canes on plats 1 and 6 were badly injured, indicating that the simple irrigating of the vines was not enough protection to prevent the canes from being winter killed. In the spring when the vines were uncovered, it was found that the canes on the vines in plats 2, 3, 7 and 8 were fresher and plumper and the buds at the base of the canes were somewhat farther advanced than on the other plats. Soon after pruning, the first week in April, the vines in plats 2, 3, 7 and 8 started growing and they made a faster growth than the canes on the other plats. In 1911 there was a heavy crop of fruit set on the protected vines, but a very light one on the unprotected ones.

In the fall of 1911, plats 1 and 2 were irrigated October 27 and plowed on the 30th. Plats 2, 3, and 4 were covered ac-

according to the plan from the first to the eighth of November. Plats 6 and 7 were irrigated November 16th and plowed on the 20th. Plats 7, 8 and 9 were covered from the 20th to the 25th of November. The winter of 1911-'12 was practically the same as the previous one and the uncovered vines were badly injured while the protected ones were not hurt. From the 8th to the 15th of March, 1912, the vines were uncovered. On May 4 a light frost did considerable damage to the tender growth and fruit buds which had already started to develop. This reduced the crop somewhat in 1912.

Figure 3. Irrigating before plowing. Second operation.

The treatment for the winter of 1912-'13 was the same as that for previous years. From October 26th to the 29th the grape canes were tied. Plats 1 and 2 were irrigated on October 28, and the middles were plowed November 2, 1912. Plats 2, 3 and 4 were covered during the 3d to the 6th of November. Plats 6 and 7 were irrigated November 19, and plowed on the 23d. Plats 7, 8 and 9 were covered from the 24th to the 26th of November, 1912.

The winter of 1912-'13 was exceedingly cold. On January 8 the thermometer at the plats recorded a temperature of

10 degrees below zero. This was unusually cold and is the lowest temperature that has been recorded at the Experiment Station since meteorological records have been kept. While the winter was unusually cold the beginning of spring was not much later than usual. On February 26 the vines were plowed and on March 3, 4 and 5 the dirt that had been left around the vines was removed. On April 1, twenty-six days after the vines were uncovered, the pruning was started. On the whole the vines were a few days later in starting to grow in 1913 than during the previous year and while there were a number of nights of freezing weather the temperature did not drop low enough to damage the crop, except a 27-degree temperature on April 24. This temperature reduced the fruit buds, but still quite a heavy crop of fruit was set on the covered vines. On June 7 a hail storm did some injury and further reduced the crop. The canes of the unprotected vines were practically all winter killed except a few on the Muscat of Alexandria in plat 5. The following table will give an idea of the amount of injury done in 1912-1913 to the treated and untreated vines:

Amount of Injury Done to the Vines During the Winter of 1912-1913.

Plat No.	Muscata of Alexandria			New Mexico Mission			Black Corinthian			Emperor			Flame Tokay		
	No. of Vines	Condition		No. of Vines	Condition		No. of Vines	Condition		No. of Vines	Condition		No. of Vines	Condition	
		Winter Injured	Sound		Winter Injured	Sound		Winter Injured	Sound		Winter Injured	Sound		Winter Injured	Sound
1	87	87	0	61	61	0	51	51	0	42	42	0	36	36	0
2	69	0	69	59	0	59	38	3	30	33	2	31	35	1	34
3	75	0	75	54	1	53	39	2	37	33	2	31	32	1	21
4	82	1	81	58	0	58	38	0	33	27	0	27	37	5	32
5	64	58	6	44	44	0	28	28	0	26	26	0	25	25	0
6	47	47	0	42	42	0	29	0	0	34	34	0	22	22	0
7	51	0	51	53	0	53	36	0	36	21	1	26	32	0	32
8	52	0	52	52	1	52	22	1	21	20	1	17	30	8	22
9	66	2	64	55	0	55	35	0	35	25	4	21	29	10	19

The above table will give a good idea of the amount of injury done to the treated and untreated vines during the winter of 1912-'13. Plat 1 shows that all the vines of all the varieties were winter injured. Plat 2 shows that all the vines of the Muscat of Alexandria and the New Mexico Mission were sound; that thirty out of the thirty-three Black Cornichon were sound; thirty-one out of the thirty-three Emperor were sound; and that thirty-four out of the thirty-five Flame Tokay were sound. Plat 3 shows that all of the Muscat of Alexandria were sound, while the New Mexico Mission, Black Cornichon, Emperor and Flame Tokay had one, two, two and one vines injured, respectively. Plat 4 shows: one vine injured in the Muscat of Alexandria; none in the New Mexico Mission, Black Cornichon and Emperor, and five in the Flame Tokay. In plat 5, six of the Muscat of Alexandria were sound. All the vines of the other varieties were injured. In plat 6 all the vines of all the varieties were injured. In plat 7 all the vines were sound except one in the Emperor block. Plat 8 shows that all the Muscat of Alexandria were sound; and that one each of the New Mexico Mission and Black Cornichon; three in the Emperor and eight in the Flame Tokay were injured. Plat 9 had two of the Muscat of Alexandria, no New Mexico Mission and Black Cornichon, four Emperor and ten Flame Tokay, injured.

From these figures it seems that the Emperor and the Flame Tokay were the more susceptible to winter injury, as we find more injured vines in these two blocks even on the protected plats. On the other hand, the Muscat of Alexandria is probably the hardiest, as aside from the larger number of canes being uninjured in plats 1 and 6 there were six vines not hurt in plat 5.

The following table gives the yields of the treated and untreated plats for 1913:

It is interesting to note from the above table that the three varieties of grapes on the uncovered plats had a small crop, particularly on the Mission and Black Cornichon. In the case of the Black Cornichon, plats 1 and 6 did not produce any crop as all the vines were winter killed, while in plat 5 the average yield per vine was one-half pound. The Mission vines in plat 1 were all winter killed, while a few canes on plats 5 and 6 were uninjured and the average yield per vine was .5 and .81 pound, respectively. The Muscat of Alexandria vines apparently withstood the winter much better, as the average yield per vine in plats 1, 5 and 6 was 1.49, 3.09 and 1.1 pounds, respectively. Quite a number of vines in plat 5 were not hurt. In a general way it will be seen that the irrigation of plats 1 and 6 did not materially help in preventing the vines from being winter killed, as the vines on those irrigated and uncovered plats did not resist the cold any more than the vines on check plat 5.

It will also be noted that there was no material difference in the yield from the vines covered after irrigation, those covered before irrigation and the ones covered and not irrigated. From these results there was not enough difference in yields in plats 2, 3 and 4 to draw definite conclusions as to which treatment is the best. In the case of the Muscat of Alexandria, plat 4 produced more per vine than plats 2, 7 and 8. In the case of the Mission, plat 3 produced slightly more than any of the other plats. In case of the Black Cornichon plats 2 and 7 in the two series had slightly the lead of the other plats. The yield of plat 9 was not recorded. The Emperor and Flame Tokay plats were discontinued.

Apparently there is no material advantage gained by the irrigation over the dry treated plats. This question is one of convenience at the time when the work is being done. In cases where the vineyard is planted in very sandy soil the work of banking up the vines can be done easier by first irrigating the land.

On October 27 to 29, 1913, the grape canes were tied.

Plats 1 and 2 were irrigated October 30. On the 3d of November the middles between the vines were plowed. From the 3d of November to the 6th, plats 2, 3 and 4 were covered. On November 19 plats 6 and 7 were irrigated and on the 23d the middles were plowed. From the 23d to the 27th of November plats 7, 8 and 9 were covered. The winter of 1913-'14 was

Figure 4. Plowing dirt towards vines before banking. Third operation.

comparatively mild and the lowest temperature recorded at the plats was 9 1-2 degrees Fahrenheit on January 30, 1914. Though the winter was mild most of the canes on the unprotected vines of all the varieties were badly winter killed while those of the protected vines were not injured at all. At the time of uncovering the vines, it was observed that all of the part of the canes that was covered was plumper and seemed to contain more sap. Slight injury was done to the shoots by the frost of April 24. On March 1, 1914, the dirt was plowed away from the vines. Starting on the 10th the vines were uncovered. From April 1 to the 6th the pruning of the vines was done. On June 1 a hail storm did considerable damage to the crop. It was estimated that the crop was reduced by one-fifth to one-fourth. The winter treated vines, however, gave the largest yield, as is shown by the following table:

Yield for 1914.

Plat No.	How Treated	Muscat of Alexandria				New Mexico Mission				Black Cornichon			
		No. of Vines in Plat	Actual Yield per Plat, lbs.	Average Yield per Vine, lbs.	Computed Yield per Acre (680 vines), lbs.	No. of Vines in Plat	Actual Yield per Plat, lbs.	Average Yield per Vine, lbs.	Computed Yield per Acre (680 vines), lbs.	No. of Vines in Plat	Actual Yield per Plat, lbs.	Average Yield per Vine, lbs.	Computed Yield per Acre (680 vines), lbs.
1	Irrigated, not covered.....	24	108	4.50	30.0	17	24	1.41	959	12	1	0.08	54
2	Irrigated and covered.....	69	1520	22.03	1498.0	58	1286	22.17	15075	33	269	8.15	5542
3	Covered and irrigated.....	75	1088	14.51	986.7	51	993	17.71	12043	39	268	6.87	46.2
4	Covered, not irrigated.....	81	1029	21.50	8636	54	832	15.41	104.9	33	249	7.55	51.4
5	Check	63	124	1.97	1339	36	58	1.53	1040	30	10	0.33	224
6	Irrigated, not covered.....	46	103	2.24	1523	40	65	1.63	1108	29	7	0.24	103
7	Irrigated and covered.....	50	1024	20.48	13926	49	949	19.36	13164	32	265	8.28	563
8	Covered and irrigated.....	56	823	14.69	9989	50	894	17.88	12158	25	235	9.40	6392
9	Covered not irrigated.....	67	748	11.46	7793	55	675	12.27	8344	36	223	6.19	4209

Again it is seen that the plats 1, 5 and 6 of all varieties gave the smallest yields. The Muscat of Alexandria, in plats 1, 5 and 6 averaged 4.5, 1.97 and 2.24 pounds per vine, respectively; while in the early treated plats 2, 3 and 4 the average yield per vine was 22.03, 14.51 and 12.7 pounds, respectively. In the late treated plats, 7, 8 and 9, the yield was practically the same. The Mission vines in plats 1, 5 and 6 averaged 1.41, 1.53 and 1.63 pounds, respectively; while the vines treated both early and late in plats 2, 3, 4, 7, 8 and 9 averaged 22.17, 17.71, 15.41, 19.36, 17.88 and 12.27 pounds, respectively. The Black Cornichon variety seemed to be the lightest yielder. None of the plats corresponding with those of the Muscat of Alexandria and Mission produced nearly the same amount.

The uncovered Black Cornichon vines in plats 1, 5 and 6 averaged .08, .33 and .24 pound, respectively, while the yield from the early and late treated vines was fairly uniform and much larger, varying from 9.4 pounds in plat 8 to 6.19 pounds in plat 9. Plats 2 and 7, irrigated and covered, in the Muscat of Alexandria and Mission blocks, gave quite a material increase in yield over plats 3, 8, 4 and 9, covered and irrigated, and covered and not irrigated, respectively. Plats 3 and 8, covered and irrigated, also show a larger yield per vine over plats 4 and 9. In this case there is a slight indication that the irrigation of the vines had some slight influence on the yield. The same is true, in a general way, with the Black Cornichon with the single exception of plat 3, covered and irrigated, which dropped slightly below plat 4, covered and not irrigated. On the whole, taking the three varieties, the irrigated and covered vines produced a larger yield than those covered and irrigated and than the covered and not irrigated vines. The two or three weeks' difference in time of treating plats 2, 3, 4, 7, 8 and 9 did not show any material influence on the yield. Apparently the covering of the vines, if done reasonably early, is the most important factor in the practice of winter treatment.

Figure 5. A covered vine. Last operation.

From October 15 to 20, 1914, the tying of the grape canes was done. Plats 1 and 2 were irrigated October 30. On November 4 the middles were plowed and from the 5th to the 8th plats 2, 3 and 4 were covered. Plats 6 and 7 were irrigated November 20 and the middles were plowed on the 24th. From the 24th to the 29th plats 7, 8 and 9 were covered. The winter of 1914-'15 proved to be very mild. The coldest temperature recorded at the plats was ten degrees above zero on December 10, 1914. Aside from the winter being mild it was quite rainy.

The rainfall for November and December, 1914, and January and February, 1915, was .56, 4.0, .86 and .67 inches, respectively.

The large amount of moisture during the winter seems to have been a favorable factor in the prevention of the winter killing of the grape vines. Even on the unprotected vines there were only a few of the canes that were injured, while those on the protected plats were full of sap and quite plump at the time of pruning, April 6, 1915. On February 23, the dirt was plowed away from the vines. On March 10 to 13 the vines were uncovered. From April 6 to the 10th they were pruned. The spring was very favorable. There were no low temperatures during the spring and a heavy crop was set on all the vines. The following table gives the yields for 1915:

Yield for 1915.

Plat No.	How Treated	When Treated	Muscat of Alexandria				New Mexico Mission				Black Cornichon			
			No. of Vines in Plat	Actual Yield per Plat, lbs.	Average Yield per Vine, lbs.	Computed Yield per Acre (680 vines), lbs.	No. of Vines in Plat	Actual Yield per Plat, lbs.	Average Yield per Vine, lbs.	Computed Yield per Acre (680 vines), lbs.	No. of Vines in Plat	Actual Yield per Plat, lbs.	Average Yield per Vine, lbs.	Computed Yield per Acre (680 vines), lbs.
1	Irrigated, not covered.....	Early	21	178	8.48	5766	17	201	11.82	80.8	13	29	2.23	1516
2	Irrigated and covered.....	Early	55	1310	23.77	16163	58	1360	23.44	15939	83	245	7.42	5045
3	Covered and irrigated.....	Early	59	1579	26.76	18.97	51	1099	21.54	14647	37	334	9.03	6140
4	Covered, not irrigated.....	Early	58	1612	27.79	18897	55	1220	22.18	15082	33	354	10.12	7289
5	Check .....	.....	49	474	9.67	6576	43	247	5.74	3903	58	79	1.36	924
6	Irrigated, not covered.....	Later	36	329	9.14	6205	45	222	4.93	3352	29	62	2.14	1455
7	Irrigated and covered.....	Later	37	1021	27.59	18761	52	1515	29.13	15808	34	388	11.41	7759
8	Covered and irrigated.....	Later	44	635	14.43	9812	52	983	18.90	12852	28	264	9.43	6412
9	Covered, not irrigated.....	Later	56	935	16.69	11349	55	878	15.96	10853	34	380	11.17	7595

By observing the table it will be noticed that even the unprotected plats 1, 5 and 6 produced a fairly good crop. This was due mostly to the fact that the vines were not winter injured and the new sprouts grew from buds on the previous year's canes. In the Muscat of Alexandria block, plats 1, 5 and 6 averaged 8.48, 9.67 and 9.14 pounds per vine, respectively. In the Mission block the same plats averaged 11.82, 5.74 and 4.93 pounds per vine, respectively. In the Black Cornichon, the same plats averaged materially less per vine, being 2.23, 1.36 and 2.14 pounds, respectively. Again it is noticed that the vines treated early in the season did not average, on the whole, any larger yields than those in plats 7, 8 and 9, treated later in the season. It is also to be noticed that the irrigation either before or after covering the vines did not have, apparently, any material influence on the yield. For example, the Muscat of Alexandria block, plat 4, covered and not irrigated, averaged slightly higher per vine than plats 2 and 3; while plat 7, irrigated and covered, averaged practically the same as plat 4. In the New Mexico Mission block the vines in plat 4, covered but not irrigated, averaged slightly more than those in plat 3, covered and irrigated, and considerably more than those in plat 8, but less than the vines in plats 2 and 7, irrigated and covered.

This table again shows that the Black Cornichon is not as heavy a yielder as either the Muscat of Alexandria or the New Mexico Mission. The maximum average per vine on any of the Black Cornichon blocks was 11.41 pounds in plat 7, irrigated and covered; the maximum yield, per vine, of the Muscat of Alexandria was 27.79 pounds in plat 4, covered and not irrigated, while the New Mexico Mission on plat 7 averaged 29.13 pounds per vine.

By examining the table it is noticed that the Black Cornichon vines in plats 4 and 9, covered but not irrigated, averaged slightly higher than the vines on plats 2 and 7, and on 3 and 8. From these results it appears quite clear that the irrigation be-

fore covering or after covering does not necessarily have any material influence upon the yield, as long as the vine had been properly covered. It is noticed that in some cases the vines covered and not irrigated averaged higher yields than the others.

Figure 6. Plowing dirt away from the vines in spring.

Attention is also called to the fact that the covering of the vines with moist soil did not injure the canes, nor did the irrigation of the vines after they were covered injure them. A theory has prevailed among the old native vineyardists that the covering of the vines with moist soil or irrigating them after covering made the canes more susceptible to injury. The results obtained at the Station did not substantiate this theory. From the farm practice point of view, where the vineyard is growing on a good grape soil (sandy or sandy loam) it will be easier to plow the soil and cover the vines if the ground is first irrigated. As a rule, in the carrying out of these investigations the soil could be plowed in three to four days after the plats were irrigated. The irrigation of the plats which were irrigated after being covered was done immediately after the vines were covered. From the results obtained it is quite plainly brought out that the irrigation of the vines when not cov-

ered did not reduce the percentage of injury to the canes enough to justify that operation.

COST.

The covering of the grape vines is considered by some vineyardists too expensive to be practiced. For that reason some grape growers do not bank up the vines in the fall, resulting oftentimes in the canes being winter killed back to the old stump. In banking up vineyards there are from two to four operations necessary in the work, which are illustrated by figures 1, 3, 4 and 5.

First Operation: Just as soon as the first light frost occurs in the fall it is a good thing to go over the vines, gather in the canes and tie them either with one of the canes themselves or with some twine or baling wire. (See Fig. 1.) This operation has taken, on the experimental plats, sixty-four hours to tie up 1,072 grape vines six to seven years old. The actual cash outlay depends on how much is paid the laborers. At the Station it has cost an average of \$6.50 or at the rate of \$4.08 per acre.

While the vines may not be winter killed every winter it is important to protect them every fall, for the reason that the vineyardist will never be able to tell during which winter the vines will be injured. The covering of the vines is like insurance on a house: we need it but once. So it is with the vineyard. The vineyard may go two or three years before it is injured but when it is winter killed it is a great loss to the vineyardist. Sometimes the vines are materially injured by the late spring frosts. The spring frosts do not seem to hurt the old canes but they do kill the young shoots. If the spring temperature happens to be severe and late enough to kill all the shoots which have sprouted from the buds after pruning, the plant puts out new shoots mostly from adventitious buds and in many cases these shoots start from the ground. Any injury of this kind causes a great deal of loss and expense to the grape

grower. If the vines are winter killed and if they are materially injured by the spring frosts, then the grape grower has, in many cases, to start a new central stem or stump on which to build up the scaffold of the vine.

The second operation is either the irrigating or the plowing of the soil just before the banking up of the plants. This may be done one, two or three weeks after the tying up of the canes. It depends somewhat upon the local weather conditions. As a rule at the Station this work was done about the first week in November. The plowing of the vineyard may be done either when the soil is dry or wet. On good grape soil, which varies from sandy loam to very sandy, it is preferable to irrigate the vineyard a few days before plowing. (See Fig. 3.) By having the soil in a moist condition it can be plowed up to the vine to better advantage and it is also easier to handle in banking up the vines. If the soil happens to be a heavy adobe and if it is irrigated it must be done quite a while before plowing. If it is not irrigated and it happens to be very dry it will break up in a very rough condition with many large clods, making it very hard to handle in banking up the vines. The time required to plow the middles one way in the vineyard at the Station was, as a rule, from nine to ten hours (See Fig. 4), costing 75c to \$1.00 per acre, if the horse-labor is not taken into consideration.

Last Operation: Just as soon as the soil is plowed, the banking of the vines is started. This is probably the most tedious and most expensive operation in the practice of winter protection. In plowing the soil the vine is partially banked but since the mound or hill of earth should be eight to twelve inches above the old stump of the vine it is necessary to finish the banking either with a hoe or a long handled shovel. The latter is preferable, though many of the native laborers are very handy with an ordinary hoe. The banking of the vines is simply the building up of a conical mound of earth around the grape vine. Its height depends on the size of the vine. As a

rule, however, eight or twelve inches of the new canes above the old stump are covered. (See Frontispiece.) In the banking of the 1,072 vines in the Station experimental vineyard, the time averaged seventy-eight hours of work, costing from \$7.80 to \$8.00, or at the rate of \$5.00 per acre.

During the winter there is nothing to be done to the vineyard. The results from these experiments indicate that it is a good practice to start the uncovering of the vines probably a month before they are pruned in the spring. It appears that if the vines are not uncovered early, the base-buds of the canes begin to swell and are liable to burst earlier than the buds on the canes which are exposed to the air. It is not desirable to have the vineyard start growing early in the spring. The longer it is delayed in starting to grow the better. For this reason it is believed that vineyards should be uncovered from three to five weeks before they are pruned. In the uncovering of the vines the work may be done easier and cheaper by plowing the dirt away from the vines first, getting as close to the vines as possible with the plow. After the dirt has been partially removed from the vines by the plow, it is allowed to stay in this condition for a week or two. At the end of this period the rest of the dirt is removed from around the vines. If it is desired, an acme harrow or an evener may be run through the middles to level the soil. In a week or two the pruning follows.

The cost of plowing away the dirt is no more than that of plowing the dirt to the plants in the fall. The cost of removing the dirt from the vines after plowing is considerably less than the finishing up of the mound in the fall. At the Station it has averaged about \$2.50 per acre.

PROPAGATION.

Vineyards are started by cuttings. These may be rooted or not. The amateur, however, will have better success in starting his vineyard with rooted cuttings. Such cuttings may

Figure 7. As the vine looks after plowing in spring.

be rooted by the grower himself or they may be bought from the nurseries. If the cuttings are to be rooted by the grower they must be taken either in the fall and hilled-in or in the spring. In any event they should be planted in the spring in nursery rows where good care may be taken of them. The following spring they are transplanted to a permanent place in the vineyard. In case the vineyard is started without rooting the cuttings it is customary to plant two in each hole. The most common distance to plant vines is 8 by 8 feet, making approximately 680 vines per acre.

SOILS.

The best soils are sandy or sandy loam. The heavy soils are not desirable for best results with grapes. The grape will grow on poorer soil than almost any other fruit and as a rule it will not require much artificial fertilizer. The grape vine is a more drought resisting plant than almost any other fruit and consequently it will require less irrigation, especially when planted on good grape soil. At the Station the vineyard is irrigated usually from four to six times during the year.

VARIETIES.

In Station Bulletins Nos. 58 and 85, some reference is made to the varieties best adapted to our irrigated valleys and basins. In these bulletins the following varieties are mentioned as satisfactory:—

Early Varieties: Chasselas de Fontainebleau, Chasselas Rose, and Thompson's Seedless.

Mid-Season Varieties: Black Hamburg, Muscat of Alexandria, New Mexico Mission and Purple Damascus.

Late Varieties: Black Cornichon, Flame Tokay, Gros Coleman and Black Ferrara.

A good collection, ripening in succession, would be the following: Chasselas de Fontainebleau, Thompson's Seedless, Black Hamburg, Muscat of Alexandria, New Mexico Mission, Black Cornichon, Flame Tokay and Black Ferrara.

PRUNING.

The present system of pruning the vinifera grape in New Mexico is that known as the stump system. After the vine has been properly started and the stump has been established, the cane is pruned back each year to two or three buds. From each of these buds a shoot will develop in the spring and, as a rule, on each shoot there may be from one to three grape bunches. The more buds left on the pruned cane the more shoots will grow, and for best results, as far as good-sized bunches and good-sized berries are concerned, it is best not to have too many

shoots growing from the pruned canes. Figure 8 gives a good idea of the way the vine looks after it is pruned. Notice how severely the grape vine is pruned. Probably no other fruit is pruned so severely.

Figure 8. A well trained and developed stump. (Bul. 58).

The time of pruning is quite a common question among vineyardists. This is an important matter, too, and as has already been said, because of the susceptibility of young shoots to frost injury, it is necessary to delay pruning as long as possible in the spring. If the pruning is done early in the season, some of the buds at the base of the cane may start a little earlier than if the pruning is delayed as late as possible in the spring. However, it should not be delayed until the base-buds are beginning to grow, because they are very brittle and are liable to be broken off when the cane is being pruned.

The cost of pruning may vary considerably, depending on the condition of the vineyard, as to whether it has been properly cared for and properly pruned in the past. It depends also upon whether or not any of the old canes have died. In the

Figure 9. After the vine is uncovered and before pruning.

carrying out of these experiments the pruning has cost from \$3.00 to \$3.75 per acre.

SUMMARY.

1. The vinifera grape is not as resistant to winter temperatures as the native varieties, and is more or less subject to winter injury.

2. The results at the Station clearly show that the simple banking up of the dirt around the vines protected them during the winter, and the yields were very satisfactory. On the other hand, the unprotected vines were winter injured every time ex-

cept once, when there was considerable rainfall during the winter.

3. The Emperor and Flame Tokay were slightly less hardy to the winter temperatures than the Black Cornichon; while the Muscat of Alexandria and the New Mexico Mission were more resistant than any of the other varieties tried.

4. The irrigating of the vines alone and not covering them did not prevent the winter killing of the canes. There were just as many vines winter injured in the irrigated plats as there were in the non-irrigated ones.

5. The vines that were irrigated either before or right after covering, did not, on the whole, show any material advantage over those that were covered and not irrigated. In some cases the covered and not irrigated plats gave as large a yield as the irrigated ones.

6. The irrigation either before or after covering did not make the vines any more susceptible to winter injury. The old idea that covering the vines with moist soil tends to make them less hardy was not substantiated by the experimental data obtained.

7. The irrigation of the land just before covering makes the plowing of the middles and the banking of the vines easier. This is particularly true in good grape soils—sandy soils.

8. There are two to four operations necessary in the banking up of the plants: the gathering and tying of the canes; the irrigating of the ground; the plowing of the middles; and the building of the mound. The tying up of the canes may be done any time after the crop has been gathered, usually just before or right after the first frost. The irrigation of the land, if it is irrigated, may be done after all the leaves have fallen, usually from ten to fifteen days after the tying up of the canes. The plowing of the middles may be done from four to eight days after the irrigating. The time depends upon the character of the soil. The lighter the soil the quicker the plowing

may be done. Immediately after the plowing of the middles the vines are covered. The size of the mound depends upon the size of the vines. The mound should be high enough to cover about twelve inches of the current year's growth above the old stump.

9. In the uncovering of the vines the dirt is first plowed away from the plants. What dirt the plow leaves around the plant is pulled away either with a hoe or shovel.

10. Observations at the Station indicate that it is a good plan to uncover the vines from two to four weeks before the pruning takes place. If they are left covered until pruning time there is danger of the base-buds on the canes starting to grow. If this happens many of them may be injured while the vines are being uncovered or when they are being pruned.

11. Delay the pruning of the vines as late as possible in the spring. At the Station the pruning is usually done the first week in April.

12. The two or three weeks' difference in time of covering the first and second series of plats did not show any material influence on the yield. However, it is advisable to cover the vines early, that is, from two to three weeks after the first frost.

13. The best grape soil is sandy to a sandy loam. The heavy soils are not desirable, for best results with grapes.

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**New Mexico College of Agriculture
And Mechanic Arts**

**AGRICULTURAL EXPERIMENT STATION
STATE COLLEGE, N. M.**

Feeding Range Steers

By Luther Foster and H. H. Simpson

New Mexico Agricultural Experiment Station

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STEER FEEDING

INTRODUCTION

This bulletin gives the results of two experiments conducted in 1909 and 1910, at a time when but little attention was being given to livestock feeding by farmers of this State, but the work was carried on in anticipation of conditions that prevail today, when both livestock growers and farmers are making inquiry into the feasibility of feeding on New Mexico farms a part of the steers produced on the ranges of the State—at least a sufficient number to supply the local demands for beef.

These results tend to answer the questions concerning the relation of feeds to gains and the comparative values of the different home-grown crops for feeding; also the most economical proportions in which to feed these crops for satisfactory results. Grains of different kinds, for example, do not grow equally well in all parts of the State. Barley gives best results in some localities where the altitude is too high and the season too short for growing a corn crop. Again, in the dry-farming portions kafir, milo, feterita and other non-saccharine sorghums stand the effects of drouth better than other crops, mature in less time, and are, for these reasons, the best crops for those localities. While the results of these feeding experiments are not conclusive, they give a decided indication as to what results farmers may expect to get in feeding the principal grain and forage crops of the State to range steers.

EXPERIMENT NO. 1.

January 8, 1909, to April 8, 1909; 91 days.

In this experiment a comparison was made of the feeding values of barley, Indian corn, and kafir corn, each being supplemented with cottonseed meal.

A comparison was also made of the values of corn stover and kafir corn stover for replacing a definite portion of a roughage ration of alfalfa.

Another object of the experiment was to determine the effect of substituting a comparatively cheap roughage for a part of the high priced alfalfa hay; on the gains, the cost of the gains and the quality of the product.

Inquiries are frequently made as to the values of barley and kafir corn as compared with corn, for stock feeding. Tests have been run at other Stations and a general idea of their comparative values has been determined; but whether this would apply to feeding operations in New Mexico under entirely different conditions, where alfalfa is and will likely continue to be the chief roughage, is a question that

Typical New Mexico range yearlings.
(Lot I, at beginning of experiment No. 1).

can only be answered by actual trial. If New Mexico is to become important as a feeding center, if even only a portion of the large number of range cattle that are raised here are to be fed out at home, then such crops as barley, kafir, and al-

falfa will have to be depended upon largely as the general feeds.

The business of fattening steers may become profitable through furnishing a market for home-grown feed crops, concentrating the bulky farm products into minimum space for shipment, and leaving their fertilizing value on the farm.

At this time, when feeding stuffs and cattle are both high in price and there is a very small margin between the prices of feeders and finished cattle, great care will need to be taken in the choice of the feeds, the management, and the selecting of steers for feeding, if the feeder is to make a profit.

In order to get some information that could be used as a guide for farmers in regard to steer feeding in New Mexico, this experiment and others were undertaken.

Steers of Lot I at close of experiment No. 1. This lot received a daily ration that averaged 20 pounds of choice alfalfa hay, 8 pounds of ground barley, and 2 pounds of cottonseed meal per head.

Lot II at the close of experiment No. 1. During the 91 days of the experiment, this lot received a daily ration that averaged 20 pounds of choice alfalfa hay, 8 pounds of ground corn, and 2 pounds of cottonseed meal per head.

THE TEST

Twenty-five high grade yearling steers were secured from a range in the vicinity of Las Cruces, and delivered to the Station in December, 1908. They were good representative range animals, 20 being high grade Herefords and 5 grade Shorthorns. One Shorthorn and 4 Hereford steers were put in each lot. The steers were fed on roughage—oat hay and alfalfa hay—until January 8, when the experiment started.

Lot III, at close of experiment No. 1. During the 91 days this lot received a daily ration that averaged 20 pounds of choice alfalfa hay, 8 pounds of ground kafir, and 2 pounds of cottonseed meal per head.

FEEDING

The various lots were fed as follows:

Lot I.	Alfalfa Hay	20 lbs. per day
	Ground Barley	8 lbs. per day
	Cottonseed Meal	2 lbs. per day
Lot II.	Alfalfa Hay	20 lbs. per day
	Ground Corn	8 lbs. per day
	Cottonseed Meal	2 lbs. per day
Lot III.	Alfalfa Hay	20 lbs. per day
	Ground Kafir	8 lbs. per day
	Cottonseed Meal	2 lbs. per day
Lot IV.	Alfalfa Hay	10 lbs. per day
	Shredded Corn Stover	10 lbs. per day
	Ground Kafir	8 lbs. per day
	Cottonseed Meal	2 lbs. per day
Lot V.	Alfalfa Hay	10 lbs. per day
	Shredded Kafir Corn Stover	10 lbs. per day
	Ground Kafir	8 lbs. per day
	Cottonseed Meal	2 lbs. per day

A part of the steers of Lot IV at the close of experiment No. 1. This lot received a daily ration that averaged 10 pounds of choice alfalfa hay, 10 pounds of shredded corn stover, 8 pounds of ground kafir, and 2 pounds of cottonseed meal per head.

Each lot was started on 5 pounds grain per head per day and the quantity was gradually increased as the fattening period advanced. All lots received the same allowance each day. They had all the roughage they would clean up. Lots IV and V received corn stover and kafir stover, respectively, as one-half their roughage allowance. The grain was fed in two feeds per day.

The feeds used in the experiments reported in this bulletin are estimated at the following prices: Indian corn, kafir corn and barley \$30.00 per ton; cottonseed meal \$35.00 per ton; choice alfalfa hay \$10.00 per ton; corn stover and kafir corn stover, both shredded, at \$6.00 per ton. With the exception of the cottonseed meal, these feeds were either raised on the Station farm or purchased from local farmers. These prices closely approximate the prices at which the different feeds could have been secured during the past three years, if purchased at a favorable time of the year. During the feeding season just past, for the first time milo maize and kafir

Four of the steers of Lot V at close of experiment No. 1. This lot received a daily ration that averaged 10 pounds of choice alfalfa hay, 10 pounds of shredded corn stover, 8 pounds of ground kafir, and 2 pounds of cottonseed meal per head.

were delivered at the railroad stations in this Valley at \$20.00 per ton. Should this price continue, it will have a favorable effect on the stock feeding problems of this part of the State.

Bloating.—Considerable trouble was experienced from bloating at various times. This did not occur until after the steers had been on feed for about seven weeks. Only certain ones seemed to be affected and it usually came on in the morning after they had been watered and as soon as they began to eat their grain feed. By taking the bloated ones out of the lot and exercising them vigorously for a few minutes, they would become all right and it was never necessary to use the trocar to relieve any of them.

TABLE 1.—WEIGHTS AND GAINS BY WEEKLY PERIODS.

Date	Lot I.		Lot II.		Lot III.		Lot IV.		Lot V.	
	Alfalfa, Ground Barley, and Cottonseed Meal.		Alfalfa, Ground Corn, and Cottonseed Meal.		Alfalfa, Ground Kafir, and Cottonseed Meal.		Alfalfa, Ground Kafir, Corn Stover, and Cottonseed Meal.		Alfalfa, Ground Kafir, Kafir Corn Stover, and Cottonseed Meal.	
	Weight	Gain,	Weight	Gain,	Weight	Gain,	Weight	Gain,	Weight	Gain,
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Jan. 8	2992		2978		2902		2925		3017	
Jan. 15	2840	—152	2892	—86	2763	—139	2890	—35	2925	—93
Jan. 22.	2935	95	2958	66	2855	92	2915	25	2957	32
Jan. 29.	2967	32	2927	—31	2892	37	2930	15	2945	—12
Feb. 5.	3147	180	3125	198	2977	85	3050	120	3120	157
Feb. 12	3212	65	3193	68	3046	69	3113	63	3155	53
Feb. 19.	3270	58	3289	96	3244	198	3197	84	3227	72
Feb. 26.	3421	151	3389	109	3283	39	3297	100	3330	103
Mar. 5.	3525	104	3518	120	3337	54	3383	86	3402	72
Mar. 12.	Did not weigh on account of heavy snow storm.									
Mar. 19.	3745	220	3665	147	3574	237	3558	175	3603	201
Mar. 26.	3735	—10	3760	95	3630	56	3620	62	3665	62
Apr. 2.	3865	130	3837	77	3718	88	3643	23	3797	132
Apr. 9.	3918	53	3938	101	3788	70	3840	197	3837	40

TABLE 2.—SHOWING GENERAL RESULTS OF TEST.

	Lot I	Lot II	Lot III	Lot IV	Lot V
	Alfalfa, Ground Barley, and Cottonseed Meal.	Alfalfa, Ground Corn, and Cottonseed Meal.	Alfalfa, Ground Kafir, and Cottonseed Meal.	Alfalfa, Shredded Corn Sto- ver, Ground Kafir, and Cot- tonseed Meal.	Alfalfa, Shredded Kafir Corn Stover, Ground Kafir, and Cottonseed Meal.
Weight at beginning, lbs.....	2992	2978	2902	2925	3017
Weight at close, lbs.	3918	3938	3788	3840	3837
Total gain (5 steers), lbs.	926	960	886	915	820
Average gain per head, lbs.	185	192	177	183	164
Average daily gain per head, lbs.	2.04	2.11	1.95	2.01	1.84
Ground Barley fed, lbs.	2836				
Ground Corn fed, lbs.		2843			
Ground Kafir fed, lbs.			2808	2858	2832
Cottonseed meal fed, lbs.	709	711	702	692	708
Alfalfa hay fed, lbs.	6642	6870	6665	3616	3830
Corn Stover fed, lbs.....				3867	
Kafir Stover fed, lbs.....					3950
Average daily concentrate per head, lbs...	7.79	7.81	7.71	7.80	7.78
Average daily roughage per head, lbs.....	14.59	15.09	14.65	16.45	17.09
Concentrate fed per pound of gain, lbs....	3.83	3.79	3.96	3.88	4.32
Roughage fed per pound of gain, lbs.....	7.17	7.16	7.52	8.18	9.49
Cost per pound of gain	9.52c	9.32c	9.90c	9.25c	10.47c

TABLE 3.—FINANCIAL STATEMENT.

As an illustration to indicate what returns may be expected from steer feeding at the present time, the following financial statement is made. The prices for feeds used are approximately those that have prevailed during the past three years. The steers were such as could have been bought during the past two or three years at about \$35.00 per head, or \$5.90 per hundredweight.

LOT 1. GROUND BARLEY, COTTONSEED MEAL, AND ALFALFA HAY.

Value of 5 steers, weight 3918 lbs., at \$8.00 per hundred-weight, at close of experiment				\$313.44
Value of 5 steers, weight 2992 lbs., at \$5.90 per hundred-weight, at beginning of experiment			\$176.53	
Cost of 2336 lbs. of Ground Barley, at \$30.00 per ton....	\$42.54			
Cost of 709 lbs. of Cottonseed Meal, at \$35.00 per ton.	12.41			
Cost of 6642 lbs. of choice Alfalfa Hay, at \$10.00 per ton.	33.21	88.16		
At the beginning of the experiment this lot weighed 29 lbs. more than the average for the five lots. Since the margin of \$2.10 per hundredweight between the buying and selling prices was received on this excess, there is deducted from the profit			.61	265.30
Profit on lot, due to feeding				\$ 48.14

LOT II. GROUND CORN, COTTONSEED MEAL, AND ALFALFA HAY.

Value of 5 steers, weight 3938 lbs., at \$8.00 per hundred-weight, at close of experiment				\$315.04
Value of 5 steers, weight 2978 lbs., at \$5.90 per hundred-weight, at beginning of experiment			\$175.70	
Cost of 2843 lbs. of Ground Corn, at \$30.00 per ton....	\$42.65			
Cost of 711 lbs. of Cottonseed Meal, at \$35.00 per ton	12.44			
Cost of 6870 lbs. of choice Alfalfa Hay, at \$10.00 per ton	\$34.35	89.44		
Margin of \$2.10 per hundredweight on 15 pounds, which this lot weighed more than the average for the five lots			.32	265.46
Profit on lot, due to feeding				\$ 49.53

 LOT III. GROUND KAFIR, COTTONSEED MEAL, AND ALFALFA HAY.

Value of 5 steers, weight 3788 lbs., at \$8.00 per hundred-weight, at close of experiment		\$303.04	
Margin of \$2.10 per hundredweight on 61 pounds, which this lot weighed less than the average for the 5 lots		1.28	\$304.32
Value of 5 steers, weight 2902 lbs., at \$5.90 per hundred-weight, at beginning of experiment		171.22	
Cost of 2808 lbs. of Ground Kafir, at \$30.00 per ton	\$42.12		
Cost of 702 lbs. of Cottonseed Meal, at \$35.00 per ton	12.29		
Cost of 6665 lbs. of choice Alfalfa Hay, at \$10.00 per ton	33.33	87.74	258.96
Profit on lot, due to feeding			\$45.36

 LOT IV. GROUND KAFIR, COTTONSEED MEAL, ALFALFA HAY, AND SHREDDED CORN STOVER.

Value of 5 steers, weight 3840 lbs., at \$8.00 per hundred-weight, at close of experiment		\$307.20	
Margin of \$2.10 per hundredweight on 38 pounds, which this lot weighed less than the average for the 5 lots		.80	\$308.00
Value of 5 steers, weight 2925 lbs., at \$5.90 per hundred-weight, at beginning of experiment		\$172.58	
Cost of 2858 lbs. of Ground Kafir, at \$30.00 per ton	\$42.87		
Cost of 692 lbs. of Cottonseed Meal, at \$35.00 per ton	12.11		
Cost of 3616 lbs. of choice Alfalfa Hay, at \$10.00 per ton	18.08		
Cost of 3867 lbs. of Shredded Corn Stover, at \$6.00 per ton	11.60	84.66	257.24
Profit on lot, due to feeding			\$ 50.76

 LOT V. GROUND KAFIR, COTTONSEED MEAL, ALFALFA HAY, AND SHREDDED KAFIR STOVER.

Value of 5 steers, weight 3837 lbs., at \$8.00 per hundred-weight, at close of experiment			\$306.96
Value of 5 steers, weight 3017 lbs., at \$5.90 per hundred-weight, at beginning of experiment		\$178.00	
Cost of 2832 lbs. of Ground Kafir, at \$30.00 per ton	\$42.48		
Cost of 708 lbs. of Cottonseed Meal, at \$35.00 per ton	12.39		
Cost of 3830 lbs. of choice Alfalfa Hay, at \$10.00 per ton	19.15		
Cost of 3950 lbs. of Shredded Kafir Stover, at \$6.00 per ton	11.85	85.87	
Margin of \$2.10 per hundredweight on 54 pounds, which this lot weighed more than the average for the five lots		1.13	265.00
Profit on lot, due to feeding			\$ 41.96

At the prices given above the farmer would receive good returns for his surplus crops and a fair profit in addition. The value of the manure would, no doubt, in many cases offset the cost of the labor involved in the feeding; and in some instances might also cover the cost of grinding the grain. The returns on the last three lots,—fed kafir corn,—would be greater still if figured at the present price of this feed, viz., \$20.00 per ton; and the advantage would be decidedly in favor of the kafir fed lots and would make steer feeding a more attractive proposition than formerly. The profit on Lot III would be increased to \$59.40; on Lot IV to \$65.05; and on Lot V to \$56.12.

At the time this experiment was conducted, the prices of both feeders and beef cattle were very low, while feed prices did not differ materially from the present. Figuring the results from the prices actually paid for the steers and feed at the time, and that received for the finished product, every lot was fed at a loss. The cause of this was very plain, and showed that with the high prices paid for feeds, a greater margin between cost and selling prices was needed in order to make steer feeding profitable. The steers cost \$17.00 per head, which was \$3.21 per hundred pounds, and they sold at \$4.00; the proposition being handled on a margin of 79 cents per hundredweight. As the steers made fairly good average gains, ranging from 1.80 to 2.11 pounds per head per day, it shows that the loss was due to the high cost of feed and small margin between the buying and selling prices.

WASTE

In the comparisons of the coarse feeds, the refuse or waste is an important consideration. Taking all the alfalfa hay fed to the five lots, the refuse amounted to an average of only 2.5 per cent, while of the corn stover fed to a single lot 26.8 per cent was rejected; and of the kafir stover the refuse was 18.9 per cent. In feeding different kinds of coarse feed a certain quantity of waste is considered legitimate, depending on the character of the roughage. One would naturally expect a very much larger amount of refuse from stover than from hay. The roughage is usually the element of the ration of which the steer is given all that he will eat, the quantity being governed by the quantity and quality of what is rejected. The quality of the two kinds of stover fed seemed practically the same, but the steers ate the kafir stover with greater relish and rejected a very much smaller percentage of it, as shown by the statement above. Comparing the stover with the alfalfa hay at the relative prices of \$6.00 and \$10.00 per ton, and taking into account the waste less 2.5 per cent on all, the corn stover actually eaten would have cost \$7.92 per ton and the kafir stover \$7.18.

It will be observed that this experiment gives data covering three questions, viz., first, as to the comparative feeding values of ground corn, ground barley, and ground kafir for fattening steers; secondly, as to the substitution of a cheaper roughage for a portion of the alfalfa hay; and thirdly, a comparison of kafir corn stover with corn stover for this purpose. Keeping these three things in mind, the first three lots of the experiment should be studied together and the last three lots together.

SUMMARY

1. It required 103.4 pounds of ground barley to produce as much gain as 100 pounds of ground corn; showing barley to be 3.3 per cent below corn in feeding value.

2. It required 107 pounds of ground kafir corn to produce as much gain as 100 pounds of ground corn, indicating that kafir corn is about 6.6 per cent below corn in feeding value.

3. It required 103.5 pounds of ground kafir corn to produce as much gain as 100 pounds of ground barley, indicating that kafir corn is about 3.4 per cent below barley in feeding value.

4. The above results in which the grains alone were considered show corn to be superior to either of the other grains as a concentrate, but this is largely overcome for barley, and partially so for kafir, by the larger quantity of alfalfa hay used by the corn fed lot than by either of the other two.

5. Considering the last three lots, replacing about one-half the alfalfa hay with corn stover resulted favorably, increasing the gains 3.3 per cent and producing them at sixty-five cents per hundred pounds less. The substitution of kafir stover reduced the gains 7.4 per cent and made them cost fifty-seven cents per hundredweight more.

6. The substitution of corn stover for a part of the alfalfa hay increased the feeding value of the ration, while the substitution of the kafir stover decreased it, and it required 12 per cent less of the corn stover for 100 pounds of gain.

7. The results of this experiment show that a farmer may grow for feeding purposes whichever of the grain crops tested yield the best in his locality, and are best suited to the climatic conditions. Corn, barley, and kafir are very similar in composition, barley and kafir each carrying 1.5 per cent more digestible crude protein than corn, the barley 3 per cent less digestible fat, and the kafir 2.3 per cent less. Hence their nutritive values differ but little. Corn is the most

palatable of the three, and kafir the least. The percentages of digestible matter in barley and kafir are practically the same—about 80 per cent; while in corn it is about 5 per cent higher. They all give good results when fed with some leguminous hay, such as alfalfa or cowpeas; but with a carbohydrate roughage such as timothy hay, corn and kafir stover, they should be supplemented with a protein-rich concentrate, such as cottonseed meal. All of the non-saccharine sorghums, including kafir, milo, and feterita, are practically equal in feeding value.

EXPERIMENT NO. 2.

January 19, 1910, to April 18, 1910; 90 Days

The object of this test was to find the most economical method of fattening range steers under prevailing New Mexico conditions and with feeds grown at home or with those most readily available.

In planning this experiment it was the idea to find the cheapest way to fatten, and with this in mind, the first question was, Can steers be fattened on alfalfa alone, or on alfalfa and corn stover, or must they have grain, and if so, what is the minimum quantity that will give satisfactory results?

Lot I at close of experiment No. 2; fed choice alfalfa hay at night and shredded corn stover in the morning.

Lat II at close of experiment No. 2; fed choice alfalfa hay alone during the whole 90-day test.

STEERS USED

The steers used were long yearlings, the same age as those used in the previous experiment, but the summer and fall of 1909 were very dry and the ranges very poor; in consequence the steers were smaller and much poorer than the average animal of that age should be; in fact, the average weights show them to be 200 pounds lighter per head than those of the year before. The steers were such as could have been bought during the past two or three years at about \$28.00 a head, or \$7.49 per hundredweight. They were of the same breeding and had run on the same range as those of the previous year. There were 16 grade Herefords and 4 grade Shorthorns. Delivery was made on the 10th of January, and until the test began on January 19, they were fed on roughage, consisting of alfalfa hay and wheat and oat hay, and were all kept together. In dividing into the different lots, one grade Shorthorn and 4 Herefords were put into each, and they were chosen according to weight, conformation, and general characteristics, in order to get the lots as equally balanced as possible.

Since some little trouble was experienced the previous year from the larger steers fighting the smaller ones away from the feed racks, it was decided that they would all have a better chance if dehorned. Consequently, on January 18 and 19, they were all dehorned with the clippers.

Steers of Lot III at close of experiment No. 2. This lot was fed choice alfalfa hay night and morning and 8 pounds of ground corn per head per day during the 90-day test.

FEEDS AND FEEDING

The lots were fed as follows:

Lot I. Alfalfa hay at night. Corn stover in the morning.

Lot II. Alfalfa hay both night and morning.

Lot III. Alfalfa hay both night and morning. 8 lbs. ground corn per head per day for the entire period.

Lot. IV. Alfalfa hay both night and morning. 10 lbs. ground corn per head per day during the last 30 days.

The alfalfa hay and stover for Lot I were fed in such quantities as the steers would clean up, the thought being to allow each lot to utilize just what it would, and not an equal quantity. The grain for Lots III and IV was fed in one feed in the morning. The feeds were purchased on the local market, although the corn used was Kansas corn, except that fed during the last ten days, which was Mexican spotted corn. The steers did not eat this as well as the other.

Some little trouble was experienced with some of the steers scouring during the first part of the test, but it never remained long. It usually came after a few days of continuous increase in the quantity of hay.

Four of the steers of Lot IV at close of experiment No. 2; fed choice alfalfa hay night and morning, and in addition, 10 pounds of ground corn per head per day during the last 30 days of the experiment.

It required only a few days to get Lot III started to eating its grain, a little less time being required than for previous steers.

TABLE 4.—SHOWING GENERAL RESULTS OF TEST.

	Lot I	Lot II	Lot III	Lot IV
	Alfalfa and Corn Stover	Alfalfa	Alfalfa and 8 lbs. of Ground Corn per head per day during the entire 90-day test.	Alfalfa during entire test; 10 lbs. Ground Corn per head per day last 30 days.
Weight at beginning, lbs.	1859	1908	1888	1821
Weight at close, lbs.	2485	2736	3051	2748
Total gain (5 steers), lbs.	626	828	1163	927
Average gain per head, lbs.	125	166	233	185
Average daily gain per head, lbs.	1.39	1.84	2.58	2.06
Alfalfa hay fed, lbs.	3155	6849	4904	6361
Corn stover fed, lbs.	3046			
Ground corn fed, lbs.			3008	976
Concentrate fed per pound of gain, lbs.			2.59	1.05
Roughage fed per pound of gain, lbs.	9.91	8.27	4.22	6.86
Cost per pound of gain	3.98c	4.14c	5.99c	5.01c

FEEDING RANGE STEERS

Lot I. Alfalfa Hay and Corn Stover.

Value of 5 steers, weight 2485 lbs., at \$8.00 per hundred-weight, at close of experiment			\$198.80	
Margin of 51c per hundredweight on 10 pounds, which this lot weighed less than the average for the 5 lots.			.05	\$198.85
Value of 5 steers, weight 1859 lbs., at \$7.49 per hundred-weight, at beginning of experiment			\$139.24	
Cost of 3155 lbs. of choice Alfalfa Hay, at \$10.00 per ton.	\$15.78			
Cost of 3046 lbs. of Corn Stover, at \$6.00 per ton.....	9.14	24.92		164.16
Profit on lot, due to feeding				\$ 34.69

Lot II. Alfalfa Hay.

Value of 5 steers, weight 2736 lbs., at \$8.00 per hundred-weight, at close of experiment				\$218.88
Value of 5 steers, weight 1908 lbs., at \$7.49 per hundred-weight, at beginning of experiment			\$142.91	
Cost of 6849 lbs. of choice Alfalfa Hay, at \$10.00 per ton.			34.25	
Margin of 51c per hundredweight on 39 pounds, which this lot weighed more than the average for the 5 lots.			.20	177.36
Profit on lot, due to feeding				\$ 41.52

Lot III. Alfalfa Hay and 8 pounds of Ground Corn per head per day during the entire 90-day test.

Value of 5 steers, weight 3051 lbs., at \$8.00 per hundred-weight, at close of experiment				\$244.08
Value of 5 steers, weight 1888 lbs., at \$7.49 per hundred-weight, at beginning of experiment			\$141.41	
Cost of 4904 lbs. of choice Alfalfa Hay, at \$10.00 per ton.	\$24.52			
Cost of 3008 lbs. of Ground Corn, at \$30.00 per ton...	45.12	69.64		
Margin of 51c per hundredweight on 19 pounds, which this lot weighed more than the average for the 5 lots			.10	211.15
Profit on lot, due to feeding				\$ 32.93

Lot IV. Alfalfa Hay during the entire test, and in addition, 10 pounds of Ground Corn per head per day during the last 30 days.

Value of 5 steers, weight 2748 lbs., at \$8.00 per hundred-weight, at close of experiment			\$219.84	
Margin of 51c per hundredweight on 48 pounds, which this lot weighed less than the average for the 5 lots			.24	\$220.08
Value of 5 steers, weight 1821 lbs., at \$7.49 per hundred-weight, at beginning of experiment			\$136.39	
Cost of 6361 lbs. of choice Alfalfa Hay, at \$10.00 per ton	\$31.81			
Cost of 976 lbs. of Ground Corn, at \$30.00 per ton.....	14.64	46.45		182.84
Profit on lot, due to feeding				\$ 37.24

SUMMARY

1. The cheapest gains were made by the alfalfa and stover, though those made by alfalfa hay alone cost very little more. The most expensive gains were made by the lot fed on a small concentrate ration during the entire period.

2. The market prices of the different lots, judged according to finish or quality, were as follows: Lot I, \$6.50; Lot II, \$7.00; Lot III, \$8.00; and Lot IV, \$7.50. These relative prices would doubtless have held in any classified market.

3. According to the classification given above, the profits per lot are in direct proportion to the cost of the gains; i. e., Lot III, whose gains were made at the highest cost, gave the largest profit; and Lot I, whose gains were made at the lowest cost, gave the least profit,—indicating that the finish required by the markets can be most readily secured by feeding a concentrate ration with alfalfa hay or other roughage.

4. Basing this statement on a comparison of the gains made by Lots II and III, it required 827 pounds of alfalfa hay to make 100 pounds of gain, or 527 pounds of corn; showing that as fed 100 pounds of corn replaced 156 pounds of alfalfa hay. At the prices given for the different feeds, 78 cents' worth of alfalfa hay replaced \$1.50 worth of corn.

5. Considering the market prices the same for Lots III and IV, the results are favorable to feeding a small concentrate ration during the whole fattening period, rather than a larger concentrate ration for a thirty-day period at the close; and the result shows still more favorably at classified market prices.

6. If sold on the local markets where no distinction is made in price on account of better finish, it may be more profitable to feed on roughage alone, particularly alfalfa hay, and make the feeding period longer; or on rough feed alone during the fore part of the period and add a grain ration only during the finishing period of thirty to sixty days.

7. The alfalfa-corn-stover lot ate the limited alfalfa hay

ration without waste, while there was 19.6 per cent of the stover rejected. The other lots rejected an average of 8.2 per cent of the alfalfa. Lot II on alfalfa alone rejected the least: 5.9 per cent. Lot III, receiving a constant grain ration, rejected the most: 11 per cent; and Lot IV, with grain the last month, rejected 8.4 per cent.

BULLETIN NO. 102
APRIL, 1916

**New Mexico College of Agriculture
And Mechanic Arts**

**AGRICULTURAL EXPERIMENT STATION
STATE COLLEGE, N. M.**

Fig. 1. Differential locust (male) at right; lesser locust (male) at left. Nearly natural size. (Original.)

GRASSHOPPER CONTROL

By D. E. Merrill

New Mexico Agricultural Experiment Station

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SUMMARY

1. Every part of the State is liable to grasshopper damage; without attention such injury will increase; preventable losses in dollars and cents are enormous; damages through occasional serious outbreaks increase the toll.
2. Damage is, in the main, from non-migratory species.
3. Natural enemies are numerous but can not be depended upon always to keep the grasshoppers in check.
4. Alfalfa, garden and truck crops, grains and young fruit trees suffer most from grasshopper attack.
5. Control is possible and practicable thru destruction of breeding places and eggs and thru destruction of the grasshoppers by poisoning or by capture with machines for that purpose.
6. For best results control measures, both preventive and remedial, should be made a part of the annual farm program and should have community enforcement.
7. Provisions should be made for compelling treatment on idle land where necessary.

INTRODUCTION

This bulletin is the outcome of investigations carried on since the summer of 1912, with the exception of the summer of 1914 when the work was practically inactive.

Most of the control experiments were carried on, necessarily, in the Mesilla Valley.

In 1915, aided by instructions from the Experiment Station, County Agents J. W. Rigney and J. W. Knorr extended the control experiments into the Pecos Valley, also, into Chaves and Eddy Counties, respectively. The important part of the data secured there is included in this bulletin.

The attempt has been made to learn sufficient concerning the principal species of grasshoppers concerned in the ravages in the State to permit of judicious direction of control methods. No attempt was made to work up data on all the Grasshoppers of the State.

Every newly developed agricultural region is liable to grasshopper damage, since the cultivated area is less than the uncultivated and since cultivated crops are quite apt to be kept in more palatable conditions for longer time than uncultivated and are massed and more readily accessible.

Since the days of the scourge of the Rocky Mountain Locust damage from grasshoppers has been confined to species native to localities or regions in which injury was done either by non-migratory or semi-migratory species, any migrations being comparatively short and local, as from higher to lower levels of land, or occasionally from nearby regions of scant vegetation to regions of greater abundance. An outbreak and the ravages in eastern New Mexico of a more or less migratory species (*Dissostertia longipennis* Thomas) have been treated of by the U. S. Department of Agriculture in Department Bulletin No. 293.

It is important to be prepared beforehand against this pest

so outbreaks may be forestalled—a wiser procedure than attempting to fight hordes allowed to breed through carelessness. In our farming regions already the damage has been considerable. As the area of crops increases the liability to damage will increase if no precautions are taken, as conditions will be ripe to favor the increase of the hoppers,—succulent feeding areas with plenty of waste ground to breed in, such as ditch banks, unkept borders of fields and roadsides and fallow land. Sod land is not much infested except at the edges.

In fact, damage will result from lax farming methods and individual carelessness. Most of our injurious species breed, live and die right in one field. Control, then becomes *personal* in its application, every man's need, an item in the individual's farm management. It must be made preventive in the main, as shown later in the bulletin.

At times the problem may become one for concerted action in a crisis, but at all times the problem is one for every farmer to consider. Crises will then be rare, indeed. If some individuals are lax, action on the part of other individuals may be necessary to get them to realize the importance of such consideration.

The information contained in the following pages will apply to the various sections of the State, irrigated, dry farmed or otherwise, although each section will need to adopt control methods to suit its needs.

To make the discussion plainer to some, perhaps, it may be stated that the terms "locust" and "grasshopper" are used synonymously. The term "locust" is applied by many to the big, noisy cicada or Harvest fly, so the above explanation will help to avoid confusion.

NATURE AND EXTENT OF INJURY

Grasshoppers belong to the group of insects that feed by consuming the substance of the plant outright. Their strong jaws enable them to eat the leaves and tender parts of the plants with astonishing rapidity. In this way large areas may be stripped clean of all but the less palatable stalks of food plants, if the number of the hoppers is great, and whole crops destroyed. This is the sort of injury that makes the person concerned take notice and call for help—usually after the damage is practically done. However, there is an enormous amount of loss every year to crops, especially alfalfa, that is never noticed due to the feeding of the hoppers that are always present in numbers somewhat below what may be called scourge proportions. The young are small and inconspicuous but they feed right along and always on choice parts of the plants. The adults may be numerous enough to eat the edges of the fields out some short distance, but still their presence is regarded as a matter of course and no steps are taken to prevent the injury. This yearly loss is thus very insidious but likely amounts to as much as the occasional lump losses during outbreaks.

In 1911 and 1912 grasshopper damage in the Animas region was rather severe. In 1912 and 1913 in the upper part of the Mesilla Valley considerable damage was done in localized areas. In the lower part of the valley in 1912 the promise was for a worse infestation the next year. A warning was not heeded and in 1913 the injury was very severe over most of the area cited. The climax seemed to be reached that season and since damage has been less. This latter condition is due also to more consideration being given the control of the pest annually. In 1914 various sections of the northern part of the State reported local injury.

In the Pecos Valley damage has been considerable since 1911, but apparently the crisis of the infestation was reached

last season, 1915, when enormous losses resulted through the Valley, in spite of the control measures applied too tardily.

The account of the outbreak of 1913 in the Elida district has been cited.

Every season reports damage from one place or another, showing the pest to be a general one over the State but showing also the damage is *local* and calls for local consideration.

SPECIES OF GRASSHOPPERS CONCERNED IN INJURY

The number of species occasioning the usual damage is not large. The following list* may lack a few kinds injurious in parts of the State where the writer has not had the opportunity to visit. Inquiries for information on grasshoppers almost always come to the Station unaccompanied by specimens, since nearly every one knows grasshoppers as such and does not stop to consider what, if any, species may be more injurious than others.

Of the list below, probably the first three occasion more damage than any others.

DESCRIPTIONS

The differential locust (*Melanoplus differentialis*) (Figs. 1 and 2) is a large species about 1 1-2 in. long with wing expanse of 2 1-2 inches. It is yellowish-green in color, there being sometimes a darker variety. The under side is a brighter yellow. The hind wings are yellowish, marked with black.

The two-striped locust (*Melanoplus bivittatus*) is nearly the same size as the above, but of a greenish-brown color, with a distinct yellow stripe on each side from eye to end of wing.

*Note. The identifications of the species listed were kindly verified by Mr. M. P. Somes, Entomologist, Mountain Grove (Missouri) Fruit Experiment Station.

Fig. 2.—Differential locust (*Melanoplus differentialis*), female, at left, male in center. At right a blister beetle (*Macrobasis longicollis*). Nearly natural size. (Original.)

The lesser locust (*Melanoplus atlantis*) (Fig. 1.) is a smaller species, one inch or less in length, of a dark grayish- or reddish-brown color. The wings are long and hind femora reddish-yellow.

The common red-legged locust (*Melanoplus femur-rubrum*) is so like the last species above that the two are difficult to separate, except on structural characters. This species is very slightly larger than the lesser locust and the hind femora are more of a red-brown color.

The three-striped locust, (*Hadrotettix trifasciatus*) is a larger species than the first two, even. It is a pale tan color with three dark bars across the wing covers and inner surface of hind legs blue.

The beautiful locust (*Schistocerca venusta*) is a larger spe-

cies than the above, and of graceful build. Its color is olive green, a white median stripe down the middle of the back, and with dark red tibia.

The buffalo locust (*Brachystola magna*) is large, clumsily built, in color usually a tan brown, and has only very short rudimentary wings. It is not often reported as injurious, but occasions inquiry on account of its remarkable size and appearance.

DISTRIBUTION

The differential locust has likely the widest distribution over the State, being found nearly always wherever farming operations are carried on, excepting in high altitudes. Its closest rival is the lesser locust. The two are apt to be found associated. Along with these the red-legged locust usually occurs, in larger or smaller numbers. The two-striped locust is found from Las Vegas southward into the Pecos Valley and south from there to the State line. It seems not to be found in the western part of the State. The buffalo locust is widely distributed at moderately high altitudes. This last season, 1915, the beautiful and the three-striped locusts were reported injurious with others in the Carlsbad region, the first reports of damage by them.

LIFE HISTORY AND HABITS

Eggs and Egg Laying

The eggs of the grasshopper are yellowish in color, longer than thick, curved and slightly tapering at ends. For the larger species the eggs are about 1-8 inch long. In later summer and fall, when the females come to maturity, they lay the eggs that are to produce the one generation each year. To deposit the eggs the female selects first a suitable place—one that has

Fig. 3.—a. Eggs of differential locust, enlarged; b. broken egg "pod", showing eggs at end. (Original.)

firm soil, neither too loose nor too hard, well drained, with not too many fine roots, but usually with coarser roots that tend to make the operation easier.

Fig. 4.—Weedy borders and edges of field. Breeding and roosting places for grasshoppers. (Original.)

Fig. 5.—Sunflowers, Russian thistles and other weeds on field ditch bank. Breeding and roosting places for hoppers. (Original.)

Ideal places are found in waste ground bordering fields, fence rows, roadsides, ditch banks, borders, fallow land, and weed patches. Fields that are cultivated are not sought for egg laying, nor are places that are too hot and moist. For the latter reason eggs are not usually found mid-field in alfalfa. Some protection from sun is usually sought. Wet and cold retard egg laying.

A spot selected, the female places the four horny processes on the tip of the abdomen to the ground and by alternate opening and closing of these and downward pushing a hole is dug in the soil as deep as the extended abdomen allows. (Fig. 6.)

Fig. 6.—Female differential locust laying eggs. Somewhat enlarged. (Author's drawing from Fig. 5 (Photograph) U. S. D. A. Far. Bul. 697.)

In this hole the eggs are laid one at a time, the abdomen being gradually withdrawn to make room as the laying proceeds. As a protection to the eggs against wetting and drying, a mucilaginous liquid is secreted with the eggs which covers the eggs, fills in between them and finally fills the mouth of the hole, when dry, making of the egg mass a roughly cylindrical curved "pod". (Fig. 3.)

The depth at which the eggs are found varies from 1 to 2 inches. Very generally 2 "pods" are laid each year by each female. The number of eggs in each "pod" varies with the species. The red-legged locust lays from 20 to 30 eggs in each "pod", the number in the second being usually less than the first. The lesser locust lays about the same. The differential locust lays from 80 to 90 eggs in the first "pod". The number has been recorded by some as high as 100. The second "pod" varies from 40 to 75.

THE YOUNG AND THEIR DEVELOPMENT

The time of appearance of the young in spring varies with the season, species and region. On first hatching they are very pale in color, but soon take on colors that resemble their surroundings. This, together with the small size, 1-8 inch to 3-16 inch, renders the young hoppers very inconspicuous, so many of them may be present and escape the notice of the casual observer until they grow considerably larger. Then one wonders where they all came from so suddenly.

Increase in size is accomplished through a series of molts, a crack appearing near the neck and the outside covering of the body being cast off. After each molt the skin is soft and somewhat elastic, but soon toughens to protect the individual until the next time for shedding. The young have only indications of wings, "pads", until after the fifth and last molt when most species gain the fully formed wings. Some species, the buffalo locust for instance, never gain more than the "pads".

In the Mesilla Valley the lesser locust and the red-legged hatch between the 15th and 25th of April and adults begin to come out after the first week in June. The differential locust hatches about a month later, adults appearing about July 1st.

Laboratory rearings of the lesser locust, taken just on

hatching out of doors, gave the average time for development as follows: From hatching to first molt 11 days; to second molt 13 days; to third molt 6 days; to fourth molt 6 days; to fifth molt, appearance of adult, 6 days; the total time being 42 days.

There seems to be considerable variation in the time required for development as young in various later stages up to last may be noted for four weeks after the first adults are seen.

For one or two days after hatching the young remain grouped near where they issued before going to feed. On cold wet days they stay quiet in such dry places as they may find. Warm sunny days bring them out to feed. Cold rains at hatching time or soon after are very disastrous to the young.

Damage by hoppers begins as soon as the young begin to feed.

ADULTS

Copulation begins a week or ten days after maturity is reached; the first eggs being laid after as many more days. The period intervening between the deposition of the two "pods" is variable. The approach of cold weather restricts activity and the adults die later in the season, none hibernating.

Wet weather in summer checks activities. Rain following continued dry weather is apt to be followed by increased activity, especially in egg laying.

The feeding habits of the adults are so well known that discussion is made only of important points. Succulent vegetation is sought so food and water may both be obtained at once. Water is also drunk outright if opportunity offers. In the insectary field hoppers may be observed to drink liberally or to eat of materials that are moist in preference to more dry food.

Coarse rank vegetation bordering feeding grounds is used as shelter in day time from sun and from bird enemies and

at night as roosting places. As a rule there is a migration out from such places in the morning, after the sun is up, to feed; a return in the heat of the day; a second outward migration in evening, and a return to roost about sundown.

If the food supply in a given local area is exhausted, or is removed, as in case of mowing alfalfa, there may be short, local migrations to new food supply. Progress during such migrations is gradual, by crawling, short jumps or short flights.

NATURAL ENEMIES AND NATURAL CONTROL

The natural enemies of grasshoppers can not be depended upon to control them in all cases because these enemies are subject to conditions varying from very favorable to decidedly unfavorable. In the latter case the grasshoppers would outrun the increase of natural enemies and a critical infestation be precipitated. This accounts for the periodicity of injurious infestations in given localities where no preventive or remedial measures are employed.

The following discussion will make possible a better utilization of natural factors in control along with artificial measures.

DISEASES

A fungus disease attacking grasshoppers kills quantities of them yearly. As the disease develops, the hoppers become sluggish and crawl to the top of vegetation and cling there tightly by the legs until dead. (Fig.7.)

Hot moist weather favors the growth and spread of the disease. Such factors can not be controlled by man, so if the conditions are right the disease operates without man's aid, if not it can not be assisted. Experimentation with the South African fungus, also, has so far been unsuccessful in the main.

Fig. 7.—Grasshoppers that have been killed by the fungus, clinging to various kinds of vegetation. (Original.)

ENEMIES OF THE ADULTS AND YOUNG

Birds are of most benefit in the destruction of grasshoppers. There are very few species that do not include grasshoppers in their summer diet. Most species of hawks, even, consume quantities. Quails, meadow larks, and blackbirds probably lead in the destruction. The much hated road-runner gulps

down huge numbers daily. In all, over a hundred species of birds are prominent as feeding on hoppers. In the Mesilla Valley, fields near breeding grounds of the blackbirds are free from grasshopper damage. Domestic poultry are fond of such food. Skunks eat masses of the hoppers.

The young of certain red mites may be found in numbers on the wings of adults and young. The young of course shed the skin and mites with them. Very little injury is done the adults by these mites for active, healthy individuals may carry from one to two hundred of the parasites and seem to suffer no inconvenience. The very young may be killed but the mites do not become very plentiful early in the season.

Certain grayish, hairy flies deposit maggots on the bodies of the hoppers. These tiny maggots go into the inside of the hopper, grow to maturity there, feeding on the tissue of the host's body. When grown they come out and go into the ground to transform to the adult. In 1913 in the lower Mesilla Valley these flies killed swarms of hoppers. Unfortunately, accident destroyed collected specimens before they could be identified as to species.

Various predaceous ground inhabiting beetles eat considerable numbers of the newly hatched young.

ENEMIES OF THE EGGS

The adults of the mites mentioned above destroy large quantities of the eggs in the ground. Larvae and adults of blister beetles (Fig. 2) are even more beneficial in this respect. The larvae of the bee-flies also infest the "pods". Several birds eat the "pods", especially when stirred out by harrowing. Skunks and mice dig out many eggs for food.

CROPS ATTACKED

As a group the grasshoppers listed in this bulletin as injurious are very general feeders if necessary. In the irrigated sections alfalfa affords the ideal food, early, succulent, plenti-

ful, and undisturbed except for periodic mowings. Annual crops or those cultivated annually suffer less, except when the stable food supply of any region is short. Small grains may suffer if not too near ripe; corn when young is often attacked, but rarely so when the stalks attain large size. A field of corn may even act as a barrier to grasshopper advance, or edges of the field may be used as roosting places only.

Gardens and truck crops suffer greatly when infested because of the succulent nature of the food.

Smaller sized fruit trees may be injured severely, or killed by having the leaves stripped off, (Fig. 8) tender twigs eaten and bark gnawed.

Fig. 8.—Young orchard stripped by grasshoppers.

Damage to young orchards usually follows the cutting of alfalfa or some staple food supply from the orchard itself or from adjacent fields. The hoppers then congregate in the trees with above results.

CONTROL MEASURES

For control measures to be directed to best advantage it is necessary to have knowledge of the points brought out in the previous discussion. For control measures to be effective and certain they must be correctly applied by each farmer as his especial business; to make the results uniform, control measures should be applied by the community as a whole.

Over large areas, where the return per acre from crops is small, control measures must be economical to be practical. The more they may be made to fit into correct farm practice the more sure they are of efficient results—both financially and in practice. The following measures take both these phases of control into account.

Control of grasshoppers is discussed along two lines: Preventive and Remedial.

PREVENTIVE

Outbreaks may be prevented almost entirely by attention to prohibition of egg deposition and to destruction of eggs before they hatch. The first may be brought about in connection with remedial measures to be discussed later, by keeping such places described above as the haunts of the hoppers free from sheltering weeds. Keeping down weeds along ditch banks, field edges, borders, roadsides, where hoppers congregate, exposes the insects more to their natural enemies and they will abandon the places. There is also almost as much benefit directly in such destruction in freeing the fields of weeds. It is good farming practice merely.

Burning neglected weed patches may kill some egg pods and if burned when the hoppers are very small will kill many hoppers. So, burning should not be done until the hoppers hatch if possible. It is safer on two counts, however, to keep the weeds down in summer.

Destruction of the eggs may be accomplished by plowing, harrowing, or disking. This may be simplified by noting in

the fall where most of the eggs are being laid and treating such places particularly. Any of these above operations should be performed before the eggs hatch, of course, preferably in cold weather. Plowing should be deep enough—eight inches—to bury the eggs sufficiently to prohibit the young hoppers from coming to the surface when they hatch.

Where plowing cannot be done, harrowing or disking to a depth of 2 inches,—thoroughly done,—stirs up the “pods”, breaks many, allows the birds and other enemies a better chance at them and exposes them to fatal changes in temperature and moisture. A combination of these two is effective. Disk first and after two weeks harrow where disked. These operations are carried on at small expense at a time of year when more time may more easily be devoted to them than can be given profitably in summer to remedial measures. There is a large saving, also, in the amount of crops saved from destruction. The discussion of egg laying showed the number of eggs to be somewhere near one hundred per female per season. *How easy to kill fifty grasshoppers by destroying one pod!* How easy by the same means to *prevent* a possible 2500 eggs the next fall, allowing one-half for males and one-half for females in each fifty! It is easily observable that fields treated as above are free of hoppers in damaging numbers.

Where land is left fallow for a long time, or where considerable extent of land, affording breeding places, is held unfarmed by landowners, there should be some means of compelling the employment of measures to lessen the danger from such infection spots to adjacent farmed tracts.

REMEDIAL

If the foregoing measures have not been employed thoroughly the following means, carefully employed, will make the control of critical outbreaks possible.

MACHINES FOR CAPTURING YOUNG AND ADULTS

Hopperdozer.

The hopperdozer has been in use for years in the Central States. In 1913 the hopperdozer (Fig. 9.) was used

Fig. 9.—Hopperdozer, backstop removed. Note the partitions in the pan and lip in front. (Original.)

to free alfalfa in a young orchard of hoppers. Several bushels were caught in a two-hour run at first trial. The hoppers were grown and had already done severe injury to the young trees but later damage was stopped. After using the hopperdozer directly on the alfalfa that was nearly ready to cut, the hay was cut, the mower being followed by the hopperdozer. In this way the field was cleared.

Fig. 10.— Hopperdozer in use.

Fig. 11.— Removing hoppers from pan.

The hopperdozer consists of a galvanized iron pan mounted on runners and having a back stop of canvas or oil cloth. The pan figured is 12 feet long by 2 feet wide by 4 inches deep. The back and ends have a 2-inch flange, the front a 6-inch flange. The pan is supported by a 2x4 on either side set into the end of the runners which are 2 in. x 8 in. x 4 ft. The flanges are nailed to the wooden frame thus made. A low runner supports the bottom in the middle. The hitch is

Fig. 12 — Hopper machine in use.

made directly to the runners. A back stop 30 inches high, with triangular pieces for the ends, made of canvas nailed on a frame, is held in position by allowing cross pieces of the frame to fit into bow irons on back of pan frame. The back stop may thus be removed for better protection when not in use.

The partitions are inserted, without fastening, to reduce slopping.

In use (Fig. 10) the pan should have about 2 inches of water with a film of coal oil on top. When the hoppers caught reduce the working efficiency, remove them with a scoop, allowing the oil and water to strain back. (Fig. 11). Replenish with water and oil when necessary.

Better results will be had if the hopperdozer is used before the hoppers have attained their wings and where vegetation is only about eight inches or less high. Winged hoppers are not so easily caught, and they have already done much damage, scattered wider and thus greater expense is involved in their capture. Once over with this machine, as with the two types following, is rarely sufficient if hoppers are very numerous.

Mr. J. W. Rigney, County Agriculturist of Chaves County, reported catching, with a hopperdozer similar to the above, but only 10 feet long, "Six bushels of hoppers during the last half of the forenoon." The farmer using this machine reported to him later "that he had caught 60 bushels off 7 1-2 acres." Mr. Rigney reported that at another trial in less than two hours one machine collected eight bushels. This machine was 15 feet long, made with two pans 20 inches wide set on floors of 1-inch material allowing some play where the inside ends came together, a good modification for rough land, especially, when the machine is long. Some twenty hopperdozers were put in operation in his County in 1915.

The cost will vary from \$6.00 to \$10.00.

The cost for oil to run will vary from \$.50 to \$1.50 a day.

Another type of hopperdozer (Fig. 13) was designed by

the author to be used where the ground was rough and where the use of a shallow pan would not be so practical. The pan was 9 inches deep, 12 inches wide at the bottom, and 8 inches at the top. At the upper front edge was a 20-inch lip slanting downward to serve as a threshold to the pan. Having the sides slant inward from bottom to top prevented slopping when the pan

Fig. 13.—Type of hopperdozer designed for use on rough land. a and b, timbers supporting the pan, p, l, lip, resting on cleat, c. Scale, 1-10 inch equals 2 inches. (Original.)

was in use on rough ground. The cut will show the plan of construction.

Fig. 14.—Hopper machine, front view. Note curved metal shield in front.

Fig. 15.— Back view of machine in Fig. 14.

After the oil has evaporated the hoppers caught in the hopperdozer are good feed for pigs or poultry. Too many should not be fed at once, of course.

THE HOPPER MACHINE

The hopper machine (Figs. 14 and 15) makes possible the

Fig. 16.— Close view of machine in Fig. 15, showing hoppers clinging to screen back.

capture of the hoppers alive, on sloping ground and without the use of any oil. This type

Fig. 17.—Diagram of end of hopper machine, showing curved shield, t; lip, l, and space below the edge of shield for entrance of hoppers. (Original.)

of machine was used in Colorado in 1902. It consists essentially of a box of length to suit the needs—12 to 16 feet, square or rectangular in cross section, 2 x 2 feet or 2 x 1 feet. The back and top may be entirely or partly of screen wire, provision being made somewhere for getting the hoppers out. The front is a curved shield 2 1-2 feet high, of smooth metal or oil cloth, extending to within 2 inches of the bottom of the box. The

box is prolonged (Fig. 17) 3 inches in front of the bottom of the shield, a lip projecting upward there and forming the remainder of the front of box. The box is set on runners 2 inches by 4 inches by 4 feet. The hitch is made to ends of a 2x4 running in front of the lip and extending across the ends of the box.

In operation (Fig. 12) the hoppers jump up, hit the curved shield and toboggan down into the space between the lip and lower edge of shield. Here they see room and light in back of box (Fig. 16) so crawl and jump for that space. A few may jump out over the lip instead. The Utah Experiment Station (Bul. 138) makes the lip of curved metal so as to form a second minor toboggan that shoots the hoppers automatically past the lower edge of shield into the box behind.

In 1913 Mr. P. H. Bailey, in the lower Mesilla Valley, made and operated a machine of this type with the rectangular box 2 feet wide, 1 foot deep and 16 feet long. The catch with it was enormous, the pile of stacked grasshoppers being a huge

testimony to the efficiency of the machine. In order to unload the catch a wooden piston was made with a head to fit loosely in the box and rod to reach the opposite end. The piston was shoved into the box when the machine was in operation. The machine full, it was hoisted on to two 3-foot trestles. A sack was then held at the end with the removable door and the door opened. The plunger was pulled out far enough to bring with it hoppers to fill the sack. It was then pushed in, door closed, first sack removed and another put in position and the operation repeated. The space between the lip and shield was stuffed with sacks to prevent hoppers from crawling out there.

If the hoppers are not to be sacked, an easy way to unload is to deposit them in a sufficiently large pit in the ground. They may be killed with a very little sprinkling of kerosene.

Fig. 18.—Pile of dead hoppers captured by hopper machine.

In 1915 Mr. J. W. Knorr, Agriculturist of Eddy County, reported excellent success with machines built after the Utah plans. (Utah Exp. Sta. Bul. 138.) Figure 18 bears witness.

The cost of one of the above machines varies with size from \$8.00 to \$15.00. The operating expense is nothing extra as in case of the hopperdozer where oil must be supplied and extra water as well. The trouble of getting the hoppers out is a little more in the case of the dry machine. On the whole the principal advantage of the latter type over the former is in the possibility of its use over rougher, sloping ground.

If either kind of machine is built it should be *well made* in the first place and then *preserved* for use in succeeding years. It will then always be ready to meet crises that may come, due usually, to lack of attention to the preventive measures.

POISONING

Poisoning may be effected by applying the poison directly to the hoppers by a contact spray, to the vegetation, by a stomach spray, or by distribution of poisoned bait.

Oftentimes there are conditions where it is possible to kill enormous quantities of young, or sometimes adults as well, by spraying with kerosene. If hoppers are found on areas of vegetation that may be killed without loss, then the application of a spray of kerosene or strong kerosene emulsion will quickly and effectively clear such areas. Weed patches, ditch banks, etc., could be well treated thus.

Poisoning the vegetation is often practicable for killing *young* when they are still localized. Arsenate of lead at the rate of 3 lbs. powder to 50 gallons water is a good spray to use. This strength may injure some foliage but a less strength is apt not to be effective. It is not advisable to spray a forage crop when about ready to cut. Adults are apt to leave poisoned vegetation and go to food not poisoned. They are also

more resistant to the poison and if numerous will do permanent injury to crop before enough are killed. Spraying young fruit trees is usually time lost as there is so little foliage that all will be eaten in spite of poison.

To get the young, spray considerable areas adjacent to the masses of hoppers. They will then eat of the poison.

The means of poisoning by distributing poisoned bait is of wide application and ranks with the hopperdozer and machine as a remedial measure.

The old Criddle Mixture—horse droppings, salt, Paris green and water—was modified by the writer in 1915 as follows and with good effect:

Three small lemons were grated into 1 gallon of water and to this 1-2 lb. of Paris green and 3-4 lb. salt were added. This was stirred up thoroughly and added at once to 2 pails of horse droppings, half fresh and half partly dried. The mass was stirred up well and left over night.

Before sunrise it was placed in teaspoonful heaps near the roosting places of the hoppers. The results were quite satisfactory. A gentle shower came a few days after the application and moistened the bait, increasing the effectiveness. This was tried in 1912 without the fruit, as a protection to a cabbage patch, being distributed through the patch in heaps the size of one's fist. The piles were moistened daily. Dead hoppers accumulated in masses near the piles in a few days. Then came several showers in sultry weather and the grasshopper fungus practically cleared the field.

Kansas in the last few years has improved the old Bran Mash by adding grated oranges or lemons and syrup or molasses. Their formula and modifications have given remarkable results in many sections of the country. The writer used the following formula:

Wheat bran	20 pounds
Paris Green	1 pound
Lemons	6 or 8 fruits
Sorghum molasses	3 quarts
Water	3 1-2 gallons

The bran and Paris green were mixed *dry* in small amounts in a big galvanized iron wash tub, these being transferred to a second tub when the mixture was complete. For large quantities some mechanical mixer would be necessary to hasten the process and to protect the workers from the dust from the Paris green.

After the fruits were grated into the water the molasses was stirred in and the resulting mixture stirred thoroughly into the bran so that every part was wet. This was allowed to stand twenty-four hours to start fermentation.

This mash was sown broadcast in early morning, before the hoppers started to feed, where they were roosting and in fields where injury from feeding was noted. Results were excellent, masses of hoppers being killed at each application. Even the dried mash was eaten. Whole local swarms were cleared from the fields where trials were made.

One trial failed. The application was made in early morning just after a light shower the preceding night. Food was plentiful and hoppers were not present in injurious numbers. Only two dead hoppers were found at any time, even tho the bait stayed moist several days in protected places.

Substitution of alfalfa meal for bran has been tried by some experimenters with fair success.

County Agriculturists J. W. Rigney and J. W. Knorr of Chaves and Eddy Counties respectively, reported excellent results with the bran mixture where used. (Fig. 19).

Note. Experimentation has shown there is no danger to poultry from eating the bran mash if it is scattered broadcast. The writer has seen no dead wild birds over ground that

was treated. One season a pan of the prepared bran mash was exposed where chickens could get it if they wished. Only occasionally would one peck at the bran and then only desultorily. None showed any signs of poisoning.

Reports have come to the writer of chickens dying from eating grasshoppers, both alive and poisoned. Such deaths were evidently due to overeating of a food to which the fowls were not accustomed.

Fig. 19.—Orchard separated from alfalfa field by salt cedar hedge. This orchard was protected from ruin in 1915 by the use of the fruit-bran-mash along and on this hedge.

USE OF POULTRY

Chickens and turkeys as a factor in grasshopper control rightly come under the head "Preventive". They are exceedingly effective yearly over smaller areas by eating great quantities of young especially. However, their possibilities should not be overestimated. It is impossible to raise sufficient poultry to patrol all the land in New Mexico subject to grasshopper damages. During the years when hoppers are scarce they will be kept down but there is bound to come

a crisis when the poultry present will be unable to cope with them. The writer has seen alfalfa eaten short by the hoppers in the face of large flocks of poultry.

The most benefit may be derived from the poultry by keeping them shut in an enclosure, portable if necessary, and then herding them to feed for a time daily on infested ground. They will thus eat more exclusively of them.

Poultry are very good *as far as they go*, in control work but can not be relied upon to the exclusion of all other means.

DRIVING

Driving as a temporary relief from invasion by hoppers may be employed in such places as gardens, small orchards, or small plats of various sorts where vegetation is not too dense. The writer has seen such places cleared in short time and imminent danger averted until more final measures could be employed. To drive grasshoppers one must proceed slowly, as they tire easily and then drop to the ground and hide instead of moving on. It is best, thus, to beat back and forth with leafy branches in the rear of the swarm at right angles to the line of advance, giving part resting time while another part is moving. Just after the beginning of the morning feeding time is best for driving.

PROTECTION OF YOUNG ORCHARDS

In many places it is a common practice to grow crops in between rows of young trees. If alfalfa is grown there, trouble is almost sure to follow from grasshoppers unless precautions are taken. Trouble is not so great, usually, from crops that are rotated annually or oftener.

All preventive means should be employed yearly of course. If the numbers of young seem then to indicate later damage, use the poisoned bran and hopperdozer or hopper machine after the first and second cutting of the alfalfa. This should clear the orchard before the majority become adult and capable of serious damage. If hoppers are bad in adjacent fields

—and this *caution* applies to any case—*do not cut the field clear or the hoppers will migrate to the orchard or next field and perhaps do greater injury. When cutting leave a strip of feed for them where they are most numerous and as soon as possible use remedial measures that are most applicable to kill them.*

Spraying young trees is ineffective because there are enough hoppers to eat all the foliage even if some are killed. Covering with mosquito netting is too expensive. This is also too light in weight, as holes are frequently eaten through it. Unbleached cheesecloth is cheaper and better, but of course small trees are the only ones that it is practical to cover with cloth. In case of an invasion by adults from without, *drive* them out at once to *prevent immediate damage*. Then apply remedial measures.

Note.—Control will be most effective in any case when based on a full general knowledge of grasshoppers; on accurate observations of the given, particular grasshoppers in need of control; and when the application of control measures is thorough.

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To Mr. M. P. Somes, Entomologist, Mountain Grove (Missouri) Fruit Experiment Station, thanks are due for kind assistance in identification of several species of grasshoppers.

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And Mechanic Arts**

**AGRICULTURAL EXPERIMENT STATION
STATE COLLEGE, N. M.**

**The Utilization of Feed by Range Steers of
Different Ages**

II. Alfalfa Hay and Milo Maize Meal

By F. W. CHRISTENSEN, H. H. SIMPSON and LUTHER FOSTER

New Mexico Agricultural Experiment Station

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THE UTILIZATION OF FEED BY RANGE STEERS OF DIFFERENT AGES

II. Alfalfa Hay and Milo Maize Meal

INTRODUCTION

This bulletin presents the results of the second series of experiments on the Utilization of Feed by Range Steers of Different Ages. The results of the first series, in which alfalfa hay alone was fed, were published in Bulletin No. 91 of this Station.

The objects of the investigations, as briefly stated in the bulletin just cited, are (1) to study the nutritive effect of our most important feeds for the production of beef with range steers; (2) to study the effect, and uses made, of feed by range steers of different ages; and (3) to study the nutritive effect and digestion coefficients during the three different stages of fattening.

For the purpose of comparing the steers of different ages in these experiments, five steers each of calves, yearlings, two-year-olds and three-year-olds were fed like rations under similar conditions during a period of 120 days. The utilization of the feed is measured by the gains in live weight, feed consumed per unit of gain, degree of finish of the steers, slaughter and block tests, analysis of certain cuts of meat, and a comparison of digestion coefficients at various stages of fattening. In all cases individual records are kept. The relative digestive powers of the various groups of steers are compared by conducting digestion trials at certain intervals during the feeding period, using two steers of each age for this purpose.

Cattle grown on the ranges in this section of the country are usually subjected to longer or shorter submaintenance periods when the pickings on the ranges become scanty, as during the winter and early spring months. At such times, the cattle are likely to lose weight and weigh less in the spring than in the fall, unless supplied with additional feed by the ranch owner. Incidentally, some observations have been made as to whether or not the digestive powers of the animals have been affected by these conditions, and will be considered later.

Equipment and Methods Used.

Feed Lots. The feed lots used in this series are the same as those used in the alfalfa hay series, and are described in Bulletin No. 91 of this Experiment Station. The lots are 10 by 36 feet in size, equipped with suitable mangers and stanchions, and fenced with woven wire fencing five feet high. The steers were fed in the open, except while on digestion trials; no shelter being provided, other than a natural windbreak of trees and evergreens on two sides of the feed lots.

Digestion or Metabolism Stalls. The stalls used in the digestion trials are contained in a house adjoining the feed lots. The stalls are arranged for the use of rubber ducts and funnels in collecting the excreta. These ducts and funnels are the same as those so successfully used by Armsby and Fries in the Institute of Animal Nutrition of the Pennsylvania State College, and therefore will not be described here. The floors of the stalls were well padded with excelsior and heavy matting, for the comfort of the steers.

The Digestion Trials. The alfalfa hay for the digestion trials and preliminary periods was carefully mixed, then weighed up into large canvas bags, a day's ration to the bag. The milo maize meal was similarly mixed and weighed into covered lard cans, a day's ration to the can. Enough

rations for the whole of the preliminary and digestion periods were weighed out in advance and the samples for chemical analysis taken at this time.

In conducting the digestion trials a preliminary feeding period of eight days was observed, during which the steers received identically the same rations as during the following ten-day digestion period, but the steers were not placed in the metabolism stalls at the beginning of the period. It has been found impracticable to tame our steers sufficiently to permit of their removal from the stalls for exercise while on the digestion trials. Therefore, in order not to keep the steers in the stalls longer than necessary, they were placed in the stalls only a day or two before the beginning of the digestion period proper, during the series of 1913. As the steers are sometimes disturbed by being removed from the feed lots to the digestion stalls, they were taken to the stalls four to five days before the beginning of the digestion trials in the 1915 series.

For the sake of convenience in caring for the samples of excreta in the digestion trials, the experimental day was made to begin and end at 1 o'clock P. M. The feces and urines for 24-hour intervals were collected at this hour for ten successive days, unless interrupted through accident; all receptacles were changed promptly, and the collected excreta weighed, carefully mixed and sampled as soon as practicable.

Feeding. The steers were fed regularly at 7 o'clock A. M. and 4:30 P. M. Approximately one-half of the day's ration was fed in the evening and the other half in the morning. This practice was followed throughout the feeding periods. The hay and grain were fed together and mixed more or less after being placed in the feed boxes. Any feed residues remaining in the feed boxes were collected from time to time and weighed up at the end of each ten-day period. The feed residues for the ten-day periods, from each steer, were reserved separately until the end of the month; at which

time the separate portions, if any, were united, mixed and sampled for analysis. Any feed residues collected during the digestion trials were analyzed separately from the other residues.

Watering. The steers were watered once each day, at about 9:30 A. M., during the experiments of 1913. The practice of watering only once each day was unsatisfactory in some respects, and therefore watering troughs were placed in the feed lots so as to allow access to water during the greater part of the day during 1915. The troughs were provided with covers, which were closed at the time of the evening feeding and kept closed until after the steers were weighed the next morning at about 9 o'clock. This method of watering has been found more satisfactory than the one used heretofore.

Weighing. In the experiments of 1913 all the steers were weighed for three successive days at the beginning of the experiment and at the end of each thirty days. They were also weighed once every ten days during each month, except when on digestion trials. The steers used in the digestion tests were weighed for three successive days before entering the stalls, and again for three days after coming out.

For various reasons, it was deemed advisable to make weighings every day, and therefore, in the experiments of 1915 the steers were weighed daily, except when on digestion trials. In all cases,—both years,—the steers were weighed sixteen hours or more after drinking.

Sampling of Feeds and Feed Residues. At the time of weighing up the rations for the digestion trials a shovelful of the cut hay was put aside for every three or four rations weighed up. When the weighings were completed the portion thus set aside was reduced by quartering to a convenient sized sample, which was then finely chopped with a draw cut meat chopper, and taken to the laboratory, where a weighed portion was dried at about 60° C. The dried samples were allowed

to cool and come into equilibrium with atmospheric conditions, weighed, ground, and reserved for analysis in sealed glass stoppered bottles.

The milo maize meal was sampled and treated in the same way as the hay, except that it was not run through the meat chopper.

In addition to the samples taken for the digestion trials, composite or monthly samples were taken by setting aside portions of hay and meal each day as the rations for the steers in the feed lots were weighed out. At the end of the month the portions set aside were thoroughly mixed and sampled.

The feed residues collected from time to time, exclusive of digestion trials, were weighed up every ten days. These ten-day residues, if any, were combined at the end of the month and again weighed, and sampled. These samples were treated the same as the hay samples. In order to reduce the analytical work as far as possible, the feed residues, exclusive of digestion trials, were composited separately for each steer for the entire feeding period of 1913 according to the method shown in Bulletin 91 of this Station.

In the 1915 experiments there were only a few small residues which were analyzed separately, except for the first month. Through a misunderstanding, our attendant combined all the feed residues from the feed lots at the end of the first month, instead of simply combining the ten-day residues for each steer.

Sampling the Excreta. The excreta were weighed and sampled once during each twenty-four hours for a period of ten days. As soon as practicable after changing the receptacles, the excreta from the various steers were weighed and sampled. The total feces collected during the day from each steer were thoroughly mixed on a zinc covered platform and reduced to a convenient sized sample by the method of quartering.

The samples obtained in this way were taken to the laboratory, where uniform aliquots, usually corresponding to 1-50 or 1-25 of the total feces, were weighed out and placed in zinc cans; one can being provided for each steer. The cans were provided with covers, which were tightly sealed by means of broad rubber bands. During the trials the samples were kept in a well iced refrigerator and further preserved by means of carbon bisulphide. At the end of the digestion trial these aliquots formed a composite sample for the period, which was thoroughly mixed and analyzed by the usual methods.

Aliquot samples of the urine were weighed up each day, as in the case of the feces, and at the end of the trial the nitrogen content of the samples was determined. The samples were kept in a well iced refrigerator and preserved with chloroform.

Chemical Analyses. All analyses of feeds, feed residues, feces and urines were made according to the methods of the Association of Official Agricultural Chemists, except the moisture determinations, and the nitrogen determinations in the fresh feces. The moisture determinations were made by drying in vacuum desiccators in the presence of sulphuric acid, while the nitrogen determinations in the fresh feces were made by digesting to a liquid state 100 grams of the fresh feces, with sulphuric acid and mercury, making the whole up to volume and determining the nitrogen in aliquot portions of this by means of the regular Kjeldahl method, as described in our previous publication.

Terms Used. As applied to the feeds and feed residues, the term "protein" refers to "true protein," excluding the non-protein nitrogenous substances, and is calculated from the protein nitrogen by the conventional factor 6.25. The total nitrogen of the feces and meat samples has been multiplied by 6.25 to obtain the protein.

The "non-protein" has been obtained by multiplying the difference between the total nitrogen and the protein nitro-

gen, as determined by the Stutzer method, by use of the factor 4.7.

The unit for energy employed in this bulletin is the "therm," and is equal to 1,000 large or kilogram calories.

THE EXPERIMENTS.

Our facilities permit of feeding only ten steers at a time, and therefore to carry out the plan outlined in the introduction, namely, the feeding of four groups of steers, ranging in ages from calves to three-year-olds, with five in each group, necessitates two separate feeding periods. In this experiment we followed the plan of feeding calves and yearlings in 1913 and two-year-olds and three-year-olds in 1915. This arrangement is rather unfortunate since the groups fed during the different years were fed under different climatic conditions, from different lots of feed, and, as happens in this case, the steers used in 1915 differed in type and breeding from those of 1913. On this account the results for the series as a whole are not as comparable as might be desired. However, aside from the uncontrollable factors and unavoidable differences in the steers and lots of feed, the experiments during the two years were conducted under as nearly like conditions as possible.

The feeding period proper extended over 120 days in each case, during which all feed offered was carefully weighed and sampled for analysis and any feed residues were also weighed and sampled. The steers used in the experiments were received at the Experiment Station from six weeks to two months before the experimental feeding was begun. During this time the steers were tamed as much as possible and fed enough alfalfa to keep them in good condition without making appreciable gains. As the time for starting the feeding period drew near, small amounts of milo maize meal were added to the grain before the experiment was begun.

As the steers used in the experiments of 1915 had not been dehorned before delivery to the Station, this operation caused considerable delay in starting the experiments that year, as the steers could not be tamed until the wounds from the dehorning had been healed, or nearly so. This explains why the experiments of 1913 began early in January and those of 1915 not until February 25. As the feeding was begun so late in 1915 it was deemed best to omit the third digestion trial in the series, on account of hot weather.

The experiments of the two years are really parts of one experiment, and therefore will be considered as such, with such deviations as may seem necessary on account of variations in the conditions. To facilitate the comparison of the feeding periods of the two years, general schedules of the experiments by months as well as dates of digestion trials, are given herewith.

GENERAL SCHEDULES OF THE EXPERIMENTS

Experiments of 1913: Calves and Yearlings.

First month or period, January 2 to February 1.

Digestion trial I, January 20 to 30.

Second month or period, February 1 to March 3.

Third month March 3 to April 2.

Digestion trial II, March 11 to 21.

Fourth month, April 2 to May 2.

Digestion trial III, April 15 to 25.

Experiments of 1915: Two- and Three-year-olds.

First month, February 25 to March 27.

Digestion trial I, March 15 to 25.

Second month, March 27 to April 26.

Third month, April 26 to May 26.

Digestion trial II, May 4 to 14.

Fourth month, May 26 to June 25.

Animals Used.

The animals used in the experiments of 1913 were mostly high-grade Hereford range steers, representative of the steers grown by the most progressive cattlemen of the South-western range country, and were obtained from the ranges in the vicinity of the College and Station. In selecting the steers an attempt was made to secure animals that were fairly uniform as to type, weight, age and condition, and at the same time representative of the general run of range steers of their respective ages.

Considerable difficulty was experienced in securing the two- and three-year-old steers used in the experiments of 1915, owing to the practice of selling the stock off the ranges at an earlier period. Since no steers of these ages could be obtained for feeding in 1914, arrangements were made to secure steers for the completion of this series in 1915. In this, however, we were not especially fortunate, inasmuch as the steers finally secured differed from those used in 1913, in breeding, being largely grade Shorthorn stock; and also in type, condition and uniformity. The lack of uniformity in type and condition was especially noticeable in the three-year-olds. These steers were of necessity chosen from "left-overs" brought in from another part of the State, and it was found impossible to get a uniform bunch of this age or individuals that were really comparable with the other ages of steers used in the tests. The two-year-olds, of course, differed from the calves and yearlings in breeding, but compared fairly well with them in other respects.

The designations, calves, yearlings, two-year-olds, and three-year-olds, as employed in this bulletin, are relative terms only. The exact ages of the animals are unknown. What we refer to as "calves" means calves dropped during the spring or summer preceding the feeding period, which occurred during the winter and spring months. Thus the "calves" were probably

10 to 12 months of age at the end of the experiment. The yearlings, twos and threes were "long" yearlings, twos and threes, so that at the end of the feeding periods the various groups of steers were practically one-, two-, three- and four-year-olds.

For the sake of convenience and simplicity in the presentation and discussion of the data and results, the individual steers will be referred to by number or age groups. The groups and numbers of the steers are as follows: calves, 26 to 30; yearlings 21 to 25; two-year-olds, 36 to 40; three-year-olds, 31 to 35.

Conformation, Type and Finish of Steers.

Calves. Of the steers composing this group, steer 26 was the poorest in the bunch. He was light boned, rather leggy and his body was narrow and shallow. His top line was fairly good but dropped off somewhat at the rump. He appeared delicate in constitution and proved a poor feeder. At the end of the feeding period he lacked finish throughout.

Steer 27 was a fairly broad, short-limbed, blocky individual with staggy head and coarse, heavy neck, with fair shoulders but was "tied in" somewhat around the chest. His hind parts appeared better than his foreparts.

Steers 28, 29, and 30 were good smooth, well balanced steers, having good depth of body and showing no undue paunchiness. Steer 28 was one of the smoothest steers in the bunch, being well balanced throughout, and having a broad loin, and shapely well covered hips. He showed the best and most uniform finish of any of the calves, and probably better quality than any of the others in 1913. He had a good top line, a smooth well covered shoulder, and well formed hips, but was a little off-type, rather light in the hind parts, and somewhat leggy, but he carried a fairly good smooth finish. Steer 30 was the lightest of the calves. He had a straight back, a smooth shoulder and well developed hind parts. In quality he was just fair, having medium bone, rather thick

hide, and carried a good amount of flesh. He was a little plain and coarse about the head and appeared a little heavier in front than behind.

Yearlings. Steer 21 was well shaped about the shoulders and chest, being rather deep and broad, but was a trifle low in the back. His greatest fault was his paunchiness, although he also lacked symmetry. Compared with the fore parts, he was a little high at the tail head and somewhat light in the hind quarters. He was rather large boned, but was not a coarse steer. At the end of the feeding period he was in good average condition, but not especially fat.

Steers 22 and 23 were both well balanced, symmetrical individuals, neither steer showed any excessive paunchiness. Steer 22 appeared a little upstanding, but this was apparently due to depth of body rather than length of legs. He showed good front, middle and hind parts but was a trifle low in the back. At the end of the feeding period he was well filled in the twist and flank, but was not as well filled along the back, hip, and rump as might have been desired. However, he showed more quality than any of the other yearlings. Steer 23 differed from steer 22 chiefly in that he had a better top line, rather short and broad head and neck, and in being particularly smooth in front, that is, over the brisket, shoulder and chest. He had somewhat finer bone and a well distributed covering of natural flesh. The ribs were well sprung and covered with a good layer of flesh. The loins and hips were also well covered, and the hind quarter presented, on the whole, a nice well filled appearance, except for a slight lack of fullness at the rump. Steers 24 and 25 differed noticeably from the other three steers of this group in that they were more unstanding and not so well balanced. Both steers were rather high-cut in the hind flank, but steer 24, although a little rangy, had fairly good depth of chest. Steer 25, on the other hand, lacked in depth of chest. Steer 24 proved to be a poor feeder, made very small gains and

hence lacked finish at the end of the experiment. Steer 25 had a nice top line, a smooth, well formed shoulder, and in general was a fairly smooth animal. Neck and shoulder blended nicely. As regards finish, his shoulder was well covered but he lacked filling in the loin, rump, and thighs. A little longer time in the feed lot would probably have made him a well finished and balanced animal.

Two-Year-Olds. The difference between 36, 39, and 40 was very small as regards type. All three of the steers were desirable in most respects. Steer 36 conformed very closely to the requirements of a beef animal. He had a square, low-set, compact appearance but was a little plain about the shoulders and light in the flank and did not carry down well in the hind quarters; however, he was desirable as a feeder because of his beefy conformation, square head, short neck, and general beef producing characteristics. Steer 39 was a little coarse and rough, showing lack of quality, but possessed the characteristic big bone, and square, low-set conformation that is indicative of a good beef animal. His barrel was a little undersize and his hind quarters lacked flesh. The tail head was high, giving him an ungainly, rangy appearance. Steer 40 possessed the desired low-set, compact appearance, but was rough and his barrel not quite large enough. His ribs were not well sprung, and the covering over the loin was rather light. The hind quarters were not well fleshed, but they were large and capable of filling out. He belonged to the class of feeder steers possessing the peculiar ability of developing into good beef animals far beyond the expectation of the feeder.

At the close of the feeding experiment steer 36 was one of the leading steers of the lot. While he did not carry his flesh evenly distributed, he was more uniformly finished than any of the others. He was not as well developed in the hind quarters as either 39 or 40, but showed a general symmetrical outline, and in general came nearer to the ideal beef type than any of the others fed this year.

No. 39 was a close rival of No. 36. While his barrel was smaller and deeper, the ribs were not so well sprung, but his hind quarters were much deeper and broader; in fact, his rear quarters were the most desirable of any steer in the experiment. The chief objections to him were that he was a little rangy and cut-up in the flank. His bone appeared somewhat coarse, yet he showed more quality than No. 40. This animal improved wonderfully the last few days of the feeding trial, and if he had been fed another sixty days, he probably would have exhibited a very desirable type of a finished beef animal.

No. 40 was more evenly fleshed over the back and ribs than No. 39, but his hind quarters did not carry down as well and his rump was irregular, showing a patchy condition of flesh. He possessed a large bone, but he was a little on the rangy type, being cut-up in the flank, giving him a leggy appearance. However, he proved a good feeder.

Steers 37 and 38 were off-type and were lacking in quality. Their conformation was such as to suggest dairy type rather than beef type. The body of No. 37 did not show the low-set blocky appearance desired in a beef animal. His head and neck evidenced femininity and his shoulders were coarse. The ribs were not well sprung, but his back, though narrow, was deeply fleshed but patchy. He lacked development in the hind quarters and size of bone to carry a large amount of flesh. No. 38 had a fairly large bone, but was narrow in the body. His barrel was small and his ribs not well sprung. The hind quarters were light and did not possess the desired conformation for beef production. At the completion of the feeding trial steer 37 had fleshed up fairly well over the back and loin, but he still possessed a lean and rough appearance. His head, neck and fore quarters did not show the width and depth indicative of a finished steer. With steer 38 the most conspicuous defects, aside from his being off-type, were his small middle and irregular top and bottom

lines. His head and neck were coarse, but his shoulders carried their flesh well. His ribs were not well sprung and his back and loin did not carry the desired amount of flesh. He did not fill out sufficiently to overcome his leggy appearance.

Three-Year-Olds. Steer 31 was a very large rough individual, evidencing poor feeding qualities. He was a good representative of the extreme rangy type, having a narrow, upstanding body of decidedly poor quality, coarse bone, and general conformation diametrically opposed to good fleshing qualities. At the completion of the feeding trial this animal showed considerable improvement, in that he had fleshed up over the shoulders fairly well, but his back and loin were still deficient in flesh. His barrel was small and his hind quarters were not developed in proportion with his fore quarters. If he had been fed another sixty days he probably would have shown more finish, but he never could have reached the standard of a prime finished steer, because of his off-type. Steer 32 was very similar to 31 in that he was rangy and upstanding, but he was a more desirable type, being a little more symmetrical, large boned, but not so coarse as 31, and his body and hind quarters were not so rough, carrying more flesh and being developed more uniformly. At the end of the feeding period this steer evidenced a marked improvement. He had taken on flesh uniformly and had developed in spring of rib, thickness of loin, and width of back. His hind quarters were still a little light, because the flesh did not carry down well. He still retained some of the rough, ungainly appearance he had at the beginning. Steer 33 conformed more nearly to the desirable type of a feeder steer, having a large frame and possessing more of the desirable feeding characteristics. He had rather light hind quarters and small barrel, and was cut-up in the flank. He lacked the proper width and depth of back and loin, but his general appearance was such as to make him desirable for the feed lot. He evidenced the fact that he was a good feeder at the end of the feeding

trial, had fleshed up well over the back and loin, had a more desirable spring of rib, and broader back, and his hind quarters carried more flesh. The hind quarters were not in proportion with the rest of his body, being smaller and not nearly as well developed as the fore quarters. Steers 34 and 35 were decidedly off-type, and were not good subjects for the feed lot. No. 34 was a leggy, narrow-bodied, large, coarse-boned animal. His barrel was small and his back thinly fleshed. Steer 35 was very similar to 34, having a narrow body, was leggy and showed very poor quality. He was very light in the middle and cut-up in the flank, dropped off at the tail head and showed poor development of hind quarters. Neither of these steers showed any marked improvement at the finish of the feeding trial. No. 34 had taken on flesh to some extent, but did not develop in the region of the barrel as a good feeder should, and his flesh was patchy. It was especially well placed over the upper part of the shoulders. The hind quarters were lacking in flesh. No. 35 filled out a little more than 34 but he, too, was not well fleshed. He had not filled out fully over the back and loin. His arched back, high tail head, and high-cut flank, taken together, made him appear very rough and ungainly.

If the two- and three-year-old steers were considered from the feeder's point of view with respect to the most desirable finish exhibited by each steer, they would have ranked as follows:

- No. 36, first place.
- No. 39, second place.
- No. 40, third place.
- No. 32, fourth place.
- No. 33, fifth place.
- No. 37, sixth place.
- No. 35, seventh place.
- No. 38, eighth place.
- No. 34, ninth place.
- No. 31, tenth place.

Feeds and Rations.

Feeds; Kinds and Preparation. First cutting alfalfa hay and milo maize meal of good quality constituted the feeds in these experiments. The alfalfa fed in 1913 was a good grade of hay, having good color, together with an abundance of leaves and light to medium stems, but that fed in 1915 was rather coarse stemmed, although it also had good color and an abundance of leaves. The coarseness of the latter is clearly indicated by its high percentage of crude fiber. All the hay used in the experiments had been grown under irrigation in the vicinity of the Experiment Station.

To facilitate the weighing of the rations, and the sampling of the hay, it was chopped into lengths of about one inch by running it through a feed cutter. The whole mass of chopped hay was then thoroughly mixed and the rations weighed up from it during the progress of the experiment.

The milo maize was purchased on the market, and probably came from the dry farming sections of New Mexico or Texas. The grain was clean, with well-developed kernels, and on the whole would be considered a good grade of milo.

It was ground in the mills at the Experiment Station sufficiently fine to insure the cracking of all, or practically all, of the kernels. Some of the smaller kernels occasionally passed through the mill without being crushed, but the amount was small.

Rations Fed. Since the various groups of steers, ranging in ages from calves to three-year-olds, were to be compared as to their ability to utilize feeds, it was necessary that they should receive like rations during corresponding periods of the experiment. It was therefore decided to keep the ratio of hay and grain the same for all the animals during corresponding intervals of the feeding period, but to allow them all the feed they would consume. Thus during the first month the ratio of alfalfa to milo maize meal was 2 to 1. Dur-

ing the second month, the proportion of grain to hay was increased from time to time so as to reach a ratio of 1 to 1 by the twentieth day of the month. This ratio was maintained during the remainder of the experiment, but the amounts fed were determined by the appetites of the steers.

The ratio of hay to grain was kept constant throughout the entire first month, for the reason that two steers of each age were used in the digestion trials during the latter part of the month, and therefore required unchanged rations, during this time; that is, for 18 days. In this way, the steers remaining in the feed lots had no undue advantage over the ones in the digestion stalls, as the rations were not changed except as to quantity, while the digestion trials were in progress. Hence, differences noted in the rates of gains between the steers in the digestion stalls and those outside must be ascribed to differences in the quantities of food consumed, rather than to differences in the kinds of rations supplied, and also to differences in the conditions surrounding the steers in each case. Of course under this plan, rather more time was allowed in bringing the steers onto full feed than is customary, but for our purpose it seemed the best plan to follow.

Composition of the Feeds and Feed Residues.

Different lots of feed were used in the experiments of the two years, and it will be noticed that the hay fed in 1915 was inferior to that used in 1913, inasmuch as it contained about 10 per cent more crude fiber and was correspondingly lower in other nutrients, especially protein and nitrogen-free extract. In the case of the milo maize meal the differences are not so marked, although, on the average, the meal of 1915 was a little higher in protein and crude fiber and lower in nitrogen-free extract than that of 1913.

TABLE 1.—COMPOSITION OF ALFALFA HAY, 1913.

	Digestion Trial I, per cent	First month, per cent	Second month, per cent	Digestion Trial II, per cent	Digestion Trial III, per cent	Third month, per cent	Fourth month, per cent	Average, per cent
Dry matter	89.63	89.74	90.31	90.25	92.16	92.52	92.97	91.08
Composition of dry matter:								
Ash	9.71	9.29	8.05	8.15	9.13	9.06	9.19	8.94
Protein	14.31	14.10	14.48	13.88	13.06	13.65	13.32	13.83
Non-protein	2.35	2.38	2.25	2.45	2.50	2.51	2.12	2.37
Crude fiber	28.07	29.29	28.28	32.00	28.46	30.24	31.01	29.62
Ether extract	1.54	1.36	1.42	1.38	1.33	1.37	1.35	1.39
Nitrogen-free extract	44.02	43.58	45.52	42.14	45.52	43.17	43.01	43.85
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total nitrogen	2.789	2.763	2.796	2.742	2.622	2.718	2.583	2.716
Protein nitrogen	2.290	2.256	2.317	2.220	2.090	2.184	2.131	2.213
Non-protein nitrogen	.499	.507	.479	.522	.532	.534	.452	.504

TABLE 2.—COMPOSITION OF MILO MAIZE MEAL, 1913.

	Digestion Trial I, per cent	First month, per cent	Second month, per cent	Digestion Trial II, per cent	Digestion Trial III, per cent	Third month, per cent	Fourth month, per cent	Average, per cent
Dry matter	86.11	85.95	85.97	86.71	87.44	86.80	88.29	86.75
Composition of dry matter:								
Ash	1.95	2.22	1.73	2.03	1.61	1.88	2.04	1.92
Protein	11.08	11.24	11.06	11.24	11.14	11.24	11.55	11.22
Non-protein	.62	.50	.43	.55	.30	.65	.59	.52
Crude fiber	2.35	2.23	2.09	1.77	1.83	2.25	2.17	2.10
Ether extract	2.81	3.31	3.42	3.54	2.67	2.71	2.47	2.99
Nitrogen-free extract	81.19	80.50	81.27	80.87	82.45	81.27	81.18	81.25
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total nitrogen	1.905	1.904	1.861	1.914	1.847	1.937	1.973	1.906
Protein nitrogen	1.773	1.798	1.769	1.798	1.783	1.799	1.848	1.795
Non-protein nitrogen	.132	.106	.092	.116	.064	.138	.125	.110

TABLE 3.—COMPOSITION OF ALFALFA HAY, 1915.

	Digestion Trial I, per cent	First month, per cent	Digestion trial II, per cent	Second month, per cent	Third month, per cent	Fourth month, per cent	Average, per cent
Dry matter	88.89	92.08	89.73	90.97	91.63	90.82	90.69
Composition of dry matter:							
Ash	7.69	7.80	8.17	8.07	8.80	7.90	8.07
Protein	10.80	10.12	11.37	11.57	12.35	9.84	11.01
Non-protein	1.91	1.93	1.66	1.87	1.97	1.74	1.85
Crude fiber	38.49	41.06	37.20	38.45	37.36	42.06	39.10
Ether extract	1.44	1.24	1.31	1.41	1.47	1.18	1.34
Nitrogen-free extract	39.67	37.85	40.29	38.63	38.05	37.28	38.63
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total nitrogen	2.134	2.030	2.173	2.249	2.395	1.944	2.154
Protein nitrogen	1.728	1.619	1.819	1.851	1.976	1.574	1.761
Non-protein nitrogen	.406	.411	.354	.398	.419	.370	.393

TABLE 4.—COMPOSITION OF MILO MAIZE MEAL, 1915.

	Digestion Trial I, per cent	Digestion Trial II, per cent	Second month, per cent	Third month, per cent	Fourth month, per cent	Average, per cent
Dry matter	86.25	86.65	87.16	87.63	88.91	87.32
Composition of dry matter:						
Ash	1.73	1.61	1.38	1.52	1.85	1.62
Protein	12.11	12.49	12.72	12.64	12.49	12.49
Non-protein	.27	.46	.32	.33	.32	.32
Crude fiber	2.55	2.67	2.28	2.44	2.84	2.56
Ether extract	3.47	3.05	2.98	2.54	3.27	3.06
Nitrogen-free extract	79.87	79.72	80.32	80.53	79.23	79.93
	100.00	100.00	100.00	100.00	100.00	100.00
Total nitrogen	1.996	2.096	2.104	2.092	2.067	2.071
Protein nitrogen	1.938	1.999	2.035	2.022	1.998	1.998
Non-protein nitrogen	.058	.097	.069	.070	.069	.073

Proportions of Hay and Grain in Feed Residues. The tables giving the composition of the feed residues have been placed in the appendix, where they can readily be referred to, if desired. In this connection it may be well to remark that the wide differences in the composition of the various residues may be traced to the habits or appetites of the various individuals. Some of the animals habitually rejected the coarse stems of the hay but cleaned up the fine particles of the ration, whereas others cleaned up all the coarser parts of the ration, leaving only the fine dust; while still others showed no decided preference in the matter. Evidently, then, the feed residues did not contain hay and grain in the same proportions as fed in the rations, and so in order to arrive at a fairly accurate figure for the amounts of alfalfa and milo maize meal actually consumed, an estimate of the proportions of each in the residues was made, upon the basis of the crude fiber content of the residues and the average crude fiber content of the feeds, by the method of calculation illustrated below.

As an example, the feed residue from steer 22 in digestion trial I in 1913, is chosen. The total residue was 6.5 pounds and contained 27.6 per cent of crude fiber, as determined by analysis. The so-called rectangular* method of calculation was found simple and convenient, and hence was employed as shown below:

The average percentages of crude fiber in the alfalfa and milo maize meal are written, respectively, opposite the upper

*See Van Nostrand's Chemical Annual, third issue, 1913, p. 563.

and lower left-hand corners of the rectangle. The percentage of crude fiber in the feed residue under consideration is written at the intersection of the diagonals. The difference between 27.6 and 29.62 is written at the lower right-hand corner, and the difference between 2.10 and 27.6 at the upper right-hand corner of the rectangle. Reading along the horizontal lines of the diagram from left to right it will be found that the figures at the right represent the parts by weight of alfalfa and milo, respectively, which will give a mixture containing 27.6 per cent of crude fiber. From this the percentage of alfalfa in the feed residue is easily calculated to be 92.66 per cent, as follows:

$$\frac{25.5}{27.52} \times 100 = 92.66.$$

The remainder, of course, is considered as milo maize.

By employing this method, the amounts of alfalfa and milo were calculated in all the feed residues and corrections applied in tables 30 to 33. Of course, objections can be raised against this method of correcting feed residues, but it seemed that for our purpose it answered the need better than any other method we could employ. The above method was employed in calculating the quantities of alfalfa and milo eaten, by months, and was not used in connection with the digestion trials.

Digestibility of Rations.

Two representative steers of each age were chosen for the digestion trials; that is, so far as possible one steer representing the better steers in the group was selected, and another representing the poorer ones. In making the selections, however, the disposition and tameness of the individuals had much to do with the choice.

Three sets of digestion trials were conducted in the experiments of 1913. Trial I was conducted from the 18th to

the 20th days; trial II from the 68th to 78th days, and the third trial from the 103rd to the 113th days of the feeding period. The steers selected were numbers 28 and 30 of the calves, and 22 and 24 of the yearlings. In 1915, on account of the hot weather, only two sets of digestion trials were conducted. These two trials correspond to the first and second in the series of 1913. The steers used in the tests were the following: two-year-olds, 36 and 38; and three-year-olds 31 and 33.

In trials I and III of 1913, steer 24 was off feed so badly that the results from him will be omitted in considering averages. During these trials his feces appeared very coarse and fibrous, having an odor not unlike that of silage mingled with fecal matter. At times much mucus streaked with blood was voided with the feces. During trial II this steer ate well and appeared normal, so it was thought he would pass through the third trial in good condition.

Steer 31 of the 1915 trials passed through the first digestion trial very well, but went off feed badly during trial II, refusing more than one-third of the feed offered him. This was evidently due to the bad wire punctures of the stomach which were observed when he was slaughtered.

In the first set of trials each year alfalfa and milo maize meal were fed in the proportions of 2 of the former to 1 of the latter, but in the second and third trials equal parts of hay and grain were fed.

The composition of the feeds used in the digestion trials is given in tables 1 to 4. For reference, the weights of feeds, feed residues, excreta, composition of feeds and feed residues, feces, nitrogen in urine and other data connected with these trials are given in tables 30 to 47 of the appendix.

The coefficients of digestibility were determined in the usual manner, by subtracting the average amounts of the various nutrients voided daily by the different individuals from the average daily intake and considering the difference

as representing the quantities of the nutrients digested in each instance. From the quantities ingested and digested, the percentage digestibility or coefficients of digestibility were calculated. Since metabolic products were not considered, the coefficients here given represent apparent digestibility.

Since different lots of feed were used during the two years, the coefficients of one year cannot well be compared directly with those of the other. The results of the various digestion trials during the two years are given in the following tables:—

TABLE 5.—PERCENTAGE DIGESTIBILITY OF RATIONS, 1913.
Alfalfa Hay and Milo Maize Meal.

	Dry matter, per cent	Ash, per cent	Organic matter, per cent	Protein, per cent	Non-protein, per cent	Crude fiber, per cent	Nitrogen-free extract, per cent	Ether extract, per cent	Total nitrogen, per cent
Digestion Trial I.									
Yearlings.									
Steer 22,	66.15	50.45	67.36	56.69	100.00	39.61	79.09	47.55	63.17
Steer 24,	63.08	52.02	63.86	54.72	100.00	-2.84	77.75	48.28	59.48
Average	64.62	51.24	65.61	55.70	100.00	18.39	78.42	47.92	61.32
Calves.									
Steer 28	71.20	57.94	72.15	58.39	100.00	45.27	82.20	51.08	64.07
Steer 30	65.32	48.88	66.57	54.95	100.00	41.55	77.50	44.57	61.40
Average	68.26	53.41	69.36	56.67	100.00	43.41	79.85	47.83	62.74
Average of all	66.44	52.33	67.49	56.19	100.00	30.90	79.14	47.88	62.04
Average, omitting steer 24,	67.56	52.42	68.69	56.68	100.00	42.14	79.60	47.73	62.88
Digestion Trial II.									
Yearlings.									
Steer 22	69.22	41.96	70.56	55.43	100.00	43.86	79.67	61.25	60.78
Steer 24	69.76	39.60	71.35	53.84	100.00	50.37	80.42	58.69	59.93
Average	69.49	40.78	70.96	54.64	100.00	47.12	80.04	59.97	60.36
Calves.									
Steer 28	68.45	37.05	70.16	57.91	100.00	41.28	80.47	59.85	63.73
Steer 30	67.85	42.38	69.21	49.97	100.00	51.24	77.89	54.82	56.63
Average	68.15	39.72	69.69	53.94	100.00	46.26	79.18	57.34	60.18
Average of all	68.82	40.25	70.33	54.29	100.00	46.69	79.61	58.66	60.27
Digestion Trial III.									
Yearlings.									
Steer 22	71.80	41.99	73.18	56.06	100.00	39.72	82.33	51.79	60.47
Steer 24	71.33	41.16	73.11	53.76	100.00	36.32	84.00	42.67	58.98
Average	71.57	41.58	73.15	54.91	100.00	38.02	83.17	47.23	59.73
Calves.									
Steer 28	69.03	45.82	70.05	52.83	100.00	36.66	81.44	49.21	59.20
Steer 30	69.59	49.02	70.75	52.20	100.00	37.81	81.10	45.82	57.99
Average	69.31	47.42	70.40	52.52	100.00	37.24	81.27	47.52	58.60
Average of all	70.44	44.50	71.78	53.72	100.00	37.63	82.22	47.38	59.17
Average, omitting steer 24	70.14	45.61	71.33	53.70	100.00	38.06	81.62	48.94	59.22
Average, second and third trials	69.63	42.11	70.74	53.23	100.00	42.54	80.92	53.06	59.72
Average, second and third trials, omitting steer 24 in trial III,	69.40	42.55	70.75	54.03	100.00	42.99	80.47	54.49	59.82

TABLE 6.—PERCENTAGE DIGESTIBILITY OF RATIONS, 1916.
Alfalfa Hay and Milo Malze Meal.

	Dry matter, per cent	Ash, per cent	Organic matter, per cent	Protein, per cent	Non-protein, per cent	Crude fiber, per cent	Nitrogen-free extract, per cent	Ether extract, per cent	Total nitrogen, per cent
Digestion Trial I.									
Three-year-olds.									
Steer 31	57.11	28.59	58.84	51.29	100.00	33.57	72.40	53.53	58.13
Steer 33	60.79	31.81	62.56	53.59	100.00	37.59	76.40	56.18	60.04
Average	58.95	30.20	60.70	52.44	100.00	35.58	74.40	54.86	59.09
Two-year-olds.									
Steer 36	62.42	36.37	63.99	53.57	100.00	40.27	77.37	60.53	60.11
Steer 38	65.03	41.80	66.45	60.18	100.00	39.50	80.79	60.74	65.79
Average	63.73	39.09	65.22	56.88	100.00	39.89	79.08	60.64	62.95
Average of all	61.34	34.65	62.96	54.66	100.00	37.74	76.74	57.75	61.02
Digestion Trial II.									
Three-year-olds.									
Steer 31	68.46	49.76	70.02	66.03	100.00	31.23	82.01	71.42	69.64
Steer 33	64.96	37.59	66.38	58.13	100.00	34.90	78.14	65.21	62.58
Average	66.71	43.68	68.20	62.08	100.00	33.07	80.08	68.32	66.11
Two-year-olds.									
Steer 36	64.59	40.58	65.84	55.71	100.00	34.66	77.91	63.54	60.44
Steer 38	65.91	38.33	67.34	55.55	100.00	42.95	77.66	59.54	60.31
Average	65.25	39.46	66.59	55.63	100.00	38.81	77.79	61.54	60.38
Average of all omitting steer 31	65.15	38.84	66.52	56.46	100.00	37.50	77.90	62.76	61.11

Effect of Age and Individuality of Animals on Digestion Coefficients. To facilitate the consideration of the relative digestive powers of the various individuals and ages of steers with special reference to any influence of age and individuality upon the same, the differences between the coefficients obtained with individuals of the same age and the average coefficients of steers of different ages are given in the following tables:—

TABLE 7.—DIFFERENCES IN DIGESTION COEFFICIENTS, 1913.

	Difference above other coefficient or coefficients					
	Calves		Yearlings		Calves	Yearlings
	Steer 28	Steer 30	Steer 22	Steer 24		
Digestion Trial I.						
Dry matter	5.88		3.07		2.11	•
Ash	9.06			1.57	2.96	
Organic matter ..	5.58		3.50		2.00	
Protein	3.44		1.97			.02
Non-protein						
Crude fiber	3.72				3.80	
Nitrogen-free ex-						
tract	4.70		1.34			.76
Ether extract	6.51			.73	.28	
Total nitrogen	2.67		3.69			.43
Digestion Trial II.						
Dry matter	.60			.54		1.34
Ash		5.22	2.26			1.06
Organic matter ..	.95			.79		1.27
Protein	7.94		1.59			.70
Non-protein .....						....
Crude fiber		9.96		6.51		.86
Nitrogen-free ex-						
tract	2.58			.75		.86
Ether extract	5.03		2.56			2.63
Total nitrogen	7.10		.85			.18
Digestion Trial III						•
Dry matter		.56	.47			2.49
Ash		3.20	.83		5.43	
Organic matter ..		.70	.07			2.78
Protein	.63		2.30			3.54
Non-protein .....						....
Crude fiber		1.15	3.40			2.48
Nitrogen-free ex-						
tract	.34			1.67		1.06
Ether extract	3.39		9.12			4.27
Total nitrogen	1.21		1.49			1.87

*As steer 24 was badly off feed during these trials, the results with steer 22 alone are used in comparisons in trials I and III.

TABLE 8.—DIFFERENCES IN DIGESTION COEFFICIENTS, 1915.

	Difference above other coefficient or coefficients					
	Two-year-olds		Three-year-olds		Two-year-olds	Three-year-olds
	Steer 36	Steer 38	Steer 31	Steer 33		
Digestion Trial I.						
Dry matter		2.61		3.68	4.78	
Ash		5.43		3.22	8.89	
Organic matter ..		2.46		3.72	4.52	
Protein		6.61		2.30	4.44	
Non-protein .....		.....		.....	.....	
Crude fiber	.77	.....		4.02	4.31	
Nitrogen-free extract	3.42	.....		4.00	4.68	
Ether extract .....	.....	.21		2.65	5.78	
Total nitrogen ...	5.68	.....		1.91	3.86	
Digestion Trial II.						
Dry matter		1.32	3.50		.29	*
Ash	2.26		12.17		1.87	
Organic matter ..		1.50	3.64		1.21	
Protein	.16		7.90			2.50
Non-protein .....	.....	.....	.....	.....	.....	.....
Crude fiber		8.29		3.67	3.91	
Nitrogen-free extract	.25		3.87			.35
Ether extract ...	4.00		6.21			3.67
Total nitrogen ...	.13		7.06			2 20

*In digestion trial II the coefficients from steer 33 alone are compared with the averages of steers 36 and 38, as steer 31 was badly off feed during this trial.

From a cursory inspection of the data in table 7, it appears that steer 28 digested his rations decidedly better than steer 22 in trial I. In the second trial the advantage is still with steer 28, although with reference to dry matter and organic matter, it is not large. Comparing the results for dry and organic matter in trials II and III, it will be seen that in trial II the advantage is with steer 28, whereas in trial III it is with steer 30; the advantage in either case being about the same.

A comparison of steers 22 and 24 makes it appear that steer 22 digested his rations better than steer 24 in trials I and III, but when it is recalled that steer 24 was off feed and

apparently having digestive disturbances, the comparison is of little value. In trial II, when steer 24 appeared normal, the results are mixed in character, with no decided advantage either way.

Steer 38 of the two-year-olds digested the dry and organic matter of the ration better than 36 in both digestion trials, but when the individual nutrients are considered, rather wide variations are found.

Steer 33 in digestion trial I digested his ration, as a whole, noticeably better than steer 31; but in trial II, when steer 31 was markedly off feed, the results are practically reversed.

While it appears in some instances that certain individuals digested their rations better than the others, the results are not consistent, and when the various other influences affecting the results are considered it seems doubtful if any real difference in digestive powers is indicated between individuals of the same age.

A comparison of the differences in the average coefficients from different ages of steers shows no conclusive difference in favor of one age over another. The comparisons, of course, are not very satisfactory, as in trials I and III in 1913 the averages of coefficients from two calves are compared with those of only one steer, and a similar comparison is made in trial II in 1915.

On the whole, there appears to be as great, or even greater, differences between the coefficients of individuals of the same age as between average coefficients of the steers of different ages.

In the case of the calves and yearlings it appears that the yearlings which had passed through at least one of the semi-starvation or submaintenance periods digested their rations as well as the calves which had not experienced any such period. A comparison of the results with the two-year-olds and three-year-olds indicates that in trial I the former di-

gested their rations better than the latter; but in the second trial there is not much difference, although it lies chiefly in favor of the two-year-olds.

The data under consideration afford no conclusive evidence of any impairment of the digestive powers of the animals because of these submaintenance periods, as the variations observed might be due to other causes. In general, the coefficients of digestibility of the dry matter in the trials with the older steers are lower than those from the calves and yearlings for corresponding periods; but this is probably due to the coarser hay fed to the former.

Effect of Amount of Feed on Digestion Coefficients

As to whether or not some of the variations in the digestion coefficients observed among the various individuals, and trials, might be ascribed to differences in the amounts of feed consumed will be considered briefly in connection with the data of tables 9 and 10.

TABLE 9.—DRY MATTER OF ALFALFA HAY AND MILO MAIZE MEAL
EATEN IN DIGESTION TRIALS, 1913.

		Dry matter consumed per day	
	Average live weight, pounds.	Per head, pounds.	Per 1,000 pounds live weight, pounds.
Digestion Trial I.			
Yearlings.			
Steer 22.....	745.5	15.979	21.434
Steer 24.....	739.0	7.684	10.398
Calves.			
Steer 28	546.0	8.372	15.333
Steer 30	445.0	9.054	20.346
Digestion Trial II.			
Yearlings.			
Steer 22	900.6	19.339	21.473
Steer 24	764.7	10.923	14.284
Calves.			
Steer 28	667.0	10.924	16.376
Steer 30	514.5	8.779	17.046
Digestion Trial III.			
Yearlings.			
Steer 22	986.2	16.533	16.764
Steer 24	813.7	8.712	10.707
Calves.			
Steer 28	739.5	12.731	17.216
Steer 30	575.7	9.816	17.051

TABLE 10.—DRY MATTER OF ALFALFA HAY AND MILO MAIZE MEAL EATEN IN DIGESTION TRIALS, 1915.

	Average live weight, pounds	Dry matter consumed per day.	
		Per head, pounds.	Per 1,000 pounds live weight, pounds.
Digestion Trial I.			
Three-year-olds.			
Steer 31	999.1	13.965	13.978
Steer 33	1080.1	17.463	16.168
Two-year-olds.			
Steer 36	922.1	13.097	14.203
Steer 38	880 0	13.970	15.875
Digestion Trial II.			
Three-year-olds.			
Steer 31	1058.1	12.382	11.702
Steer 33	1191.7	21.387	17.947
Two-year-olds.			
Steer 36	1028.5	19.443	18.904
Steer 38	972.7	19.431	19.976

Various investigators have found that with an increase in the ration there results a decrease in apparent digestibility. If the data of the foregoing tables are considered with this in mind, it will be seen that in digestion trial I steer 28 consumed about one-fourth less feed per 1000 pounds live weight than steer 30, and the resulting coefficients are higher than those of steer 30. In trial II steer 28 consumed nearly as much feed as steer 30, with the result that the former steer has but little advantage over the latter, as regards dry and organic matter; while in trial III, where steer 28 consumed slightly more feed than steer 30, the advantage is with the latter, so far as dry and organic matter are concerned.

In trial II, steer 22 consumed about one-third more feed per 1000 pounds live weight than steer 24, and the advantage

is in favor of the latter as far as dry matter, organic matter, crude fiber, and nitrogen-free extract are concerned; thus agreeing, in a general way, with the results obtained with the calves in showing a tendency of the coefficients to vary inversely with the amount of feed.

However, a comparison of the relation of the amount of feed and the resulting coefficients in the digestion trials of 1915 give results that are almost directly opposed to those of 1913. Of course, our comparisons are not the same as comparisons of different amounts of feed and the resulting coefficients with the same individuals in successive trials, but evidently the observed variations in the coefficients cannot be accounted for through differences in the amounts of feed consumed.

A METHOD OF CALCULATING THE PERCENTAGE DIGESTIBILITY OF THE COMPONENTS OF THE RATIONS.

For the energy calculations it was desirable that the digestibility of the components of the rations, namely, alfalfa hay and milo maize meal, should be calculated. Since the digestibility of the feeds composing the rations had not been determined, except as fed in combination, the usual method of subtracting the digestible nutrients of one feed from the total nutrients digested in the mixed ration, and considering the remainder as being digested from the grain, was not applicable. Attempts to apply some of the average coefficients of digestibility of alfalfa as determined in previous experiments proved unsatisfactory, on account of differences in the composition of the hays fed in the various experiments; and it therefore became necessary to resort to another method.

In our experiments we had fed alfalfa and milo maize meal in different proportions in at least two trials, and since the milo maize apparently was more digestible than the alfalfa, as was indicated by the higher coefficients of digestibility when the proportions of milo were increased, it seemed alto-

gether feasible that the digestibility of the components of the ration could be calculated by taking into consideration the effect of the varying proportions of the constituents of the ration upon the resulting coefficients.

As applied to rations composed of two different feeds, the problem may be stated as follows: "To calculate the coefficients of digestibility of the components of similar rations from the results of digestion trials in which the components have been fed in combination, but in different proportions.

The known quantities are the amounts of feed consumed in each digestion trial and the resulting coefficients; and the unknown quantities, the percentage digestibility of each of the components. In general terms, the problem may be stated algebraically by representing the unknown quantities by letters x and y and the known quantities by letters a , a' , b , b' , etc., as shown below:—

Let x = Percentage digestibility of alfalfa.

Let y = Percentage digestibility of milo maize meal.

Let a = Grams of alfalfa eaten in digestion trial I.

Let b = Grams of milo maize meal eaten in digestion trial I.

Let a' = Grams of alfalfa eaten in digestion trial II.

Let b' = Grams of milo maize meal eaten in digestion trial II.

Let c = Percentage digestibility as determined in trial I.

Let c' = Percentage digestibility as determined in trial II.

From the foregoing statements the following equations were formulated:—

$$(1) \quad \frac{ax + by}{a + b} = c$$

$$(2) \quad \frac{a'x + b'y}{a' + b'} = c'$$

To illustrate the application of the foregoing equations

to the problem at hand, the calculation of the coefficients of digestibility of the dry matter of the rations fed in the digestion trials of 1913 will suffice.

In the first set of trials, an average of 3217.3 grams of alfalfa and 1833.6 grams of milo maize meal were eaten on a dry matter basis, and the resulting coefficient for the dry matter of the ration was 67.56. Similarly, in the second set of trials the steers ate on an average 2670.5 grams of alfalfa and 3098.9 grams of milo maize meal, and the resulting coefficient in this case was 69.40.

Substituting these known values in the foregoing equations, the values of x and y are found by solving the equations as shown below.

$$(1) \quad \frac{3217.3x + 1833.6y}{5050.9} = .6756$$

$$(2) \quad \frac{2670.5x + 3098.9y}{5769.4} = .6940$$

$$(1) \quad 3217.3x + 1833.6y = 3412.388$$

$$(2) \quad 2670.5x + 3098.9y = 4003.964$$

$$(1) \quad 1.755x + y = 1.8610$$

$$(2) \quad .862x + y = 1.2921$$

$$.893x = .5689$$

$$x = .6371$$

$$y = .7429$$

From the calculated values of x and y , it appears that the coefficients of digestibility of the dry matter of the alfalfa and milo maize meal in these trials were 63.71 and 74.29, respectively.

The method of calculation just illustrated is not as complicated as it appears at first sight, and, on the whole, is probably simpler and shorter than the usual methods employ-

ed for the purpose. In addition, the method affords a means of calculating the digestibility of the feeds composing the rations in cases where these feeds have been fed in combination but in different proportions in successive digestion trials, and where no determinations on the digestibility of any of the components of the rations have been made separately. In this method of calculation, as in others of this sort, the assumption is that the digestibility of the feeds composing the rations remains unchanged, although the proportions of the different feeds in the rations are varied.

PERCENTAGE DIGESTIBILITY OF THE COMPONENTS OF THE RATIONS.

The coefficients of digestibility of the alfalfa and milo maize meal fed in the experiments of 1913 and 1915 were calculated in the manner just illustrated and are given in the following table:—

TABLE 11.—COEFFICIENTS OF DIGESTIBILITY OF THE COMPONENTS OF THE RATIONS.

	Alfalfa hay, 1913, per cent	Milo maize meal 1913, per cent	Alfalfa hay, 1915, per cent	Milo maize meal, 1915, per cent
Dry matter	63.71	74.29	53.81	76.88
Organic matter	64.16	76.06	55.77	76.99
Protein	61.28	46.46	50.77	61.83
Non-protein	100.00	100.00	100.00	100.00
Crude fiber	41.28	67.70	37.96	36.90
Ether extract	31.66	63.18	40.10	70.84
Nitrogen-free extract	77.02	82.03	73.21	70.00
Total nitrogen	68.13	49.43	60.34	60.34

Owing to the wide variations in the coefficients for the ash in the different trials, no satisfactory results could be obtained by the foregoing method of calculation, and these they have been omitted from the table.

DIGESTIBLE NUTRIENTS IN FEEDS

The percentage of digestible nutrients in the feeds of the two years have been calculated from the average composition of the feeds as given in tables 1 to 4 by means of the coefficients given in the preceding table.

TABLE 12.—PERCENTAGES OF DIGESTIBLE NUTRIENTS IN DRY MATTER OF FEEDS.

	Alfalfa hay, 1913, per cent	Milo maize meal, 1913, per cent	Alfalfa hay, 1915, per cent	Milo maize meal, 1915, per cent
Dry matter	63.71	74.29	53.81	76.88
Organic matter	58.42	74.60	51.27	75.65
Protein	8.48	5.21	5.59	7.72
Non-protein	2.37	.52	1.85	.34
Crude fiber	12.23	1.42	14.84	.79
Ether extract	.44	1.89	.54	2.23
Nitrogen-free extract	33.77	66.65	28.28	64.21
Total nitrogen	1.850	.942	1.310	1.272

ESTIMATED ENERGY VALUES OF FEEDS

Although having previously pointed out that the metabolizable energy per unit of digestible organic matter in feeds of the same class is remarkably constant, Armsby* has recently published a set of values for the digestible organic matter in feeds of different classes, to be used in estimating the metabolizable energy where no direct determinations have been made.

As the hays fed during the two feedings differed considerably in composition, it was considered better to calculate the metabolizable energy from the digestible organic matter by means of the factors suggested, rather than using a fixed average value for the two years. The metabolizable energy of the milo maize meal was estimated in the same way.

On page 484 of the publication just cited, Armsby gives

*Armsby, H. P., "Net Energy Values of Feeding Stuffs for Cattle," in *Journal of Agricultural Research*, Vol. III, No. 6, p. 453.

the net energy values of a number of feeding stuffs, from which it may be calculated that the net energy of alfalfa and maize meal is 39.15 and 56.9 per cents, respectively, of the metabolizable energy in each case.

The energy values of the feeds, calculated in the manner just indicated, are given in table 13. The net energy value of milo maize has been calculated by assuming the same percentage availability of the metabolizable energy as that calculated for maize meal, from the publication just cited.

TABLE 13.—ESTIMATED ENERGY VALUE OF FEEDS PER POUND OF DRY MATTER.

	Metabolizable energy, therms	Net energy, therms
Alfalfa, 1913	.9275	.3631
Alfalfa, 1915	.8140	.3187
Milo maize meal, 1913	1.3197	.7509
Milo maize meal, 1915	1.3383	.7615

GAINS IN LIVE WEIGHTS

The steers used in the experiments of 1913 were delivered at the Experiment Station about the middle of November, 1912, and were put into the individual feed lots on November 26. From this date until the experiments started, January 2, 1913, the steers were fed a light but sufficient ration to keep them in good condition, without making appreciable gains. About fifteen days before beginning the regular feeding periods small amounts of milo maize meal were fed, so as to accustom the animals to the grain. The quantity of grain was increased as the date for starting the experiment drew near, so that at the time of starting the feeding periods proper, the steers might be considered as being in equilibrium with their rations. This pre-

liminary period was necessary in order to tame the steers sufficiently to use them in the digestion trials.

The steers used in the experiments of 1915 were delivered at the Experiment Station during November and the first part of December. They were dehorned December 11, and in order to allow their wounds to heal, no effort was made to tame the steers until after January 6, 1915, when they were removed to the individual feeding lots used in the experiments. The wounds of steers 31 and 39 became infested with worms, thus requiring treatment for some time.

Owing to the slowness with which the wounds healed, and the fact that these steers were wilder than those fed in 1913, a longer time was required for taming the steers sufficiently to begin the experiment. These steers, like those of 1913, were fed only enough to keep them in condition during this preliminary period.

Before considering the actual gains in live weight, it may be well to consider the diagrams showing graphically the gains of the various steers, during the experiments.

The points in the diagrams for the calves and yearlings at the beginning of the experiment and at the end of each 30 days, are the results of averages of three weighings on successive days, whereas the intermediate points are the results of single weighings by 10-day periods; but in the diagrams of the weights for 1915, all points were determined by averaging the weights for three successive days.

Calves Considering first the calves, it will be noticed from the diagram (Fig. 1) that steer 26 made but small and somewhat irregular gains. This was the poorest steer in the bunch, and could not be induced to eat enough to make satisfactory gains.

Steer 27, although a better steer, was especially subject to fasting and consequently irregular in his eating. From the 50th to the 110th days he made rather regular gains, but dropped off during the last ten days of the experiment. When

slaughtered a very noticeable gritty deposit, apparently chiefly inorganic, was found on the leaf like papillae on the inner walls of the paunch. The cause of the deposit and what connection it may have had with the tendency of this steer to bloat, we cannot say; but that there is a connection seems certain, as similar deposits, though not so marked, have been observed in other individuals with this same tendency.

The remaining steers of this group, although showing considerable irregularity in their gains during the early part of the period, made fairly regular gains later. Steer 28 was found to have a piece of baling wire through the back part of his tongue, when slaughtered, but apparently this had not caused much trouble, as he was one of the best steers in the group.

FIGURE 1.

Yearlings. A glance at the diagram (Fig. 2) shows at once that steer 24 made very poor gains. He went off feed during the first and third digestion trials and apparently never really thrived during the whole period. No definite cause can be assigned for this.

Steer 21 shows considerable irregularity during the first month, but thereafter gained regularly until the fourth month was reached. During this month he was irregular in his eating and made no gains in weight. This falling off in the rate of gain during the fourth month was evidently due to wire punctures through the walls of the honey-comb, as two punctures were found when the steer was slaughtered.

Steer 22 made by far the best gains of any of the steers, being the lightest steer in the group at the start and finishing nearly as heavy as steer 23, the heaviest of the yearlings.

Steer 23 made fairly regular gains throughout the period, while steer 25 was irregular during the early part of the period and a little irregular toward the end.

FIGURE 2.

Two-year-olds. In this group, as in the others, there is an "off steer;" the one in this group being steer 37. This steer, like No. 27 of the calves, bloated frequently and therefore would not eat enough to make satisfactory gains. As in the case of steer 27, a gritty deposit on the inner walls of the paunch was observed, although it was not as marked as in the former case.

The most noticeable feature in regard to the other steers is the general parallelism of the gains. Upon close inspection it will be observed that the steers kept in the open feed lots throughout the period made better gains than the ones used in the digestion trials. These greater gains appear to be due to advantage gained through increasing the rations while the other steers were on the digestion trials.

FIGURE 3.

Three-year-olds. That this was an unsatisfactory lot of steers for experimental purposes has been commented upon previously, but a glance at the diagram brings this out more clearly. It will be observed that they differed greatly as regards live weights at the start, and the lack of uniformity of type, condition, etc., has already been mentioned. From such a lot of steers one could not expect very satisfactory results, but it was thought they would show up a little better than they did.

Steer 35 is the "off steer" of this lot, so far as gains are concerned. He was the lightest steer of the bunch and never thrived in the feed lot, although he was picking up towards the end of the experiment. When slaughtered it was found that he had some tumors along the digestive tract, but he was not tubercular. This condition, no doubt, accounts for the small gains which he made.

Steer 31 started out fairly well, but went off feed badly during the second digestion trial. Following this trial, he appeared to be recovering satisfactorily when suddenly he again went off feed and this time he continued to fail to the end of the experiment. Upon examination at the time of slaughtering, a piece of baling wire was found deeply imbedded in the musculature surrounding the orifice between the first and second stomachs, in such a way as to cause irritation and pain. Evidently this was the cause for his poor showing.

Steer 32 dropped off slightly early in the feeding period, but soon began gaining and continued to do so satisfactorily, up to the sixtieth day, when he suddenly went off feed. He recovered in a few days and gained fairly well to the end of the test, but never quite overcame the effects of the "set-back."

Steer 33 gained regularly and satisfactorily up to within ten days of the end of the test. He then suddenly went off feed for a few days, and was just beginning to recover when

the test ended. He continued to gain up to the time he was slaughtered, a few days later.

Although steer 34 appeared in every respect the poorest steer in the group, he was the only one that made regular and satisfactory gains throughout the period. He was very thin at the start, and was by no means a well finished or well balanced animal at the end, although he had improved considerably.

FIGURE 4.

Comparative Gains of the Various Ages of Steers. For convenience in comparing the gains made by the various groups of steers, the following table has been prepared.—

TABLE 14.—LIVE WEIGHTS AND GAINS IN LIVE WEIGHT.

	Average weight, pounds	Initial weight, pounds	Final weight, pounds	Total gain, pounds	Average gain per day, pounds	Average daily gain per 1,000 pounds live weight, pounds
Experiment, 1913.						
Calves.						
Steer 26	513.5	482.3	580.3	98.0	.82	1.60
Steer 27	610.1	559.7	663.7	104.0	.87	1.43
Steer 28	653.1	556.7	767.3	210.6	1.76	2.69
Steer 29	572.5	498.7	681.3	182.6	1.52	2.66
Steer 30	501.5	422.3	588.3	166.0	1.38	2.75
Average per steer	570.1	503.9	656.2	152.2	1.27	2.23
Average, omitting steer 27	560.1	490.0	654.3	164.3	1.37	2.43
Average, omitting steers 26 and 27	575.7	492.6	678.9	186.4	1.55	2.70
Yearlings.						
Steer 21	820.4	720.0	904.7	184.7	1.54	1.88
Steer 22	862.2	703.3	999.0	295.7	2.46	2.85
Steer 23	888.1	778.3	1005.5	227.4	1.90	2.14
Steer 24	773.2	734.0	807.7	73.7	.61	.79
Steer 25	828.2	734.3	931.0	196.7	1.64	1.98
Average per steer	834.4	739.9	929.6	195.6	1.63	1.93
Average, omitting steer 24	849.7	734.0	960.1	226.1	1.89	2.21
Experiment, 1915.						
Two-year-olds.						
Steer 36	1018.4	911.7	1151.3	239.6	2.00	1.96
Steer 37	881.1	856.7	920.0	63.3	.53	.60
Steer 38	957.8	871.7	1065.0	193.3	1.61	1.85
Steer 39	1040.1	894.7	1190.7	296.0	2.47	2.76
Steer 40	974.6	833.3	1119.3	286.0	2.38	2.44
Average per steer	974.4	873.6	1089.3	215.6	1.80	1.92
Average, omitting steer 37	997.7	877.9	1131.6	253.8	2.12	2.25
Three-year-olds.						
Steer 31	1033.3	995.0	1023.7	28.7	.24	.23
Steer 32	1030.6	945.0	1107.7	162.7	1.36	1.32
Steer 33	1160.1	1063.3	1247.7	184.4	1.54	1.33
Steer 34	947.3	853.3	1071.0	217.7	1.81	1.91
Steer 35	839.2	806.7	896.7	90.0	.75	.89
Average per steer	1002.1	932.6	1069.4	136.7	1.14	1.14
Average, omitting steers 31 and 35	1044.5	953.9	1142.1	188.3	1.57	1.52

In considering the gains made by the various groups of steers it is well to remember that the calves and yearlings were fed one year, the two- and three-year-olds another, and that different lots of feed were used each year. The most striking difference in the composition of the feeds is with the alfalfa—that of 1915 being considerably coarser than that of 1913. Also, as previously stated, the steers used in 1913 differed from those of 1915 in reference to breeding, type, condition, etc.

Disregarding for the time being the different conditions just mentioned and considering the groups as a whole, it will be seen that the yearlings and two-year-olds made somewhat greater gains per day and head than the calves and three-year-olds, and that the last two made nearly equal gains. This holds true whether the average results of all the steers in each group or the averages with doubtful or abnormal steers omitted are considered. Taking the results with doubtful steers omitted, the average gains per day and head were as follows: calves, 1.55; yearlings, 1.89; two-year-olds, 2.12; and three-year-olds, 1.57 pounds. When the gains are calculated to a common basis of gains per 1,000 pounds of live weight, the figures for the respective ages of steers are 2.70, 2.21, 2.25 and 1.52 pounds; which shows that although the calves made about the same gains per day and head as the three-year-olds, and less gains than the yearlings and two-year-olds, they were, nevertheless, gaining at a more rapid rate per unit of body weight.

The figures for the gains per 1,000 pounds live weight in the case of the three-year-olds are, no doubt, too low in comparison with the others. Steer 33 made an average daily gain of 2.13 pounds during the first 110 days of the feeding period, which if continued for another ten days, would have raised the rate of gain for these steers considerably. There was also a break in the continuity of the gains by steer 32, which tended to make his gains a little low.

However, in spite of irregularities, the results in general are in harmony with those obtained in the experiments with alfalfa hay, in showing a decrease in rate of gain per unit of body weight with advancing age.

Feed Consumed for Gains Made

Although all the steers had been pretty well tamed before starting the regular feeding period, they were, no doubt, disturbed somewhat by being fastened up in the stanchions, led around with ropes, etc., especially during the first two or three weeks of the feeding period. On this account they probably did not consume as much feed as they would have done without these disturbances, and consequently did not make as large gains as they might have done under different conditions.

The amounts of feed consumed by individual steers and groups of steers of different ages, per day, per 1000 pounds live weight and per pound of gain are given in table 15.

TABLE 15.—FEED CONSUMED ON BASIS OF DRY MATTER.

	Feed consumed per day				Food consumed per pound gain in live weight, pounds
	Alfalfa hay, pounds	Milo maize meal, pounds	Total per steer, pounds	Per 1,000 pounds average live weight, pounds	
Experiment, 1913.					
Calves.					
Steer 26	5.16	3.60	8.76	17.06	10.68
Steer 27	5.17	4.20	9.37	15.36	10.77
Steer 28	6.36	4.80	11.16	17.09	6.34
Steer 29	6.08	4.69	10.77	18.81	7.09
Steer 30	5.58	4.70	10.28	20.50	7.45
Average per steer	5.67	4.40	10.07	17.76	8.47
Average, omitting steer 27	5.80	4.45	10.25	18.37	7.89
Average, omitting steers 26 and 27	6.01	4.73	10.74	18.80	6.96
Yearlings.					
Steer 21	10.33	6.86	17.19	20.95	11.16
Steer 22	10.69	9.25	19.94	23.12	8.11
Steer 23	10.75	8.59	19.34	21.78	10.18
Steer 24	6.66	5.79	12.45	16.10	20.41
Steer 25	8.57	6.03	14.60	17.62	8.90
Average per steer	9.40	7.30	16.70	19.91	11.75
Average, omitting steer 24	10.09	7.68	17.77	20.87	9.57
Experiment, 1915.					
Two-year-olds.					
Steer 36	10.29	8.37	18.66	18.32	9.33
Steer 37	6.66	5.29	11.95	13.56	22.55
Steer 38	10.53	8.53	19.06	19.90	11.84
Steer 39	11.76	9.52	21.28	20.46	8.62
Steer 40,	11.51	9.28	20.79	21.33	8.73
Average per steer	10.15	8.20	18.35	18.71	12.21
Average, omitting steer 37	11.02	8.93	19.95	20.00	9.63
Three-year-olds.					
Steer 31	8.66	6.71	15.37	14.87	64.04
Steer 32	10.77	8.53	19.30	18.73	14.19
Steer 33	11.43	9.09	20.52	17.69	13.32
Steer 34	10.33	8.32	18.65	19.69	10.30
Steer 35	7.57	5.84	13.41	15.98	17.88
Average per steer	9.75	7.70	17.45	17.59	23.95
Average, omitting steers 31 and 35	10.84	8.65	19.49	18.70	12.60

Considering the averages of all the steers in each group, the various groups of steers per day and head consumed, in pounds, the following amounts of feed: calves, 10.07; yearlings, 16.70; two-year-olds, 18.35; three-year-olds, 17.45; while per 1,000 pounds average live weight the amounts are: 17.76, 19.91, 18.71, and 17.59, respectively. Considered as above the amounts of feed consumed per pound of gain are: calves, 8.47; yearlings, 11.75; two-year-olds, 12.21; and three-year-olds, 23.95.

If the results from the steers previously mentioned as doubtful or abnormal are omitted, the average amounts of feed consumed per steer and per 1,000 pounds live weight are increased somewhat; but on the other hand, the amounts of feed consumed per pound of gain are decreased and show smaller differences among the different groups. The amounts in pounds of feed consumed per steer, on this basis, are: calves, 10.74; yearlings, 17.77; two-year-olds, 19.95; and three-year-olds, 19.49; whereas, per 1,000 pounds live weight they are: calves, 18.80; yearlings, 20.87; two-year-olds, 20.00; and three-year-olds 18.70. It will be noticed that the calves and three-year-olds ate nearly the same amounts of feed per 1,000 pounds live weight, and less than either the yearlings or two-year-olds. Table 14 shows that the calves and the three-year-olds made practically the same gains per day and head, and that the yearlings and two-year-olds, which, as shown above, consumed relatively more feed, also made greater gains. However, the yearlings ate relatively more feed than the two-year-olds, but made smaller gains.

The pounds of feed consumed per pound of gain are as follows: calves, 6.96; yearlings, 9.57; two-year-olds, 9.63; and three-year-olds, 12.60. Although the calves and three-year-olds consumed practically the same quantity of feed per unit of body weight, the three-year-olds required nearly twice as much feed as the former per pound of gain, and the yearlings and two-year-olds nearly one-third more. In this series

of experiments, as in the alfalfa series previously referred to, there was very little difference between the amounts of feed consumed per unit of gain by the yearlings and two-year-olds, and they occupy an intermediate position, as compared with the calves and three-year-olds.

The amounts of feed required by the three-year-olds per pound of gain are probably a little high, owing to the fact that steer 33 went off feed badly, about ten days before the experiment ended, and consequently did not end up in good condition. During the first 110 days of the experiment this steer required only 10.76 pounds of feed per pound of gain, as compared with 13.32 for the whole period. For practical purposes the yearlings and two-year-olds required the same quantities of feed per unit of gain, as the differences observed are too small to be significant; especially in consideration of the differences in the feed, steers used, etc.

Character of Gains Indicated by Nitrogen Balances.

In connection with the digestion trials the urine was collected, weighed, sampled, and its nitrogen content determined. From the nitrogen content of the feeds, feed residues and excreta the income and outgo of nitrogen during the several digestion trials has been calculated. In the following tables a correction for the growth of epidermal tissues has been applied, using the average values given by Armsby and Fries* and calculating the amounts in proportion to the two-thirds power of the live weights of the steers:—

*Armsby, H. P., and Fries, J. August, "The Influence of Type and Age upon the Utilization of Feed by Cattle," U. S. Dept. of Agriculture, Bureau of Animal Industry, Bul. 128, p. 198.

TABLE 16.—NITROGEN BALANCES, 1913.

	Calves				Yearlings			
	Steer 28		Steer 30		Steer 22		Steer 24	
	Income, grams	Outgo, grams	Income, grams	Outgo, grams	Income, grams	Outgo, grams	Income, grams	Outgo, grams
Digestion Trial I.								
Alfalfa hay	107.2		90.5		141.5		136.5	
Milo maize meal	35.4		29.7		46.4		44.8	
Feed residues		51.3		17.6		7.3		96.4
Feces		32.8		39.6		66.5		34.4
Urine		41.7		47.1		96.5		59.0
Epidermal tissues ...		1.3		1.1		1.6		1.6
Gain +; loss -		+15.5		+14.8		+16.0	-10.1	
	142.6	142.6	120.2	120.2	187.9	187.9	191.4	191.4
Digestion Trial II.								
Alfalfa hay	69.3		59.4		143.5		74.2	
Milo maize meal	46.5		39.8		96.3		49.8	
Feed residues				6.5		39.9		9.2
Feces		42.0		40.2		78.4		46.0
Urine		56.2		39.3		106.7		57.8
Epidermal tissues ...		1.5		1.2		1.8		1.6
Gain +; loss -		+16.1		+12.0		+13.0		+9.4
	115.8	115.8	99.2	99.2	239.8	239.8	124.0	124.0
Digestion Trial III.								
Alfalfa hay	77.3		72.5		140.2		91.8	
Milo maize meal	51.7		48.5		93.7		61.4	
Feed residues		.8		21.5		79.1		69.1
Feces		52.3		41.8		61.2		34.5
Urine		62.1		44.2		91.8		60.6
Epidermal tissues ...		1.6		1.3		1.9		1.7
Gain +; loss -		+12.2		+12.2	— .1		-12.7	
	129.0	129.0	121.0	121.0	234.0	234.0	165.9	165.9

TABLE 17.—NITROGEN BALANCES, 1915.

	Two-year-olds				Three-year-olds			
	Steer 36		Steer 38		Steer 31		Steer 33	
	Income, grams	Outgo, grams	Income, grams	Outgo, grams	Income, grams	Outgo, grams	Income, grams	Outgo, grams
Digestion Trial I.								
Alfalfa hay	85.4		91.1		91.0		113.8	
Milo maize meal	38.7		41.3		41.3		51.6	
Feces		49.5		45.3		55.4		66.1
Urine		77.9		79.8		83.0		107.3
Epidermal tissues ...		1.8		1.8		1.9		2.0
Gain +; loss —	-5.1			+5.5	-8.0		-10.0	
	129.2	129.2	132.4	132.4	140.3	140.3	175.4	175.4
Digestion Trial II.								
Alfalfa hay	97.5		97.5		97.5		107.2	
Milo maize meal	90.8		90.8		90.8		99.9	
Feed residues				.1		71.7		
Feces		74.5		74.7		35.4		77.5
Urine		98.5		110.6		73.6		109.4
Epidermal tissues ...		2.0		1.9		2.0		2.2
Gain +; loss —		+13.3		+1.0		+5.6		+18.0
	188.3	188.3	188.3	188.3	188.3	188.3	207.1	207.1

For convenience in considering the data, the average live weights of the steers during the digestion trials, the gains or losses of nitrogen and the equivalent protein per head and per 1,000 pounds live weight are given in table 18. The factor 6.0 was used in calculating the equivalent protein.

TABLE 18.—GAINS OF NITROGEN AND PROTEIN, 1913 AND 1915.

	Average live weight, pounds.	Gain of nitrogen, grams.	Equivalent Protein	
			Per head, grams.	Per 1,000 lbs. live weight, grams.
Experiment 1913.				
Calves.				
Steer 28.				
Digestion trial I.	546.0	+15.5	+ 93.0	+ 170.3
Digestion trial II.	667.0	+16.1	+ 96.6	+ 144.8
Digestion trial III.	739.5	+12.2	+ 73.2	+ 99.0
Steer 30				
Digestion trial I.	445.0	+14.8	+88.8	+ 199.5
Digestion trial II.	514.5	+12.0	+72.0	+ 139.9
Digestion trial III.	575.7	+12.2	+73.2	+ 127.1
Yearlings.				
Steer 22				
Digestion trial I.	745.5	+16.0	+96.0	+ 128.8
Digestion trial II.	900.6	+13.0	+78.0	+ 86.6
Digestion trial III.	986.2	-0.1	-0.6	- .6
Steer 24				
Digestion trial I.	739.0	-10.1	-60.6	- 82.0
Digestion trial II.	764.7	+ 9.4	+56.4	+ 73.8
Digestion trial III.	813.7	-12.7	-76.2	-93.6
Experiment, 1915.				
Two-year-olds.				
Steer 36				
Digestion trial I.	922.1	-5.1	-30.6	-33.2
Digestion trial II.	1028.5	+13.3	+ 79.8	+77.6
Steer 38				
Digestion trial I.	880.0	+5.5	+33.0	+37.5
Digestion trial II.	972.7	+1.0	+6.0	+6.2
Three-year-olds.				
Steer 31				
Digestion trial I.	999.1	-8.0	-48.0	-48.0
Digestion trial II.	1058.1	+5.6	+33.6	+31.8
Steer 33				
Digestion trial I.	1080.1	-10.0	-60.0	-65.5
Digestion trial II.	1191.7	+18.0	+108.0	+90.6

Although the results are irregular and in some instances fluctuate greatly from one trial to the next, with the same individual, it is obvious from the data in the last column of the table that the calves were gaining in protein at a much more rapid rate than the others. While there is an indication that the yearlings were gaining in protein a little more rapidly than the older steers, the irregularity of the results preclude any definite statement to that effect. Owing to a number of accidents, resulting in losses of urine during the experiments of 1915, some of the irregularities observed may possibly be due to that.

Net Energy, Digestible Protein and Nitrogen Consumed, and Estimated Energy in Gains.

The average net energy values of the rations consumed by the steers by months and for the entire feeding period were calculated for all the steers by means of the values given in table 13. Estimations of the maintenance requirements, the energy available for gains and the energy in each pound of gain were also made for the various steers by months, as well as for the entire feeding period. The maintenance requirement was calculated in proportion to the two-thirds power of the average live weights, on the basis of 6.16* therms per 1,000 pounds live weight. In estimating the maintenance requirements in this way we are aware that a variety of conditions affect these requirements, among which may be mentioned, muscular activity, time spent standing and lying, age, individuality, condition, etc. Armsby** has pointed out that the maintenance requirements of young cattle appear to be relatively higher than for older ones, and this has been confirmed in the experiments of Trowbridge, Moulton and Haigh†

*Armsby, H. P., "The Maintenance Rations of Farm Animals," U. S. Dept. of Agriculture, Bureau of Animal Industry Bul. 143, p. 47

**Same bulletin, pp. 64-74.

†Trowbridge, P. F., Moulton, C. R., and Haigh, L. D., "The Maintenance Requirement of Cattle," Missouri Agricultural Experiment Station Research Bulletin No. 18.

at the Missouri Experiment Station. Other things being equal, then, our estimates for the maintenance of the calves and yearlings are relatively too low, as compared with the older steers. On the other hand, the calves and yearlings, as a rule, are more easily tamed and in general are more quiet in the feed lots; which would have a tendency to offset the higher maintenance requirements as compared with the older steers. As we have no direct determinations of the maintenance requirements of the various individuals, nor any data on the relative muscular activity, time spent standing and lying, etc., it seems likely that for comparative purposes the estimates already made are, perhaps, as satisfactory as any.

TABLE 19.—NET ENERGY, DIGESTIBLE PROTEIN AND NITROGEN CONSUMED, AND ESTIMATED ENERGY IN GAINS.

	Digestible nitrogen per day, pounds	Digestible protein per day, pounds	Net energy per day			
			In feeds, therms	Estimated mainten- ance requirements, therms	Available for gain, therms	Estimated energy in one pound of gain therms
Experiment, 1913.						
Calves.						
Steer 26	.13	.60	4.58	3.95	.63	.77
Steer 27	.14	.65	5.03	4.43	.60	.69
Steer 28	.16	.79	5.92	4.54	1.38	.78
Steer 29	.14	.75	5.73	4.25	1.48	.97
Steer 30	.14	.71	5.55	3.89	1.66	1.20
Average	.14	.70	5.36	4.21	1.15	.88
Average, omitting steers 26 and 27.	.15	.75	5.73	4.23	1.51	.98
Yearlings.						
Steer 21	.31	1.20	8.90	5.40	3.50	2.27
Steer 22	.29	1.38	10.82	5.58	5.24	2.13
Steer 23	.28	1.34	10.35	5.69	4.66	2.45
Steer 24	.18	.86	6.76	5.19	1.57	2.57
Steer 25	.21	1.02	7.64	5.43	2.21	1.35
Average	.25	1.16	8.89	5.46	3.44	2.15
Average, omitting steer 24	.27	1.24	9.43	5.53	3.90	2.05
Experiment, 1915.						
Two-year-olds.						
Steer 36	.24	1.22	9.65	6.24	3.41	1.71
Steer 37	.15	.78	6.15	5.66	.49	.92
Steer 38	.25	1.25	9.85	5.99	3.86	2.40
Steer 39	.28	1.39	11.00	6.32	4.68	1.83
Steer 40	.27	1.36	10.74	6.06	4.68	1.97
Average	.24	1.20	9.48	6.05	3.42	1.78
Average, omitting steer 37	.26	1.31	10.31	6.15	4.16	1.99
Three-year-olds						
Steer 31	.20	1.00	7.87	6.30	1.57	6.54
Steer 32	.25	1.26	9.93	6.29	3.64	2.68
Steer 33	.27	1.34	10.57	6.81	3.76	2.44
Steer 34	.24	1.22	9.63	5.94	3.69	2.04
Steer 35	.1	.87	6.86	5.45	1.41	1.88
Average, omitting steer 31	.23	1.17	9.25	6.12	3.13	2.26
Average, omitting steers 31 and 35	.25	1.27	10.04	6.35	3.70	2.39

Protein. Considering first the amounts of digestible protein consumed by the various groups of steers, omitting the abnormal individuals in each group, it will be seen that the calves, yearlings, two-year-olds, and three-year-olds consumed .75, 1.24, 1.31, and 1.27 pound, respectively, of digestible true protein per day. A comparison of these data with the standards of Armsby*, in connection with the average live weights of the steers as given in table 14, shows that in every instance more protein was consumed than was necessary for maintenance, but on the other hand, none of the steers received as much protein as Armsby recommends for growing cattle. As might be expected, the discrepancy in respect to protein is greatest with the calves, as no provision was made to meet the relatively greater demand for protein on the part of the younger animals. However, the amounts of protein consumed by the steers are smaller than it was intended they should be, as the steers consumed less feed than anticipated.

Net Energy of Rations. From a consideration of the estimated energy values of the rations, it appears that the calves received more than enough energy for maintenance, but not as much as Armsby allows for growing cattle. The other steers, apparently, received an ample allowance of energy for maintenance and growth, with a surplus for fattening purposes.

The relatively small gains made by the calves in this series of experiments are no doubt due to the lack of sufficient protein and energy in the rations consumed, on account of the relatively small amount of feed eaten.

Relative Energy Content of Gains. The data regarding the estimated energy content per unit of gain, taken as they stand, indicate that the yearlings and two-year-olds stored approximately twice as much energy per unit of gain, and

*Armsby, H. P., United States Department of Agriculture, "The Computation of Rations for Farm Animals by the Use of Energy Values;" Farmers' Bulletin No. 346, pp. 16-18.

the three-year-olds nearly two and a half times as much as the calves. In other words, with increasing age of the animals, and consequent decrease in rate of growth, there is an increase in the energy stored per unit of gain. If the maintenance requirements of the younger animals are relatively greater than the requirements of the older ones, other things being equal, the differences just noted should be larger.

With reference to the energy stored per unit of gain during the different months of the feeding period by the various steers, it should be stated that wide variations were observed among the individuals of the same group, as well as with the same individuals, during the different months. In general, however, the steers consumed more and more energy above the maintenance requirements as the feeding period advanced, and also more energy was stored per unit of gain. To bring out the latter point more clearly, the average amounts of energy stored by the various groups of steers have been tabulated by months, and are given in table 20. In preparing the averages the diagrams of the live weights were referred to and only those steers showing fairly regular and uniform gains for a given month were considered. For instance, the data regarding steer 32 are included in the averages for the first, second and fourth months, with the third month omitted, as he was off feed for several days during the month. The averages are intended to indicate the nature of the gains of the different groups of steers by months, while making fairly uniform gains; and therefore those steers showing any great irregularity for any cause have been left out of consideration in this connection.

TABLE 20.—ESTIMATED ENERGY IN GAINS BY MONTHS

Estimated energy in one pound of gain, therms				
	First month	Second month	Third month	Fourth month
Calves	1.04	.53	1.09	1.24
Yearlings	1.95	1.75	1.76	3.68
Two-year-olds ...	.70	1.49	2.34	3 16
Three-year-olds..	2.15	1.52	2.44	2.79

The estimated energy per unit of gain for the first month shows considerable irregularity among the groups and also averages noticeably higher than during the following month, except in the case of the two-year-olds. A glance at the diagram of the live weights reveals greater irregularities in the gains of the individuals during the first month than during the later months of the periods, and possibly this may account, in part, for the irregularities noted. Aside from the high values during the first month, the general tendency is toward a greater storage of energy per unit of gain as the feeding period advances.

SLAUGHTER TESTS.

All the steers fed in these experiments were slaughtered shortly after the feeding period ended. As there are no facilities for slaughtering at the Experiment Station, this was done under difficulties at a privately owned slaughter house near by. However, the tests were conducted as carefully as possible under the conditions.

The evening preceding the slaughter, the steers were taken to the yards at the slaughter house, where they received enough alfalfa to keep them quiet and contented until they were slaughtered in the morning. The steers, in each case, were weighed immediately before going to the slaughter house but as the scale was some distance from the killing room, oc-

casionally losses of feces and urine occurred, which make it impossible to tell just what the fill of the animal was at the time of weighing.

The results of the slaughter tests are given in detail in tables 50 to 55 of the appendix. The average results for the steers of different ages are summarized in the following table:

TABLE 21.—RESULTS OF SLAUGHTER TESTS, AVERAGE PERCENT-AGES, 1913 AND 1915.

	Calves, average per cent.	Yearlings, average per cent.	Two-year-olds, average per cent.	Three-year-olds, average per cent.
Dressed beef, warm	57.08	59.24	58.72	57.59
Right half carcass	28.35	29.44	29.23	28.75
Left half carcass	28.73	29.80	29.49	28.82
Hide	7.85	7.48	6.51	6.67
Tail	.26	.21	.23	.23
Head	2.86	2.51	2.47	2.57
Tongue and trimmings	.63	.57	.51*	.56
Feet	1.88	1.71	1.68	1.88
Heart	.45	.41	.40	.44
Lungs and windpipe	1.45	1.42	1.35	1.44
Liver	1.07	1.08	1.13	1.05
Fat,				
Total	1.85	2.83	2.86	2.28
Caul	1.15	1.65	1.36	1.07
Intestinal and pluck	.70	1.18	1.49	1.20
Stomachs with contents	13.87	12.52	11.88	13.06
Stomachs empty	3.15	3.30	3.10	3.13
Intestines empty	1.97	1.88	2.02	2.00
Spleen .....	....	....	.21	.24
Internal organs and trimmings not in- cluded above	1.42	1.50	1.17	1.10

*Average results from four steers only owing to a doubtful weight in the case of steer 37.

On the average, the calves yielded a lower percentage of dressed beef than the yearlings or two-year-olds, and nearly the same as the three-year-olds. Reference to tables 51 and 53 of the appendix shows that steers 26 and 27 dressed 53.28 and 52.37 per cents, respectively. Since these were "off steers" throughout the experiment, it may be well to consider the average with these omitted, in which event the average percentage of dressed beef for this group is 59.92; which compares favorably with the yearlings and two-year-olds. If steer 35 of the three-year-olds, which averaged about 3 per cent lower than the lowest of the others, is omitted, the average for the remaining three-year-olds is 58.42, an average pretty close to the two-year-olds. Considering the small number of steers in each lot, there are, apparently, no really significant differences in the percentages of dressed beef yielded in favor of one age or group of steers over another.

However, a comparison of the percentages of dressed beef in this series of experiments with those of the alfalfa hay series, is of interest in this connection.

TABLE 22.—AVERAGE PERCENTAGES OF DRESSED BEEF IN ALFALFA HAY AND MILO MAIZE MEAL EXPERIMENTS.

	Calves, per cent	Yearlings, per cent	Two-year-olds, per cent	Three-year-olds, per cent
Dressed beef, alfalfa experiment	52.75	50.32	51.10	57.30
Dressed beef, milo maize experiment	57.08	59.24	58.72	57.59
Difference in favor of alfalfa and milo maize meal	4.33	8.92	7.62	.29

With the exception of the three-year-olds, the steers fed on alfalfa and milo maize dressed a considerably higher per

cent of beef than the steers of corresponding ages in the alfalfa hay series. This, of course, is in harmony with the better finish possessed by the former at the end of the tests.

Wholesale Cuts of Beef. The right halves of the carcasses of two steers from each group were taken to the refrigerator at the Experiment Station, where they were thoroughly chilled, and at the end of forty-eight hours, cut up into the regular "wholesale cuts." The latter part of the foregoing statement requires qualification, however. Meat cutters were employed to do the cutting up of the carcasses, with instructions to divide them into the usual wholesale cuts. We have since learned that in this section of the country the carcasses are not divided in accordance with the methods in use in the packing houses of the larger cities, and on this account these data are not strictly comparable with similar data where the packing house methods have been followed.

In separating the fore and hind quarters, the practice in this locality is to leave two ribs on the hind quarter, instead of one, so that our hind quarters are relatively heavier than the front quarters as compared with carcasses divided according to the usual method.

We have, of necessity, employed different persons to do the meat cutting, from year to year, and as a result we find that the different individuals do not make the cuts in exactly the same way. In other words, such meat cutters as we have been able to secure, apparently have not been trained to cut meat according to any standardized method. On this account, too much importance should not be attached to minor variations of the data.

TABLE 23.—AVERAGE PERCENTAGES OF FORE AND HIND QUARTERS AND OF WHOLESALE CUTS IN RIGHT HALF CARCASS, 1913 AND 1915.

	Calves, per cent	Yearlings, per cent	Two-year-olds, per cent	Three-year-olds, per cent
Fore quarter	49.93	49.64	51.23	51.23
Hind quarter	50.07	50.36	48.77	48.77
Right half carcass	100.00	100.00	100.00	100.00
Chuck	24.14	24.71	20.61	19.50
Prime rib	11.77	12.62	13.86	13.84
Plate and shank	14.03	12.29	16.83	17.91
Loin	18.53	22.04	19.76	20.13
Rump	7.47	6.16	7.65	9.18
Round and shank	20.23	19.07	19.31	18.34
Flank	3.83	3.11	2.09	1.99

Perhaps the most striking differences in the data of the foregoing table are the differences in the percentages of the fore and hind quarters in the case of the calves and yearlings, on the one hand, and the older steers on the other. The averages for the calves and yearlings show but little difference between the fore and hind quarters, although the hind quarters average a little higher, whereas with the two-year-olds and three-year-olds the fore quarters average nearly 2.5 per cent higher than the hind quarters. By a strange coincidence, the average percentages of fore and hind quarters for the two-year-olds and three-year-olds are identical.

The differences in the percentages of fore and hind quarters may possibly be ascribed to differences in the type and breeding of the steers used during the two years; but the differences observed in the percentages of chuck, prime rib, etc., are no doubt due in part to differences in the cutting up of the carcasses, since different persons did the cutting each year.

Chemical Analysis of Meats.

From the two half carcasses of each age of steers that

were taken to the Experiment Station refrigerator, four sample cuts were taken and analyzed for water, protein, and fat. These cuts were from the round, loin, rib, and shoulder. The fifth cut of the round was made in as nearly the same place as possible and taken for analysis. The loin cut was the first of the "flat bone" cuts, in cutting from the rear end of the loin. From the ribs the second prime rib from the rear was taken, which is the 10th rib from the front. The cut from the shoulder was the first cut after removing the plate and shank and was what is termed locally "arm steak." Obviously, it is impossible to make some of these cuts exactly comparable in every case, but it seems probable that the errors between individuals and groups of individuals are not likely to be all in the same direction.

The samples for chemical analysis were taken immediately after the quarters had been divided into the cuts. These sample cuts were put into tared friction top pails and weighed when taken to the laboratory. Before the samples were chopped up for chemical analysis, the bone, lean, and visible fat were separated and weighed. After weighing, the bone was discarded and the fat and lean samples were combined and finely chopped with a meat chopper. The chopped meat was returned to the friction top pail, where any remaining meat juices were thoroughly incorporated with it before portions were taken for analysis. The slight, unavoidable losses attending the chopping of the samples have been considered as representing moisture.

The average percentage of bone, lean, and fat, in the various cuts of meat are shown in table 24.

TABLE 24.—AVERAGE PERCENTAGES OF BONE, LEAN AND VISIBLE FAT IN THE VARIOUS CUTS OF BEEF, 1913 AND 1915.

	Calves, average per cent.	Yearlings, average per cent.	Two-year-olds, average per cent.	Three-year-olds, average per cent.
In Total Cut.				
Rib.				
Bone	16.15	13.39	15.57	16.88
Lean	54.97	49.15	55.94	55.84
Fat	28.89	37.47	28.49	27.29
Shoulder.				
Bone	14.15	11.20	7.78	9.30
Lean	70.78	74.42	74.99	75.62
Fat	15.08	14.39	17.23	15.08
Round.				
Bone	3.00	3.62	2.97	3.10
Lean	83.97	84.87	88.73	86.44
Fat	13.03	11.77	8.30	10.46
Loin.				
Bone	11.61	10.30	13.21	12.18
Lean	59.41	56.85	59.16	61.67
Fat	28.91	32.86	27.63	26.15
In Bone-Free Portion.				
Rib.				
Lean	65.55	56.73	66.27	67.17
Fat	34.45	43.27	33.73	32.84
Shoulder.				
Lean	82.47	83.77	81.34	83.31
Fat	17.54	16.23	18.66	16.69
Round.				
Lean	86.57	87.81	91.46	89.21
Fat	13.44	12.19	8.54	10.79
Loin.				
Lean	67.32	63.56	68.16	70.22
Fat	32.69	36.45	31.84	29.78

No certain or characteristic differences appear in the percentages of lean and visible fat that might be ascribed to differences in the ages of the animals. A comparison of the data of this series with those of the alfalfa hay series, however, shows a noticeably higher percentage of fat in the rib, round and loin of the former.

TABLE 25.—AVERAGE PERCENTAGES OF WATER, PROTEIN AND FAT IN BONE-FREE CUTS OF BEEF, 1913 AND 1915.

	Calves, average per cent.	Yearlings, average per cent.	Two-year-olds, average per cent.	Three-year-olds, average per cent.
Rib.				
Water	49.79	45.34	47.58	51.05 a
Protein	14.35	13.00	14.00	12.97 a
Fat	35.42	41.18	37.53	34.08 a
Shoulder.				
Water	67.64	67.16	65.17	66.64
Protein	17.88	17.82	17.72	17.94
Fat	14.11	13.67	16.27	14.56
Round.				
Water	68.70	69.01	71.01 a	68.67
Protein	18.88	19.22	21.75 a	19.57
Fat	11.09	10.91	8.32 a	10.41
Loin.				
Water	56.33	55.15	57.09	56.83
Protein	15.26	14.72	15.71	16.23
Fat	27.53	28.97	27.11	26.36

(a) Results from one steer only.

From the results in the foregoing table it appears that the yearlings were, on the average, a little fatter than the other steers; as judged by the fat of the rib and loin cuts. The calves and the two-year-olds, judged in the same manner, compare favorably with each other; while the three-year-olds show less fat than any of the other groups. Since the averages are the results of averaging figures that do not agree especially well with each other, it is possible that no particular significance should be attached to the small differences just noted. However, a comparison of the data from these steers with those of the alfalfa hay experiments shows appreciably higher percentages of fat in the rib and loin cuts of the former, but no marked differences in the round and shoulder cuts. For comparison, the percentages of fat in the bone-free cuts of meat in the alfalfa hay experiments are given below.

TABLE 26.—AVERAGE PERCENTAGES OF FAT IN BONE-FREE CUTS OF MEAT; ALFALFA HAY EXPERIMENT*

	Calves	Yearlings	Two-year-olds	Three-year-olds
Rib	15.91	(20.00)	20.09	36.79
Shoulder	14.65	14.81	10.44	24.15
Round	4.92	6.85	5.19	8.07
Loin	13.09	20.04	16.59	24.04

*From Bulletin No. 91 of this Experiment Station.

On the whole, then, there appears to be no striking difference between the steers of various ages, so far as fatness is concerned, as judged from the analysis of the cuts of meat; but the steers fed on alfalfa and milo maize meal showed noticeably more fat in the rib and loin cuts than the steers of corresponding ages fed on alfalfa alone, excepting the three-year-olds. In the alfalfa hay experiments there was an increase in the percentage of fat, especially in the rib and loin cuts, with increasing age of animals; but no such relation appears in the data of the alfalfa and milo maize experiments. This is no doubt due, in a large measure, to the better fattening qualities of the alfalfa and milo maize rations, although the steers as a whole were also in better condition of flesh at the beginning of the experiments.

Quality of Meat.

Calves and Yearlings. Calves 28 and 29 and yearlings 22 and 23 were the steers selected for the comparison of the two ages, of steers in regard to quality of the meat. No distinctive difference in the color of the meat of the two ages of steers was apparent. The meat from steer 28, a calf, was much lighter than that of 23, a yearling; but on the other hand, the meat from calf number 29 was darker than that of

yearling 22. In other words, the differences in color appeared to be individual differences rather than age differences.

In general, the meat of the yearlings appeared a little firmer than that of the calves and showed a greater abundance of fat, both external and internal; as well as a better distribution of the same through the lean. The meat of both lots of steers was tender and juicy and of good flavor, although there was nothing about the flavor that could be attributed to the particular feeds used.

The meat of the calves and yearlings was in every respect equal, if not superior, to that of the older steers, and had the advantage of being a little more tender.

Two- and Three-year-olds, 1915. Steers 36 and 40 of the two-year-olds and 32 and 33 of the three-year-olds, were the ones from which the sample cuts of meat were taken, and were also the ones considered more in detail as regards quality of meat.

No striking differences were observed between the cuts of meats of the two-year-olds and three-year-olds in reference to color. Steer 40 appeared, in general, better than any of the other three; with number 36 a close second. The cuts from these steers were, in general, more plump and finished in appearance than those of the three-year-olds. As regards relative thickness of cuts, steers 36 and 40 appeared the best, although in thickness of loin, steer 33 was a little better than 36. The distribution of the fat through the lean, producing the so called marbled effect, was most noticeable in steer 40; with number 33 next. Taken as a whole, the marbling of the flesh was decidedly more pronounced in these steers than in the ones fed only alfalfa hay.

The fat was a clear white in all the cuts. The flavor of the meat was good, but suggested nothing distinctive. Aside from the slightly coarser grain of the meat from the three-year-olds and the fatness of the cuts from the two-year-olds, there was not much difference in the appearance of the meat

from the two lots of steers. The meat was not quite as tender as that of the younger steers, although that from steers 36 and 40 was very good. Such differences as were observed between the two ages of steers might easily be individual differences and not necessarily due to the differences in the ages of the animals.

Messrs. O. A. Danielson and W. J. Ritz of El Paso, both experienced in the marketing of beef, expressed the opinion that in reference to quality of meat, the steers would be ranked as follows: first, 40; second, 36; third, 33; and fourth, 32. They stated that the meat would probably be classed as grade 2 on the market.

Summary and Conclusions

Five range steers each of calves, yearlings, two-year-olds and three-year-olds were fed for a period of 120 days; during which all feeds and feed residues were weighed, sampled and analyzed, and individual records were kept of feeds consumed, gains in live weights and the condition or finish of the steers. Slaughter tests were made at the end of the feeding period and certain cuts of meat from representative steers of each age were analyzed. The digestibility of the rations fed was also determined, using two representative steers from each group for this purpose.

Three sets of digestion trials were conducted in the series of experiments with the calves and yearlings, as follows: one near the end of the first month; the second about the middle of the third month and the third during the latter part of the fourth month. In the experiments with the two- and three-year-olds, only the first two sets of digestion trials were conducted.

The coefficients of digestibility of the rations, as determined in the various trials, are given, and the effects of age of animal, individuality and amount of feed consumed upon the same are considered.

The results of the digestion trials indicate no appreciable or certain superiority of one age of animals over another as

regards digestive powers, nor do they show that any particular individual or individuals consistently digested their rations better than others. Apparently the steers used in the tests digested their rations about equally well.

The variations noticed in the digestion coefficients among the several steers from one trial to the next and on the same trials, apparently, are not due to differences in the amounts of feed consumed, as no direct relation between the amounts of feed consumed and the resulting coefficients was observed. However, the rations consumed were not especially heavy at any time.

A method is given for calculating the digestibility of the components of a ration composed of two or more feeds from the coefficients of digestibility of the feeds when fed in combination, but in different proportions, in two or more trials, and when no separate determinations of digestibility of any of the components of the ration have been made.

The coefficients of digestibility of the alfalfa and milo maize meal fed each year were calculated by the foregoing method and are given in the text of the bulletin.

The digestible nutrients in the alfalfa and milo maize meal, as given in the bulletin, were calculated from the average composition of the feeds by means of the calculated coefficients of digestibility of the feeds.

The energy values of the feeds were obtained by calculating the metabolizable energy from the digestible organic matter by means of the factors proposed by Armsby (previously cited) and from this the net energy, upon the assumption that the percentage availability of the metabolizable energy was the same as given by Armsby for alfalfa and maize meal.

The average daily gains made by the different groups of steers, per head, omitting the abnormal or doubtful ones, are as follows: calves, 1.55; yearlings, 1.89; two-year-olds, 2.12; and three-year-olds, 1.57 pounds. When the gains are calculated to a common basis of gains per day and head per 1,000 pounds

live weight, they become: calves, 2.70; yearlings, 2.21; two-year-olds, 2.25; and three-year-olds, 1.52 pounds. While the calves and three-year-olds made practically the same gains per day and head, the calves gained much more rapidly per unit of body weight. Per unit of body weight, the yearlings and two-year-olds made nearly equal gains, and in respect to rate of gains they are about midway between the calves and three-year-olds.

The various groups of steers consumed, on the average, the following amounts of feed, per day and head: calves, 10.74; yearlings, 17.77; two-year-olds, 19.95; and three-year-olds, 19.49 pounds; whereas, per 1,000 pounds live weight the amounts are 18.80, 20.87, 20.00, and 18.70 pounds, respectively. The amounts of feed consumed for each pound of gain are: calves, 6.96; yearlings, 9.57; two-year-olds, 9.63; and three-year-olds, 12.60 pounds. Although the calves and three-year-olds consumed nearly the same quantities of feed per unit of body weight, the former required only a little more than half as much feed per pound of gain as the latter, and about two-thirds as much as the yearlings or two-year-olds.

The nitrogen balances show considerable irregularities with the same individuals in successive trials and between the groups of different ages, but it is evident that the calves were gaining in protein at a much more rapid rate than the other steers. The data suggest that the yearlings were gaining in protein somewhat more rapidly than the older steers, but owing to the irregularities in the results, this is not clearly shown.

The average amount of energy stored in each pound of gain was estimated for the various individuals and groups of steers, and the results indicate that it was least among the calves and highest among the three-year-olds. The estimated energy stored per unit of gain by the latter was two and a half times that of the former; and the yearlings and two-year-olds stored about twice as much energy per unit of gain as the calves. These results, taken in conjunction with the nitrogen bal-

ances and the amounts of feed consumed per unit of gain, indicate a relatively greater production of fat by the older steers; especially as compared with the calves.

Estimations of the energy content of the gains by months during the feeding period show—with the exception of the first month—a tendency towards an increasing energy content of gains from month to month.

So far as percentages of dressed beef are concerned, no really significant differences that can be ascribed to differences in ages appear among the different groups of steers. However, the steers fed in the series on alfalfa and milo maize meal, excepting the three-year-olds, yielded considerably higher percentages of dressed beef than the corresponding groups of steers in the alfalfa hay experiments. This is, no doubt, largely due to the better balanced ration fed in these experiments.

No distinctive differences are apparent in reference to the wholesale cuts from the various steers.

The average results of the chemical analysis of the cuts of meat from the different groups of steers show no decided differences among them, but the percentages of fat in the rib and loin cuts are, in general, about twice as great as in the corresponding cuts and ages of steers in the alfalfa hay experiments. The fat content of the round and shoulder cuts is about the same for the different ages of steers and in the two series of experiments.

In quality of meat, the yearlings surpassed the calves, chiefly on account of the larger amount and better distribution of the fat through the lean and in the firmness of the meat. The meat of the calves and yearlings appeared a little finer in grain and was more tender than that of the two- and three-year-olds. All the meat was of good quality, showing more fat than the corresponding cuts and ages of steers in the alfalfa hay experiments; but no distinctive flavor was noticeable.

A tabulated summary of the main data of the experiments is given in the following tables:—

TABLE 27.—GENERAL SUMMARY OF RESULTS, 1913.

	Calves					Yearlings				
	Steer 26	Steer 27	Steer 28	Steer 29	Steer 30	Steer 21	Steer 22	Steer 23	Steer 24	Steer 25
Initial weight, lbs.	482.3	559.7	556.7	498.7	422.3	720.0	703.3	778.3	734.0	734.3
Final weight, lbs.	580.3	663.7	767.3	681.3	588.3	904.7	999.0	1005.7	807.7	931.0
Total gain, lbs.	98.0	104.0	210.6	182.6	166.0	184.7	295.7	227.4	73.7	196.7
Average daily gain, lbs.	82	87	1.76	1.52	1.38	1.54	2.46	1.90	.61	1.64
Average daily gain per 1,000 lbs. live weight, lbs.	1.60	1.43	2.69	2.66	2.75	1.88	2.85	2.14	.79	1.98
Alfalfa hay, total eaten, lbs.	619.27	620.32	763.86	729.74	669.63	1238.86	1282.58	1289.49	798.59	1028.16
Milo maize meal, total eaten, lbs.	432.09	503.54	576.46	562.33	503.43	823.26	1109.84	1030.44	694.39	723.00
Total feed eaten, lbs.	1051.36	1123.86	1340.32	1292.07	1233.06	2062.12	2392.42	2319.93	1492.98	1751.16
Alfalfa hay eaten per day, lbs.	5.16	5.17	6.36	6.08	5.58	10.33	10.69	10.75	6.66	8.57
Milo maize meal eaten per day, lbs.	3.60	4.20	4.80	4.69	4.70	6.86	9.25	8.59	5.79	6.03
Total feed eaten per day, lbs.	8.76	9.37	11.16	10.77	10.28	17.19	19.94	19.34	12.45	14.60
Alfalfa hay eaten per pound of gain, lbs.	6.29	5.94	3.61	4.00	4.04	6.71	4.35	5.66	10.92	5.23
Milo maize meal eaten per pound of gain, lbs.	4.39	4.83	2.73	3.09	3.41	4.45	3.76	4.52	9.49	3.67
Total feed eaten per pound of gain, lbs.	10.68	10.77	6.34	7.09	7.45	11.16	8.11	10.18	20.41	8.90
Dressed beef, lbs.	333.00	386.00	449.00	385.00	352.50	535.50	607.00	632.50	602.00	557.50
Dressed beef, per cent	53.28	52.37	63.50	55.79	60.46	63.52	55.84	61.89	58.24	56.71

The amounts of feeds in the above table are all on a dry matter basis

TABLE 28.—GENERAL SUMMARY OF RESULTS, 1915.

	Two-year-olds					Three-year-olds				
	Steer 36	Steer 37	Steer 38	Steer 39	Steer 40	Steer 31	Steer 32	Steer 33	Steer 34	Steer 35
Initial weight, lbs.	911.7	856.7	871.7	894.7	833.3	995.0	945.0	1063.3	853.3	806.7
Final weight, lbs.	1151.3	920.0	1065.0	1190.7	1119.3	1023.7	1107.7	1247.7	1071.0	896.7
Total gain, lbs.	239.6	63.3	193.3	296.0	286.0	28.7	162.7	184.4	217.7	90.0
Average daily gain, lbs.	2.00	.53	1.61	2.47	2.38	.24	1.36	1.54	1.81	.75
Average daily gain per 1,000 lbs. live weight, lbs.	1.96	.60	1.85	2.76	2.44	.23	1.32	1.33	1.91	.89
Alfalfa hay, total eaten, lbs.	1234.27	799.27	1263.96	1410.08	1381.41	1039.09	1292.39	1371.81	1240.00	908.93
Milo maize meal, total eaten, lbs.	1004.96	635.04	1023.58	1142.93	1113.36	804.70	1023.43	1090.60	998.52	700.49
Total feed eaten, lbs.	2239.23	1434.31	2287.54	2553.01	2494.77	1843.79	2315.82	2462.41	2238.52	1609.42
Alfalfa hay eaten per day, lbs.	10.29	6.66	10.53	11.76	11.51	8.66	10.77	11.43	10.33	7.57
Milo maize meal eaten per day, lbs.	8.37	5.29	8.53	9.52	9.28	6.71	8.53	9.09	8.32	5.84
Total feed eaten per day, lbs.	18.66	11.95	19.06	21.28	20.79	15.37	19.30	20.52	18.65	13.41
Alfalfa hay eaten per pound of gain, lbs.	5.30	12.56	6.54	4.76	4.84	36.08	7.92	7.42	5.71	10.09
Milo maize meal eaten per pound of gain, lbs.	4.03	9.99	5.30	3.86	3.89	27.96	6.27	5.90	4.59	7.79
Total feed eaten per pound of gain, lbs.	9.33	22.55	11.84	8.62	8.73	64.04	14.19	13.32	10.30	17.88
Dressed beef, lbs.	664.50	552.00	628.00	689.00	655.50	636.75	630.00	712.50	619.50	482.50
Dressed beef, per cent.	57.78	60.00	60.10	57.18	58.52	58.69	57.01	58.40	59.57	54.21

The amounts of feeds in the above table are all on a dry matter basis.

TABLE 29.—GENERAL SUMMARY OF RESULTS.
AVERAGES.

	Calves (a)	Yearlings (b)	Two-year-olds (c)	Three-year-olds (d)
Initial weight, lbs.	492.6	734.0	877.9	953.9
Final weight, lbs.	678.9	960.1	1131.6	1142.1
Total gain, lbs.	186.3	226.1	253.7	188.3
Average daily gain, lbs.	1.55	1.89	2.12	1.57
Average daily gain per 1,000 lbs. live weight, lbs.	2.70	2.21	2.25	1.52
Alfalfa hay, total eaten, lbs.	721.08	1209.80	1322.43	1304.73
Milo maize meal, total eaten, lbs.	567.41	921.64	1073.71	1037.52
Total feed eaten, lbs.	1288.49	2131.44	2396.14	2342.25
Alfalfa hay eaten per day, lbs.	6.01	10.09	11.02	10.84
Milo maize meal eaten per day, lbs.	4.73	7.68	8.93	8.65
Total feed eaten per day, lbs.	10.74	17.77	19.95	19.49
Alfalfa hay eaten per pound of gain, lbs.	3.90	5.34	5.19	7.10
Milo maize meal eaten per pound of gain, lbs.	3.06	4.23	4.44	5.50
Total feed eaten per pound of gain, lbs. ..	6.96	9.57	9.63	12.60
Dressed beef, lbs.	395.50	583.10	659.25	654.00
Dressed beef, per cent	59.92	59.49	58.40	58.87

The amounts of feeds in the above table are all on a dry matter basis.

- a. Average omitting steers 26 and 27.
- b. Average, omitting steer 24.
- c. Average, omitting steer 37.
- d. Average, omitting steers 31 and 35.

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The authors hereby express their appreciation of the services rendered by these persons in connection with the experiments.

Fig. 5.—Calves, Experiment of 1913: left, at beginning of test; right, at end; numbers of steers, from top to bottom, 26, 27, 28, 29 and 30.

Fig. 6.—Yearlings, Experiment of 1913; left, at beginning of test; right, at end; numbers of steers, from top to bottom, 21, 22, 23, 24, and 25.

Fig. 7.—Two-year-olds, Experiment of 1915; left, at beginning of test, right, at end; numbers of steers, from top to bottom, 36, 37, 38, 39 and 40.

Fig. 8.—Three-year-olds, Experiment of 1915; left, at beginning of test; right, at end; numbers of steers, from top to bottom, 31, 32, 33, 34 and 35.

Fig. 9.—Cuts of meat from calves 28 and 29, and yearlings 22 and 23; from top to bottom, front view of ribs, rear view of ribs, loins and rounds.

Fig. 10. Cuts of meat from two-year-olds 36 and 40, and three-year-olds 32 and 33; from top to bottom, front view of ribs, rear view of ribs, loins and rounds.

APPENDIX

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TABLE 30.—FEED AND FEED RESIDUES, 1913.

Calves.

	Alfalfa hay			Milo maize meal			Feed residues		
	Amount fed, pounds	Amount eaten, pounds	Dry matter eaten, pounds	Amount fed, pounds	Amount eaten, pounds	Dry matter eaten, pounds	Total, pounds	Alfalfa hay, pounds	Milo maize meal, pounds
Steer 26.									
First month	172.90	170.05	154.88	86.45	77.04	66.83	12.26	2.85	9.41
Second month	137.33	130.87	119.20	113.74	92.39	80.15	27.81	6.46	21.35
Third month	137.17	126.63	115.33	137.17	102.34	88.78	45.37	10.54	34.83
Fourth month	263.67	252.37	229.86	263.67	226.32	196.33	48.65	11.30	37.35
Total	711.07	679.92	619.27	601.03	498.09	432.09	134.09	31.15	102.94
Steer 27.									
First month	250.63	238.33	217.07	126.24	120.97	104.94	17.57	12.30	5.27
Second month	162.25	150.39	136.98	135.17	130.09	112.85	16.94	11.86	5.08
Third month	178.57	139.58	127.13	178.57	161.87	140.42	55.69	38.99	16.70
Fourth month	178.57	152.77	139.14	178.57	167.52	145.32	36.85	25.80	11.05
Total	770.02	681.07	620.32	618.55	580.45	503.54	127.05	88.95	38.10
Steer 28.									
First month	283.73	212.93	193.94	140.52	129.09	111.99	82.24	70.81	11.43
Second month	203.31	201.40	183.44	106.40	105.93	91.89	2.38	1.91	.47
Third month	204.15	198.14	180.47	204.14	202.66	175.81	7.49	6.01	1.43
Fourth month	227.08	226.19	206.01	227.08	226.71	196.77	1.26	.89	.37
Total	918.26	838.54	763.86	678.14	664.39	576.46	93.37	79.62	13.75
Steer 29.									
First month	248.11	235.45	214.45	124.08	111.84	97.02	24.90	12.66	12.24
Second month	172.89	159.77	145.52	142.67	129.98	112.76	25.81	13.12	12.69
Third month	177.91	165.23	150.49	177.91	165.65	143.70	24.94	12.68	12.26
Fourth month	240.75	240.75	219.28	240.75	240.75	208.85	.....	.....	.....
Total	839.66	801.20	729.74	685.41	648.22	562.33	75.65	38.46	37.19
Steer 30.									
First month	241.10	197.75	180.11	120.57	112.50	97.59	51.42	43.35	8.07
Second month	196.98	191.29	174.23	162.15	161.34	139.96	6.50	5.69	.81
Third month	176.37	165.47	150.71	176.37	173.97	150.92	13.30	10.90	2.40
Fourth month	205.47	180.70	164.58	205.47	201.68	174.96	28.56	24.77	3.79
Total	819.92	735.21	669.63	664.56	649.49	563.43	99.78	84.71	15.07

TABLE 31.—FEED AND FEED RESIDUES, 1913.

Yearlings.

	Alfalfa hay			Milo maize meal			Feed residues		
	Amount fed, pounds	Amount eaten, pounds	Dry matter eaten, pounds	Amount fed, pounds	Amount eaten, pounds	Dry matter eaten, pounds	Total, pounds	Alfalfa hay, pounds	Milo maize meal, pounds
Steer 21.									
First month	365.97	363.61	331.18	183.20	172.27	149.44	13.29	2.36	10.93
Second month . . .	357.74	351.19	319.86	295.97	265.74	230.53	36.78	6.55	30.23
Third month	350.54	338.11	307.95	350.54	293.17	254.32	69.80	12.43	57.37
Fourth month . . .	332.02	307.28	279.87	332.02	217.83	184.97	138.93	24.74	114.19
Total	1406.27	1360.19	1238.86	1161.73	949.01	823.26	258.80	46.08	212.72
Steer 22.									
First month	378.69	366.70	333.99	189.58	188.35	163.39	13.22	11.99	1.23
Second month . . .	401.15	399.71	364.06	332.81	332.63	288.56	1.62	1.44	.18
Third month	391.98	351.15	319.83	391.98	289.21	337.64	43.61	40.83	2.78
Fourth month . . .	390.22	290.63	264.71	390.22	369.16	320.25	120.67	99.59	21.05
Total	1562.04	1408.19	1282.58	1304.59	1279.35	1109.84	179.09	153.85	25.24
Steer 23.									
First month	372.14	370.88	337.80	182.80	182.22	158.08	1.84	1.26	.58
Second month . . .	355.74	354.48	322.86	294.36	293.77	254.84	1.85	1.26	.59
Third month	360.68	349.80	316.60	360.68	355.54	308.43	16.02	10.88	5.14
Fourth month . . .	370.38	340.61	310.23	370.38	356.30	309.09	43.85	29.77	14.08
Total	1458.94	1415.77	1289.49	1208.22	1187.83	1030.44	63.57	43.17	20.39
Steer 24.									
First month	349.74	245.64	223.73	174.87	161.56	140.15	117.41	104.10	13.31
Second month . . .	249.55	240.38	218.94	209.43	207.03	179.60	11.57	9.17	2.40
Third month	223.11	208.05	189.49	223.11	219.21	190.16	18.96	15.06	3.90
Fourth month . . .	244.72	182.73	166.43	244.72	212.66	184.48	94.05	61.99	32.06
Total	1067.12	876.80	798.59	852.13	800.46	694.39	241.99	190.32	51.67
Steer 25.									
First month	327.14	324.58	295.63	163.53	154.20	133.77	11.89	2.56	9.33
Second month . . .	266.05	263.01	239.55	221.68	210.59	182.69	14.13	3.04	11.09
Third month	284.40	265.23	241.55	284.40	214.61	186.17	88.96	19.17	69.79
Fourth month . . .	284.40	276.05	251.43	284.40	254.03	220.37	38.72	8.34	30.37
Total	1161.99	1128.87	1028.16	954.01	833.43	723.00	153.70	33.12	120.58

TABLE 32.—FEED AND FEED RESIDUES, 1915.

Two-year-olds.

	Alfalfa hay			Milo maize meal			Feed residues		
	Amount fed, pounds	Amount eaten, pounds	Dry matter eaten, pounds	Amount fed, pounds	Amount eaten, pounds	Dry matter eaten, pounds	Total, pounds	Alfalfa hay, pounds	Milo maize meal, pounds
Steer 36.									
First month	297.63	297.63	269.22	148.80	148.80	129.93			
Second month ..	336.93	336.93	305.56	275.68	275.68	240.72			
Third month ...	332.01	332.01	301.10	332.01	332.01	289.91			
Fourth month ..	394.41	394.41	357.69	394.41	394.41	344.40			
Total	1360.98	1360.98	1234.27	1150.90	1150.90	1004.96			
Steer 37.									
First month	238.55	234.96	213.09	126.76	123.96	108.24	6.39	3.59	2.80
Second month ...	210.18	210.18	190.61	169.29	169.29	147.82			
Third month ...	218.25	218.25	197.93	218.25	218.25	190.58			
Fourth month ..	218.25	217.93	197.64	218.25	215.76	188.40	2.81	.32	2.49
Total	885.23	881.32	799.27	732.55	727.26	635.04	9.20	3.91	5.29
Steer 38.									
First month	317.46	317.46	287.90	158.73	158.73	138.60			
Second month ...	338.25	338.25	306.76	275.24	275.24	240.34			
Third month	332.01	331.70	300.82	332.01	331.94	289.85	.38	.31	.07
Fourth month ...	406.31	406.31	368.48	406.31	406.31	354.79			
Total	1394.03	1393.72	1263.96	1172.29	1172.22	1023.58	.38	.31	.07
Steer 39.									
First month	355.17	355.17	322.10	177.58	177.58	155.06			
Second month ...	403.49	403.49	365.93	326.99	326.99	285.53			
Third month ...	389.34	386.69	350.69	389.34	389.20	339.85	2.79	2.65	.14
Fourth month ...	415.13	409.49	371.37	415.13	415.13	362.49	5.64	5.64	
Total	1563.13	1554.84	1410.08	1309.04	1308.90	1142.93	8.43	8.29	.14
Steer 40.									
First month	359.58	359.58	326.10	179.79	179.79	156.99			
Second month ...	354.56	354.56	321.55	286.16	286.16	249.87			
Third month ...	382.72	382.72	347.09	382.72	382.72	334.19			
Fourth month ...	426.37	426.37	386.67	426.37	426.37	372.31			
Total	1523.23	1523.23	1381.41	1275.04	1275.04	1113.36			

THE UTILIZATION OF FEED BY

TABLE 33.—FEED AND FEED RESIDUES, 1915.

Three-year-olds.

	Alfalfa hay			Milo maize meal			Feed residues		
	Amount fed, pounds	Amount eaten, pounds	Dry matter eaten, pounds	Amount fed, pounds	Amount eaten, pounds	Dry matter eaten, pounds	Total, pounds	Alfalfa hay, pounds	Milo maize meal, pounds
Steer 31.									
First month	317.46	315.51	286.14	158.73	157.20	137.27	3.48	1.95	1.53
Second month	338.25	338.25	306.76	275.24	275.24	240.34			
Third month	285.49	237.88	215.73	285.49	232.99	203.45	100.11	47.61	52.50
Fourth month ..	259.04	254.12	230.46	259.04	256.11	223.64	7.85	4.92	2.93
Total	1200.24	1145.76	1039.09	978.50	921.54	804.70	111.44	54.48	56.96
Steer 32.									
First month	358.25	358.25	324.90	179.13	179.13	156.42			
Second month	381.47	381.47	345.96	308.39	308.39	269.29			
Third month	321.59	321.59	291.65	320.77	320.77	280.10			
Fourth month ..	363.75	363.75	329.88	363.75	363.75	317.63			
Total	1425.06	1425.06	1292.39	1172.04	1172.04	1023.44			
Steer 33.									
First month	396.84	396.84	359.89	198.42	198.42	173.26			
Second month	376.83	376.83	341.75	311.47	311.47	271.98			
Third month	364.64	364.53	330.58	364.64	364.63	318.39	.12	.11	.01
Fourth month ..	374.45	374.45	339.59	374.45	374.45	326.97			
Total	1512.76	1512.65	1371.81	1248.98	1248.97	1090.60	.12	.11	.01
Steer 34.									
First month	335.32	332.72	301.74	167.11	165.07	144.14	4.64	2.60	2.04
Second month	323.39	323.22	293.13	260.61	260.61	227.56			
Third month	334.23	334.23	303.11	334.23	334.23	291.85			
Fourth month ..	383.61	377.13	342.02	383.61	383.61	334.97	6.48	6.48	
Total	1376.55	1367.30	1240.00	1145.56	1143.52	998.52	11.12	9.08	2.04
Steer 35.									
First month	312.40	298.96	271.13	153.55	143.08	124.94	23.91	13.44	10.47
Second month	215.61	215.61	195.54	171.24	171.24	149.53			
Third month	209.44	209.21	189.73	209.44	209.44	182.88	.23	.23	
Fourth month ..	278.45	278.45	252.53	278.45	278.45	243.14			
Total	1015.90	1002.23	908.93	812.68	802.21	700.49	24.14	13.67	10.47

TABLE 34.—COMPOSITION OF FEED RESIDUES, 1913.
Percentage of Dry Matter and Nutrients in Dry Matter.

	Composite feed residue samples*									
	Comp. 21, per cent	Comp. 22, per cent	Comp. 23, per cent	Comp. 24, per cent	Comp. 25, per cent	Comp. 26, per cent	Comp. 27, per cent	Comp. 28, per cent	Comp. 29, per cent	Comp. 30, per cent
Dry matter	90.05	92.87	91.63	90.32	89.36	89.71	91.38	86.83	89.31	89.04
Composition of dry matter:										
Ash	5.77	9.31	8.58	8.73	4.68	4.68	8.84	8.47	9.33	9.91
Protein	12.96	13.08	12.27	12.92	12.49	12.50	13.50	13.37	12.53	12.46
Non-protein	1.25	2.61	2.23	2.52	1.27	1.06	2.44	2.59	1.79	2.34
Crude fiber	7.00	26.54	20.78	23.91	8.03	8.49	21.37	24.17	16.09	26.19
Ether extract	3.01	1.44	1.94	1.77	2.61	2.02	2.10	1.98	2.25	1.27
Nitrogen-free extract	70.01	47.02	54.20	50.15	70.92	71.25	51.75	49.42	58.01	47.83
100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total nitrogen	2.339	2.649	2.438	2.603	2.269	2.225	2.680	2.691	2.385	2.492
Protein nitrogen	2.074	2.093	1.963	2.067	1.999	2.000	2.160	2.139	2.005	1.994
Non-protein nitrogen	.265	.556	.475	.536	.270	.225	.520	.552	.380	.498

*Composites of all feed residues collected from the respective steers during the feeding period exclusive of digestion trials.

TABLE 35.—COMPOSITION OF FEED RESIDUES, 1915.
Percentages of Dry Matter and Nutrients in Dry Matter.

	All the steers,* first month, per cent	Steer 31, third month, per cent	Steer 31, fourth month, per cent	Steer 34, fourth month, per cent	Steer 35, third month, per cent	Steer 37, fourth month, per cent	Steer 38, third month, per cent	Steer 39, third month, per cent	Steer 39, fourth month, per cent
Dry matter	88.16	89.38	90.53	85.46	93.80	90.25	94.02	91.43	91.87
Composition of dry matter:									
Ash	8.46	5.73	7.52	5.36	6.60	4.74	6.67	7.66	6.09
Protein	12.70	12.30	11.94	6.28	7.74	12.79	7.88	8.35	5.92
Non-protein	1.81	.48	1.74	1.54	1.82	.90	1.84	1.66	1.43
Crude fiber	23.12	15.00	25.47	47.65	43.42	6.71	41.01	41.17	49.42
Ether extract	1.88	2.11	1.82	1.77	.98	3.26	.68	1.11	.66
Nitrogen-free extract	52.03	64.38	51.51	38.40	39.44	71.60	41.92	40.05	36.48
100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total nitrogen	2.417	2.072	2.281	1.332	1.626	2.238	1.652	1.687	1.251
Protein nitrogen	2.032	1.969	1.910	1.004	1.239	2.046	1.260	1.334	.947
Non-protein nitrogen	.385	.103	.371	.328	.387	.192	.392	.353	.304

*Composite of residues from all steers during the first month exclusive of digestion trials.

TABLE 36.—FEED, FEED RESIDUES, AND FECES, DIGESTION TRIAL I, 1913.

			Dry matter		
	Number of days	Fresh weight, grams	Per cent	Total, grams	Per day, grams
Steer 22.					
Alfalfa hay fed	10	56,600	89.63	50,730.6	5,073.1
Milo maize meal fed	10	28,300	86.11	24,369.1	2,436.9
Uneaten residues	10	2,950	88.71	2,616.9	261.7
Feces	10	113,955	21.41	24,397.8	2,439.8
Feces from duct	12			160.5	13.4
Total feces					2,453.2
Steer 24.					
Alfalfa hay fed	10	54,600	89.63	48,938.0	4,893.8
Milo maize meal fed	10	27,300	86.11	23,508.0	2,350.8
Uneaten residues	10	42,730	87.97	37,589.6	3,759.0
Feces	10	55,135	23.16	12,769.3	1,276.9
Feces from duct	12			120.5	10.0
Total feces					1,286.9
Steer 28.					
Alfalfa hay fed	10	42,900	89.63	38,451.3	3,845.1
Milo maize meal fed	10	21,600	86.11	18,599.8	1,860.0
Uneaten residues	10	21,565	88.46	19,076.4	1,907.6
Feces	10	47,090	23.14	10,896.6	1,089.7
Feces from duct	12			45.7	3.8
Total feces					1,093.5
Steer 30.					
Alfalfa hay fed	10	36,200	89.63	32,446.1	3,244.6
Milo maize meal fed	10	18,100	86.11	15,585.9	1,558.6
Uneaten residues	10	7,975	87.30	6,962.1	696.2
Feces	10	57,555	24.69	14,210.3	1,421.0
Feces from duct	12			35.8	3.0
Total feces					1,424.0

TABLE 37.—FEED, FEED RESIDUES, AND FECES, DIGESTION TRIAL II, 1913.

	Number of days	Fresh weight, grams	Dry matter		
			Per cent	Total, grams	Per day, grams
Steer 22.					
Alfalfa hay fed	10	58,000	90.25	52,345.0	5,234.5
Milo maize meal fed	10	58,000	86.71	50,291.8	5,029.2
Uneaten residues	10	16,475	90.54	14,916.4	1,491.6
Feces	10	120,810	22.19	26,807.7	2,680.8
Feces from duct	11			214.2	19.5
Total feces					2,700.3
Steer 24.					
Alfalfa hay fed	10	30,000	90.25	27,075.0	2,707.5
Milo maize meal fed	10	30,000	86.71	26,013.0	2,601.3
Uneaten residues	10	3,915	90.48	3,542.2	354.2
Feces	10	70,820	20.84	14,758.9	1,475.9
Feces from duct	11			244.2	22.2
Total feces					1,498.1
Steer 28.					
Alfalfa hay fed	10	28,000	90.25	25,270.0	2,527.0
Milo maize meal fed	10	28,000	86.71	24,278.8	2,427.9
Feces	10	65,175	23.82	15,524.7	1,552.5
Feces from duct	11			118.3	10.7
Total feces					1,563.2
Steer 30.					
Alfalfa hay fed	10	24,000	90.25	21,660.0	2,166.0
Milo maize meal fed	10	24,000	86.71	20,810.4	2,081.0
Uneaten residues	10	2,975	90.41	2,689.7	269.0
Feces	10	57,200	22.18	12,687.0	1,268.7
Feces from duct	11			113.4	10.3
Total feces					1,279.0

TABLE 38.—FEED, FEED RESIDUES AND FECES. DIGESTION TRIAL III, 1913.

	Number of days	Fresh weight, grams	Dry matter		
			Per cent	Total, grams	Per day, grams
Steer 22.					
Alfalfa hay fed	10	58,000	92.16	53,452.8	5,345.3
Milo maize meal fed	10	58,000	87.44	50,715.2	5,071.5
Uneaten residues	10	31,745	91.91	29,176.8	2,917.7
Feces	10	98,795	21.17	20,914.9	2,091.5
Feces from duct	11			251.9	22.9
Total feces					2,114.4
Steer 24.					
Alfalfa hay fed	10	38,000	92.16	35,020.8	3,502.1
Milo maize meal fed	10	38,000	87.44	33,227.2	3,322.7
Uneaten residues	10	31,885	90.11	28,731.6	2,873.2
Feces	10	71,975	15.54	11,184.9	1,118.5
Feces from duct	11			158.9	14.4
Total feces					1,132.9
Steer 28.					
Alfalfa hay fed	10	32,000	92.16	29,491.2	2,949.1
Milo maize meal fed	10	32,000	87.44	27,890.8	2,798.1
Uneaten residues	10	300	92.73	278.2	27.8
Feces	10	82,355	21.40	17,623.9	1,762.4
Feces from duct	11			287.2	26.1
Total feces					1,788.5
Steer 30.					
Alfalfa hay fed	10	30,000	92.16	27,648.0	2,764.8
Milo maize meal fed	10	30,000	87.44	26,232.0	2,623.2
Uneaten residues	10	10,260	91.19	9,356.0	935.6
Feces	10	56,835	23.52	13,367.6	1,336.8
Feces from duct	11			190.9	17.3
Total feces					1,354.1

TABLE 39.—FEED, FEED RESIDUES, AND FECES, DIGESTION TRIAL
I, 1915.

	Number of days	Fresh weight, grams	Dry matter		
			Per cent	Total, grams.	Per day, grams.
Steer 31.					
Alfalfa hay fed	10	48,000	88.89	42,667.2	4,266.7
Milo maize meal fed	10	24,000	86.25	20,700.0	2,070.0
Uneaten residues	10	25		22.6	2.3
Feces	10	115,220	23.54	27,122.8	2,712.3
Feces from duct	15			72.7	4.8
Total feces					2,717.1
Steer 33.					
Alfalfa hay fed	10	60,000	88.89	53,334.0	5,333.4
Milo maize meal fed	10	30,000	86.25	25,875.0	2,587.5
Feces	10	155,390	19.93	30,969.2	3,096.9
Feces from duct	15			87.5	5.8
Feces spilled in stalls	10			26.6	2.7
Total feces					3,105.4
Steer 36.					
Alfalfa hay fed	10	45,000	88.89	40,000.5	4,000.1
Milo maize meal fed	10	22,500	86.25	19,406.3	1,940.6
Feces	10	107,060	20.82	22,289.9	2,229.0
Feces from duct	15			55.4	3.7
Total feces					2,232.7
Steer 38.					
Alfalfa hay fed	10	48,000	88.89	42,667.2	4,266.7
Milo maize meal fed	10	24,000	86.25	20,700.0	2,070.0
Feces	10	112,437	19.55	21,981.4	2,198.1
Feces from duct	6			50.9	8.5
Feces from duct	9			47.6	5.3
Feces spilled in stall	10			37.5	3.8
Total feces					2,215.7

TABLE 40.—FEED, FEED RESIDUES, AND FECES, DIGESTION TRIAL II, 1915.

	Number of days	Fresh weight, grams	Dry matter		
			Per cent	Total, grams	Per day, grams
Steer 31.					
Alfalfa hay fed	10	50,000	89.73	44,865.0	4,486.5
Milo maize meal fed	10	50,000	86.65	43,325.0	4,332.5
Uneaten residues	10	36,525	87.68	32,025.1	3,202.5
Feces	10	84,025	21.01	17,653.7	1,765.4
Feces from duct	15			93.5	6.2
Total feces					1,771.6
Steer 33.					
Alfalfa hay fed	10	55,000	89.73	49,351.5	4,935.2
Milo maize meal fed	10	55,000	86.65	47,657.5	4,765.8
Feces	10	178,245	18.95	33,777.4	3,377.7
Feces from duct	15			207.9	13.9
Feces spilled in stall	10			80.5	8.1
Total feces					3,399.7
Steer 36.					
Alfalfa hay fed	10	50,000	89.73	44,865.0	4,486.5
Milo maize meal fed	10	50,000	86.65	43,325.0	4,332.5
Feces	10	143,390	21.71	31,129.9	3,113.0
Feces from duct	15			119.8	8.0
Feces spilled in stall	10			19.2	1.9
Total feces					3,122.9
Steer 38.					
Alfalfa hay fed	10	50,000	89.73	44,865.0	4,486.5
Milo maize meal fed	10	50,000	86.65	43,325.0	4,332.5
Uneaten residues	10	60	90.28	54.2	5.4
Feces	10	138,615	20.80	28,831.9	2,883.2
Feces from duct	13			139.7	10.7
Feces from duct	2			205.0	102.5
Feces spilled in stall	10			85.4	8.5
Total feces					3,004.9

TABLE 41.—COMPOSITION OF FEED RESIDUES AND FECES, 1913.
Percentages of dry matter and nutrients in dry matter.

	Feed residues				Feces			
	Steer 22, per cent	Steer 24, per cent	Steer 28, per cent	Steer 30, per cent	Steer 22, per cent	Steer 24, per cent	Steer 28, per cent	Steer 30, per cent
Digestion Trial I.								
Dry matter	88.71	87.97	88.46	87.30	21.41	23.16	23.14	24.69
Composition of Dry matter:								
Ash	8.86	7.75	8.18	8.04	10.44	8.56	9.76	10.89
Protein	14.09	12.93	13.80	12.55	16.93	16.71	18.77	17.39
Non-protein	2.50	2.33	2.27	2.43				
Crude fiber	27.60	27.14	26.98	23.59	34.69	32.66	30.44	32.15
Ether extract	1.52	1.68	1.73	1.71	3.05	3.15	3.51	3.19
Nitrogen-free extract	45.43	48.17	47.04	51.68	34.89	38.92	37.52	36.88
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total nitrogen	2.786	2.564	2.691	2.526	2.709	2.673	3.003	2.783
Protein nitrogen	2.254	2.069	2.208	2.008				
Non-protein nitrogen	.532	.495	.483	.518				
Digestion Trial II.								
Dry matter	90.54	90.48		90.41	22.19	20.84	23.82	22.18
Composition of Dry matter:								
Ash	7.93	7.33		6.66	8.82	9.98	10.28	9.05
Protein	12.99	12.79		12.03	18.13	19.19	16.79	19.64
Non-protein	2.79	2.52		2.38				
Crude fiber	28.14	24.01		23.09	27.95	27.41	31.99	25.46
Ether extract	1.71	1.98		1.89	3.08	3.38	3.10	3.48
Nitrogen-free extract	46.44	51.37		53.95	42.02	40.04	37.84	42.37
	100.00	100.00		100.00	100.00	100.00	100.00	100.00
Total nitrogen	2.673	2.584		2.431	2.902	3.071	2.687	3.142
Protein nitrogen	2.079	2.047		1.925				
Non-protein nitrogen	.594	.537		.506				
Digestion Trial III.								
Dry matter	91.91	90.17	92.73	91.19	21.17	15.54	21.40	23.52
Composition of Dry matter:								
Ash	8.27	5.33	11.82	5.93	9.01	11.43	9.42	9.00
Protein	13.44	12.57	13.96	11.41	18.10	19.03	18.28	19.29
Non-protein	2.63	1.85	2.28	2.23				
Crude fiber	23.57	19.00	18.99	25.91	26.41	28.76	31.35	27.21
Ether extract	1.91	2.31	1.87	1.72	3.44	3.49	3.22	3.63
Nitrogen-free extract	50.18	58.94	51.08	52.80	43.04	37.29	37.73	40.87
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total nitrogen	2.710	2.405	2.718	2.300	2.896	3.044	2.925	3.087
Protein nitrogen	2.150	2.011	2.233	1.826				
Non-protein nitrogen	.560	.394	.485	.474				

TABLE 42.—COMPOSITION OF FEED RESIDUES AND FECES, 1915.
Percentages of dry matter and nutrients in dry matter.

	Feed residues				Feces			
	Steer 31, per cent	Steer 33, per cent	Steer 36, per cent	Steer 38, per cent	Steer 31, per cent	Steer 33, per cent	Steer 36, per cent	Steer 38, per cent
Digestion Trial I.								
Dry matter					23.54	19.93	20.82	19.55
Composition of dry matter:								
Ash					9.56	9.99	9.68	9.56
Protein					12.75	13.29	13.87	12.79
Non-protein .....					.....	.....	.....	.....
Crude fiber					41.43	42.58	42.51	46.29
Ether extract ...					2.28	2.35	2.21	2.36
Nitrogen-free extract					33.98	31.79	31.73	29.00
					100.00	100.00	100.00	100.00
Total nitrogen ...					2.040	2.127	2.219	2.046
Protein nitrogen .								
Non-protein nitrogen								
Digestion Trial II.								
Dry matter	87.68			90.28	21.01	18.95	21.71	20.80
Composition of dry matter:								
Ash	4.68			5.40	8.12	8.81	8.30	8.95
Protein	12.48			11.16	12.49	14.24	14.91	15.54
Non-protein	1.13			1.25	.....	.....	.....	.....
Crude fiber	21.14			22.49	43.00	37.59	37.34	33.86
Ether extract ...	2.20			1.85	1.94	2.15	2.23	2.57
Nitrogen-free extract	58.37			67.85	34.45	37.21	37.22	39.08
	100.00			100.00	100.00	100.00	100.00	100.00
Total nitrogen ..	2.238			2.051	1.999	2.279	2.386	2.486
Protein nitrogen	1.997			1.786				
Non-protein nitrogen	.241			.265				

THE UTILIZATION OF FEED BY

TABLE 43.—WEIGHTS OF EXCRETA, 1913.

Date	Steer 22		Steer 24		Steer 28		Steer 30	
	Feces, grams	Urine, grams	Feces, grams	Urine, grams	Feces, grams	Urine, grams	Feces, grams	Urine, grams
Digestion Trial I.								
January 21	10,180	5,805	9,640	4,585	3,960	2,025	4,790	3,565
January 22	10,100	5,130	4,400	2,500	4,135	2,160	5,100	2,965
January 23	11,785	6,525	6,890	5,265	4,530	2,415	4,300	3,210
January 24	11,775	9,870	3,970	2,070	3,375	2,865	6,825	3,620
January 25	12,710	7,670	6,635	7,475	4,590	2,830	4,505	3,365
January 26	13,545	12,800	4,115	2,570	5,130	2,475	5,520	3,540
January 27	11,280	14,770	3,980	2,885	4,390	3,010	6,360	3,250
January 28	10,185	12,095	4,550	4,380	4,845	2,825	6,775	3,615
January 29	11,895	14,545	3,690	3,345	5,620	3,460	6,455	4,130
January 30	10,500	13,200	7,265	3,920	6,515	4,075	6,925	4,185
Total	113,955	102,410	55,135	38,995	47,090	28,140	57,555	35,445
Digestion Trial II.								
March 12	10,155	8,060	6,330	2,605	5,780	3,715	5,190	2,440
March 13	10,630	7,000	6,445	2,865	8,645	3,620	4,515	2,170
March 14	12,325	10,315	6,400	3,460	5,705	3,365	5,125	2,860
March 15	14,720	11,135	7,050	3,595	7,050	3,635	4,670	2,810
March 16	12,375	10,195	5,835	3,745	5,995	4,325	5,585	2,615
March 17	13,485	8,010	6,660	3,695	6,245	3,610	5,950	2,685
March 18	11,305	8,650	6,695	3,485	6,270	3,715	7,340	2,465
March 19	13,005	13,785	6,120	3,650	5,695	3,625	5,855	3,025
March 20	11,955	9,075	9,335	3,475	6,440	3,950	7,095	3,785
March 21	10,855	9,805	9,950	4,405	7,350	3,335	5,875	3,540
Total	120,810	96,030	70,820	34,980	65,175	36,895	57,200	28,395
Digestion Trial III.								
April 16	6,390	4,410	5,340	2,735	7,610	3,605	5,860	2,755
April 17	9,380	7,170	5,380	2,940	7,370	3,830	5,265	2,385
April 18	10,930	5,010	6,850	4,755	7,000	4,265	4,460	2,365
April 19	10,965	10,210	8,115	3,140	8,910	4,165	4,340	2,370
April 20	8,320	10,250	7,030	3,265	7,800	4,275	4,235	2,720
April 21	9,420	[6,325]*	14,120	2,525	6,705	4,105	5,600	3,130
April 22	8,085	7,450	6,245	2,560	8,560	5,070	3,675	2,750
April 23	13,255	12,830	7,350	2,315	10,050	5,210	8,170	3,415
April 24	10,330	5,780	4,170	2,805	9,080	3,970	7,005	3,525
April 25	11,720	7,125	7,375	2,685	9,270	3,580	8,225	3,715
Total	98,795	70,235	71,975	29,725	82,355	42,075	56,835	29,130

(*) A considerable amount of urine spilled, on account of a broken urine tube. No sample taken.

TABLE 44.—WEIGHTS OF EXCRETA, 1915.

Date	Steer 31		Steer 33		Steer 36		Steer 38	
	Feces, grams	Urine, grams	Feces, grams	Urine, grams	Feces, grams	Urine, grams	Feces, grams	Urine, grams
Digestion Trial I.								
March 16 ...	10,935	[5,345]†	14,790	[5,630]*	9,665	[5,175]†	11,950	[5,070]*
March 17 ...	11,995	6,020	16,270	[6,110]*	10,350	5,000	9,240	5,650
March 18 ...	11,070	4,815	15,770	[6,370]*	9,460	5,100	12,015	6,570
March 19 ...	11,720	6,675	15,030	7,135	10,815	6,770	11,090	[5,655]*
March 20 ...	13,635	6,780	18,240	7,380	11,100	6,130	13,685	9,255
March 21 ...	10,265	[4,270]*	11,510	6,970	15,160	5,285	7,670	5,915
March 22 ...	12,315	6,665	17,530	6,435	11,180	5,640	12,600	[6,215]*
March 23 ...	9,745	5,745	13,250	6,610	9,095	5,795	10,970	7,005
March 24 ...	10,335	5,470	17,220	7,990	8,350	7,985	11,705	7,125
March 25 ...	13,205	7,885	15,780	8,550	11,885	5,575	11,515	7,035
Total	115,220	50,055	155,390	51,070	107,060	53,280	112,440	48,515
Digestion Trial II.								
May 5	8,235	5,240	17,070	7,720	14,505	8,525	15,320	5,730
May 6	11,840	4,815	19,550	[5,950]*	14,280	5,780	12,555	7,825
May 7	9,360	4,855	19,360	[4,220]*	14,630	6,370	15,295	6,975
May 8	7,135	4,060	16,480	[5,910]*	14,415	6,535	12,850	6,370
May 9	9,280	7,095	20,090	9,110	13,110	7,370	12,425	6,445
May 10	5,545	3,700	15,760	6,240	14,915	7,165	15,820	8,040
May 11	8,330	3,835	18,810	6,950	14,640	7,670	14,915	9,505
May 12	6,785	4,360	21,930	6,980	12,565	7,425	11,210	[5,360]*
May 13	8,880	[3,795]*	13,490	7,020	14,990	7,240	13,505	9,945
May 14	8,635	6,495	15,705	6,905	15,340	7,690	14,720	7,670
Total	84,025	44,455	178,245	50,925	143,390	71,770	138,615	68,505

(*) Considerable amounts of urine spilled. No samples taken.

(†) Through a misunderstanding, no samples were taken.

TABLE 45.—NITROGEN IN URINES.

	Experiment, 1913				Experiment, 1915			
	Steer 22, per cent	Steer 24, per cent	Steer 28, per cent	Steer 30, per cent	Steer 31, per cent	Steer 33, per cent	Steer 36, per cent	Steer 38, per cent
Digestion Trial I.	.942	1.512	1.481	1.329	1.327	1.471	1.316	1.150
Digestion Trial II.	1.111	1.652	1.524	1.383	1.491	1.504	1.373	1.453
Digestion Trial III.	1.176	2.038	1.476	1.516				

TABLE 46.—WATER DRUNK DURING DIGESTION TRIALS, 1913.

	Steer 22, kilos	Steer 24, kilos	Steer 28, kilos	Steer 30, kilos
Digestion Trial I.				
January 20.	25.68	15.70	3.69	8.33
January 21.	7.82	7.35	8.35	4.58
January 22.	20.89	9.52	5.50	10.47
January 23.	26.57	5.02	8.64	11.55
January 24.	21.81	11.55	8.57	9.04
January 25.	22.60	3.90	4.95	8.54
January 26.	22.62	9.55	5.70	9.88
January 27.	30.65	2.20	9.80	14.06
January 28.	28.09	5.91	10.05	7.94
January 29.	25.69	8.33	14.02	13.74
January 30.	28.90	10.32	7.16	10.00
Digestion Trial II.				
March 11.	14.31	5.36	12.32	8.21
March 12.	27.30	14.51	8.44	7.19
March 13.	15.57	6.44	3.05	9.12
March 14.	22.32	12.62	7.87	8.73
March 15.	24.17	9.20	10.84	9.65
March 16.	23.92	9.78	8.81	9.93
March 17.	20.71	8.85	10.43	8.51
March 18.	28.07	13.06	8.90	10.58
March 19.	26.29	20.01	14.73	14.20
March 20.	19.39	4.79	9.30	10.32
March 21.	24.64	12.89	13.76	7.68
Digestion Trial III.				
April 15.	7.53	7.17	9.76	5.30
April 16.	27.84	15.38	17.00	10.52
April 17.	17.72	16.39	18.70	9.95
April 18.	25.39	7.99	17.23	11.10
April 19.	22.43	10.49	14.87	10.43
April 20.	29.67	21.68	19.26	17.51
April 21.	15.64	5.13	15.82	8.15
April 22.	17.49	8.59	14.52	9.68
April 23.	23.03	7.99	8.52	11.87
April 24.	19.95	9.43	10.57	13.26
April 25.	19.52	10.56	12.74	11.25

TABLE 47.—WATER DRUNK DURING DIGESTION TRIALS, 1915.

	Steer 31, kilos	Steer 33, kilos	Steer 36, kilos	Steer 38, kilos
Digestion Trial I.				
March 15	17.70	18.40	18.78	18.50
March 16	15.06	24.41	19.80	15.35
March 17	16.65	20.87	18.05	21.82
March 18	31.35	37.00	28.85	27.40
March 19	37.18	49.64	37.40	22.21
March 20	18.30	25.86	28.52	17.50
March 21	29.10	23.45	20.70	28.82
March 22	18.20	29.50	29.80	29.02
March 23	17.41	33.32	23.70	20.13
March 24	18.88	21.80	20.84	23.49
March 25	31.43	31.70	29.62	35.77
Digestion Trial II.				
May 4	15.26	28.20	30.11	17.37
May 5	18.22	32.65	33.21	33.42
May 6	20.11	33.24	30.69	17.67
May 7	16.25	27.90	27.91	26.81
May 8	22.79	35.38	29.61	28.22
May 9	14.00	33.76	30.45	29.93
May 10	19.58	39.70	28.90	29.23
May 11	15.19	37.85	30.28	22.62
May 12	22.30	36.00	33.03	31.67
May 13	10.78	40.16	41.73	37.79
May 14	29.70	33.18	47.40	47.00

TABLE 48.—LIVE WEIGHTS OF STEERS BY MONTHS, 1913.

	Steer 21, pounds	Steer 22, pounds	Steer 23, pounds	Steer 24, pounds	Steer 25, pounds	Steer 26, pounds	Steer 27, pounds	Steer 28, pounds	Steer 29, pounds	Steer 30, pounds
January 1	723	708	784	725	736	487	565	558	498	418
January 2	720	702	774	730	724	473	555	556	500	425
January 3	717	700	777	747	743	487	559	556	498	424
Average	720.0	703.3	778.3	734.0	734.3	482.3	559.7	556.7	498.7	422.3
January 31	753	752	832	723	754	461	590	581	542	461
February 1	746	754	804	735	766	453	567	585	523	440
February 2	755	760	826	738	760	458	580	584	533	450
Average	751.3	755.3	820.7	732.0	760.0	457.3	579.0	583.3	532.7	450.3
March 2	813	885	880	771	817	515	602	641	560	507
March 3	827	887	877	762	817	509	605	651	554	505
March 4	821	890	882	763	807	506	600	651	558	507
Average	820.3	887.3	879.7	765.3	814.0	510.0	602.3	647.7	557.3	506.3
April 1	910	968	960	828	902	530	658	709	600	540
April 2	904	965	958	830	904	526	653	705	598	538
April 3	900	965	950	823	900	557	627	718	580	542
Average	904.7	966.0	956.0	827.0	902.0	537.7	646.0	710.7	592.7	540.0
May 1	887	985	996	804	923	559	645	758	670	585
May 2	932	1007	1013	810	938	602	686	779	691	593
May 3	895	1005	1008	809	932	580	660	765	683	587
Average	904.7	999.0	1005.7	807.7	931.0	580.3	663.7	767.3	681.3	588.3

TABLE 49.—LIVE WEIGHTS OF STEERS BY MONTHS, 1915.

	Steer 31, pounds	Steer 32, pounds	Steer 33, pounds	Steer 34, pounds	Steer 35, pounds	Steer 36, pounds	Steer 37, pounds	Steer 38, pounds	Steer 39, pounds	Steer 40, pounds
February 24 ...	995	950	1065	850	810	915	850	870	895	835
February 25 ...	990	925	1065	855	800	900	860	865	894	830
February 26 ...	1000	960	1060	855	810	920	860	880	895	835
Average	995.0	945.0	1063.3	853.3*	806.7	911.7	856.7	871.7	894.7	833.3
March 26	990	980	1087	860	809	930	845	875	955	890
March 27	1000	990	1086	873	808	935	850	873	960	900
March 28	1012	980	1080	870	810	933	854	875	963	900
Average	1000.7	983.3	1084.3	867.7	809.0	932.7	849.7	874.3	959.3	896.7
April 25	1095	1049	1180	935	822	1015	875	960	1046	960
April 26	1093	1050	1175	937	823	1023	875	965	1039	960
April 27	1095	1056	1179	939	820	1020	870	967	1040	965
Average	1094.3	1051.7	1178.0	937.0	821.7	1019.3	873.3	964.0	1041.7	961.7
May 25	1044	1073	1219	1010	856	1061	897	1007	1116	1050
May 26	1055	1068	1230	1003	867	1085	915	1017	1107	1061
May 27	1060	1056	1233	1010	864	1085	905	1018	1120	1075
Average	1053.0	1065.7	1227.3	1007.7	862.3	1077.0	905.7	1014.0	1114.3	1062.0
June 24	1020	1105	1253	1066	890	1149	925	1066	1179	1120
June 25	1015	1098	1246	1075	900	1155	920	1061	1198	1123
June 26	1036	1120	1244	1072	900	1150	915	1068	1195	1123
Average	1023.7	1107.7	1247.7	1071.0	896.7	1151.3	920.0	1065.0	1190.7	1119.3

Average February 23, 25 and 27.

TABLE 50.—RESULTS OF SLAUGHTER TESTS, WEIGHTS, 1913.

	Calves						Yearlings					
	Steer 26, pounds	Steer 27, pounds	Steer 28, pounds	Steer 29, pounds	Steer 30, pounds	Steer 21, pounds	Steer 22, pounds	Steer 23, pounds	Steer 24, pounds	Steer 25, pounds		
Live Weight	625.00	737.00	707.00	690.00	583.00	843.00	1087.00	1022.00	862.00	983.00		
Dressed beef, warm	333.00	386.00	449.00	385.00	352.50	535.50	607.00	632.50	502.00	557.50		
Right half carcass	165.50	191.00	224.00	191.00	175.00	266.00	302.50	313.00	250.50	276.50		
Left half carcass	167.50	195.00	225.00	194.00	177.50	269.50	304.50	319.50	251.50	281.00		
Hide	49.50	55.40	53.69	50.63	51.87	73.13	70.44	75.05	61.42	76.40		
Tail	1.21	1.84	2.35	1.76	1.56	2.13	2.08	1.59	2.05	2.06		
Head	17.09	21.13	22.25	19.07	16.50	23.05	23.75	24.63	23.19	24.90		
Tongue and trimmings	3.89	4.69	5.50	3.25	3.85	5.50	5.69	5.69	5.25	5.44		
Feet	11.45	13.61	14.04	13.19	10.83	15.67	16.92	16.48	15.94	16.26		
Heart	2.46	3.00	3.69	3.16	2.75	3.66	3.61	4.50	3.44	4.35		
Lungs and windpipe	8.03	9.87	11.10	9.45	9.84	13.64	12.73	13.10	13.40	14.60		
Liver	6.07	6.44	8.81	8.07	6.46	10.94	10.28	12.08	8.53	10.00		
Fat,												
Total	9.60	12.15	14.21	13.72	12.38	36.68	28.73	27.48	19.15	21.96		
Caul	6.06	7.84	8.04	9.87	6.91	21.30	17.00	16.13	10.09	13.96		
Intestinal and p'uck	3.54	4.31	6.17	3.85	5.47	15.38	11.73	11.35	9.06	8.00		
Stomachs with contents	103.57	124.04	87.25	87.05	64.14	130.81	125.06	105.48	103.69	141.51		
Stomachs empty	18.31	21.90	23.06	23.06	17.50	26.75	30.17	34.90	31.00	35.12		
Intestines empty	13.75	13.91	12.95	12.31	12.44	15.73	18.35	19.03	18.72	17.87		
Internal organs and trimmings not in- cluded above	9.25	10.60	10.39	10.12	7.40	13.23	14.00	15.21	13.66	15.53		

TABLE 51.—RESULTS OF SLAUGHTER TESTS, PERCENTAGES, 1913.

	Calves						Yearlings			
	Steer 26, per cent	Steer 27, per cent	Steer 28, per cent	Steer 29, per cent	Steer 30, per cent	Steer 21, per cent	Steer 22, per cent	Steer 23, per cent	Steer 24, per cent	Steer 25, per cent
Dressed beef, warm	53.28	52.37	63.50	55.79	60.46	63.52	55.84	61.89	58.24	56.71
Right half carcass	26.48	25.91	31.58	27.68	30.01	31.55	27.83	30.62	29.06	28.12
Left half carcass	26.80	26.45	31.82	28.11	30.45	31.97	28.01	31.27	29.18	28.59
Hide	7.92	7.51	7.59	7.34	8.88	8.67	6.48	7.34	7.12	7.77
Tail	.19	.25	.33	.25	.27	.25	.19	.16	.24	.21
Head	2.73	2.86	3.14	2.76	2.83	2.73	2.18	2.41	2.69	2.53
Tongue and Trimmings	.62	.63	.77	.47	.66	.65	.52	.55	.60	.55
Feet	1.83	1.85	1.98	1.91	1.85	1.86	1.56	1.61	1.85	1.65
Heart	.39	.41	.52	.46	.47	.44	.33	.44	.40	.44
Lungs and windpipe	1.28	1.34	1.57	1.37	1.68	1.62	1.17	1.28	1.55	1.49
Liver	.97	.87	1.24	1.17	1.11	1.29	.95	1.18	.99	1.01
Fat,										
Total	1.53	1.64	2.00	1.98	2.12	4.35	2.64	2.69	2.22	2.23
Caul	.97	1.06	1.13	1.43	1.18	2.52	1.56	1.58	1.17	1.42
Intestinal and pluck	.56	.59	.87	.55	.93	1.82	1.08	1.11	1.05	.81
Stomachs with contents	16.57	16.83	12.34	12.61	11.00	14.34	11.51	10.32	12.03	14.39
Stomachs empty	2.92	2.97	3.54	3.34	3.00	3.16	2.77	3.41	3.59	3.57
Intestines empty	2.20	1.91	1.83	1.78	2.13	1.87	1.69	1.86	2.17	1.82
Internal organs and trimmings not in- cluded above	1.48	1.44	1.46	1.46	1.26	1.57	1.29	1.49	1.58	1.58

TABLE 52.—RESULTS OF SLAUGHTER TESTS, WEIGHTS, 1915.

	Two-year-olds						Three-year-olds					
	Steer 36, pounds	Steer 37, pounds	Steer 38, pounds	Steer 39, pounds	Steer 40, pounds	Steer 31, pounds	Steer 32, pounds	Steer 33, pounds	Steer 34, pounds	Steer 35, pounds		
Live Weight	1150.00	920.00	1045.00	1205.00	1120.00	1085.00	1105.00	1220.00	1040.00	890.00		
Dressed beef, warm	664.50	552.00	628.00	689.00	655.50	636.75	630.00	712.50	619.50	482.50		
Right fore quarter	171.00	137.50	162.00	168.25	166.00	167.50	162.00	183.00	157.00	121.00		
Right hind quarter	159.00	137.00	151.00	175.50	160.50	151.25	152.50	172.00	153.00	119.50		
Left fore quarter	173.00	138.00	160.50	170.00	166.00	163.25	159.00	181.00	156.50	119.50		
Left hind quarter	161.50	139.50	154.50	175.25	163.00	154.75	156.50	176.50	153.00	122.50		
Hide	68.53	63.75	68.38	71.25	81.03	73.00	70.78	86.84	56.97	67.56		
Tail	2.69	2.13	2.16	2.63	2.78	3.13	2.58	2.88	1.90	2.03		
Head	28.91	23.56	25.00	28.00	28.31	32.05	30.09	31.50	18.03	25.77		
Tongue and Trimmings	6.50	*	5.16	5.25	5.88	6.59	6.38	5.81	6.25	4.86		
Feet	18.00	15.56	17.94	20.00	19.68	22.15	20.25	20.81	17.90	18.66		
Heart	4.61	4.50	3.61	4.50	4.44	5.25	4.86	5.03	4.19	4.00		
Lungs and windpipe	16.25	12.63	15.50	14.75	14.45	15.63	16.83	17.09	13.90	13.49		
Liver	13.08	8.94	11.88	14.13	13.69	11.74	11.27	12.74	10.38	9.84		
Fat												
Total	30.53	15.75	37.95	43.06	30.35	20.63	32.99	35.67	22.68	12.41		
Caul	13.06	8.00	18.43	22.56	13.19	10.97	15.19	15.03	10.90	6.25		
Intestinal and pluck	17.47	7.75	19.52	20.50	17.16	9.66	17.80	20.64	11.78	6.16		
Stomachs with contents	170.93	93.75	119.63	155.25	112.16	120.69	148.53	143.09	146.74	133.28		
Stomachs empty	36.31	33.25	27.44	41.56	29.68	32.25	32.46	38.52	33.69	29.99		
Intestines empty	22.31	20.00	19.41	25.50	22.44	21.47	18.72	23.44	22.00	20.56		
Spleen	2.09	2.25	2.13	2.38	2.47	2.24	2.41	2.91	2.19	2.72		
Internal organs and trimmings not in- cluded above	14.09	9.81	12.06	15.13	13.11	13.24	11.91	12.88	11.22	9.63		

* Result omitted, as weight recorded was evidently erroneous.

TABLE 54.—WEIGHTS OF FORE AND HIND QUARTERS AND OF WHOLESALE CUTS IN RIGHT HALF CARCASS, 1913 AND 1915.

	Calves		Yearlings		Two-year-olds		Three-year-olds	
	Steer 28, pounds	Steer 29, pounds	Steer 22, pounds	Steer 23, pounds	Steer 36, pounds	Steer 40, pounds	Steer 32, pounds	Steer 33, pounds
Fore quarter	105.97	91.97	147.95	145.49	168.75	163.00	158.75	180.00
Hind quarter	102.59	95.54	146.89	150.88	156.75	159.00	151.00	171.50
Right half carcass ...	208.56	187.51	298.84	296.37	325.50	322.00	309.75	351.50
Chuck	50.03	45.57	75.46	70.63	65.18	68.28	60.46	68.44
Prime rib	26.06	20.65	35.80	38.86	47.66	42.09	38.69	53.40
Plate and shank	29.88	25.75	36.69	36.00	55.94	53.00	59.55	58.31
Loin	35.91	37.19	58.81	71.45	61.93	65.93	64.28	68.58
Rump	16.66	13.06	19.19	17.25	26.00	23.50	30.18	30.25
Round and shank	42.05	38.07	58.39	54.27	62.31	62.68	56.34	65.00
Flank	7.97	7.22	10.50	7.91	6.66	6.88	5.53	7.69

TABLE 55.—PERCENTAGES OF FORE AND HIND QUARTERS AND OF WHOLESALE CUTS IN RIGHT HALF CARCASS, 1913 AND 1915.

	Calves		Yearlings		Two-year-olds		Three-year-olds	
	Steer 28, per cent	Steer 29, per cent	Steer 22, per cent	Steer 23, per cent	Steer 36, per cent	Steer 40, per cent	Steer 32, per cent	Steer 33, per cent
Fore quarter	50.81	49.05	50.18	49.09	51.84	50.62	51.25	51.21
Hind quarter	49.19	50.95	49.82	50.91	48.16	49.38	48.75	48.79
Right half carcass	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Chuck	23.98	24.30	25.59	23.83	20.02	21.20	19.52	19.47
Prime rib	12.50	11.01	12.14	13.11	14.64	13.07	12.49	15.19
Plate and shank	14.33	13.74	12.43	12.15	17.19	16.46	19.22	16.59
Loin	17.22	19.84	19.95	24.12	19.03	20.48	20.75	19.51
Rump	7.99	6.96	6.50	5.82	7.99	7.30	9.74	8.61
Round and shank	20.16	20.30	19.84	18.31	19.14	19.47	18.19	18.49
Flank	3.82	3.85	3.56	2.67	2.05	2.13	1.79	2.19

TABLE 56.—PERCENTAGES OF BONE, LEAN AND VISIBLE FAT IN THE VARIOUS CUTS OF BEEF, 1913 AND 1915.

	Calves.		Yearlings.		Two-year-olds.		Three-year-olds.	
	Steer 28, per cent	Steer 29, per cent	Steer 27, per cent	Steer 23, per cent	Steer 36, per cent	Steer 40, per cent	Steer 32, per cent	Steer 33, per cent
In Total Cut.								
Rib.								
Bone	16.13	16.16	12.64	14.13	15.15	15.98	17.16	16.59
Lean	47.42	62.51	50.69	47.61	54.03	57.85	53.74	57.94
Fat	36.45	21.33	36.67	38.26	30.82	26.17	29.10	25.47
Shoulder.								
Bone	12.97	15.33	12.93	9.46	8.61	6.96	10.57	8.04
Lean	70.20	71.35	71.69	77.14	77.37	72.60	70.46	80.77
Fat	16.83	13.32	15.38	13.40	14.02	20.44	18.97	11.19
Round.								
Bone	3.09	2.91	4.12	3.11	2.59	3.34	3.58	2.62
Lean	83.40	84.54	87.74	81.99	85.97	91.50	85.86	87.02
Fat	13.51	12.55	8.63	14.90	11.44	5.16	10.56	10.36
Loin.								
Bone	12.86	10.35	13.05	7.55	13.85	12.57	11.97	12.38
Lean	59.71	59.27	60.50	53.19	58.04	60.28	61.45	61.89
Fat	27.43	30.38	26.45	39.26	28.11	27.15	26.58	25.73
In Bone-free Portion.								
Rib.								
Lean	56.54	74.56	58.02	55.44	63.68	68.85	64.87	69.46
Fat	43.46	25.44	41.98	44.56	36.32	31.15	35.13	30.54
Shoulder.								
Lean	80.66	84.27	82.34	85.20	84.66	78.03	78.79	87.83
Fat	19.34	15.73	17.66	14.80	15.34	21.97	21.21	12.17
Round.								
Lean	86.06	87.07	91.00	84.62	88.26	94.66	89.05	89.36
Fat	13.94	12.93	9.00	15.38	11.74	5.34	10.95	10.64
Loin.								
Lean	68.52	66.11	69.58	57.53	67.37	68.95	69.81	70.63
Fat	31.48	33.89	30.42	42.47	32.63	31.05	30.19	29.37

TABLE 57.—PERCENTAGES OF WATER, PROTEIN AND FAT IN BONE-FREE CUTS OF BEEF, 1913 AND 1915.

	Calves.		Yearlings.		Two-year-olds.		Three-year-olds.	
	Steer 28, per cent	Steer 29, per cent	Steer 22, per cent	Steer 23, per cent	Steer 36, per cent	Steer 40, per cent	Steer 32, per cent	Steer 33, per cent
Rib.								
Water	47.54	52.04	48.09	42.59	46.70	48.46	51.05	*
Protein	13.94	14.75	14.19	11.81	14.38	13.61	12.97	
Fat	38.12	32.71	37.12	45.34	36.94	38.12	34.08	
Shoulder.								
Water	66.68	68.59	66.66	67.70	66.64	63.69	65.33	67.94
Protein	17.75	18.00	17.94	17.69	18.67	16.76	17.29	18.58
Fat	15.38	12.83	13.30	14.03	13.91	18.62	16.37	12.75
Round.								
Water	68.94	68.45	70.20	67.82	*	71.01	69.62	67.71
Protein	19.44	18.31	19.88	18.56		21.75	19.45	19.68
Fat	10.43	11.75	9.31	12.51		8.32	9.49	11.33
Loin.								
Water	56.93	55.72	58.55	51.75	56.82	57.36	56.45	57.21
Protein	15.38	15.13	15.88	13.56	15.55	15.86	16.37	16.09
Fat	26.71	28.35	24.21	33.72	27.63	26.58	27.03	25.69

* Data lost through an accident.

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February, 1917

New Mexico College of Agriculture and Mechanic Arts

Agricultural Experiment Station State College, N. M.

In Co-operation with United States Department of Agriculture,
Office of Dry Land Agriculture

Harvesting "Iron" Cowpeas.
Tucumcari, N. M., Field Station, 1913.

Dry Farming in Eastern New Mexico

By

J. E. MUNDELL, Assistant in Dry Land Agriculture, U. S. D. A.,
Superintendent of the Tucumcari Field Station from
September, 1911, to June 30, 1914,
and

HERBERT G. SMITH, Assistant in Dry Land Agriculture, U. S.
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Since July 1, 1914.

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DRY FARMING IN EASTERN NEW MEXICO

INTRODUCTION.

This bulletin will be one of a popular type written for the purpose of giving to present and to prospective settlers information on general crop conditions and methods for farming the dry-land areas of eastern New Mexico. The information it contains has been gathered from several years of observations in eastern New Mexico and in other dry-farming districts, and from the results of experiments carried on at the Dry Land Field Station located at Tucumcari, New Mexico. Although the data contained herein and the suggestions made are for the conditions found in eastern New Mexico, the underlying principles pointed out may hold true in other parts of the southern portion of the Great Plains Area.

It is hoped that the information and data herein presented may be of considerable assistance to the farmers at present in the region, and especially to the newcomers, in their dry-farming operations. One of the most important points for the latter to bear in mind is that conditions in the dry-farming areas of New Mexico are very different from those of the more humid sections of the country, and may require different methods. As a rule, those who have succeeded best in the past have been the ones who have adapted their farming operations most promptly and thoroughly to conditions as they exist.

It is the object of the present bulletin to present data secured, not so much for the purpose of attracting more settlers to this region, but to give helpful information to those who are here and those who may settle in this part of the State in the future. The methods suggested in the following pages are the practices of successful settlers and are methods which have thus far, from the experiments carried on at this Station, shown themselves to be the best.

DESCRIPTION OF THE DRY LAND FIELD STATION.

The New Mexico Dry Land Field Station is located

about three miles northeast of the city of Tucumcari, New Mexico. The elevation of the Station is about 4,200 feet. The topography of the immediate section is rolling. The Station farm contains 320 acres of arable land, about 100 acres of which are in crops each year. The soil is of a residual type and is classified by the Bureau of Soils of the United States Department of Agriculture as a fine sand. The sand extends down to a depth of from one to three feet, gradually blending into a clay which goes down, in many places, to a depth of at least 135 feet, as noted during the drilling of two wells on the Station grounds. The soil is of a dark chocolate color and is naturally fertile enough for the amount of precipitation normally received in this section.

Fig. 1.—Office, Implement Shed, and Barn.
Tucumcari, N. M., Field Station.

The New Mexico Dry Land Field Station is an outgrowth of a demonstration farm started near Tucumcari in 1909. The farm was financed by an appropriation made by the State legislature. In the fall of 1911 the United States Department of Agriculture took over the work of the Station and placed it under the jurisdiction of the Office of Dry Land Agriculture. In the summer of 1912 the present site of the Station was purchased by

the citizens of Tucumcari and deeded to the New Mexico College of Agriculture and Mechanic Arts. The land was then leased to the United States Department of Agriculture and the expense of all buildings and other permanent improvements, and of equipment, maintenance and operation of the Station has been provided for from Federal funds administered through the Office of Dry Land Agriculture, Bureau of Plant Industry, United States Department of Agriculture. Although this Station was organized primarily for the purpose of conducting experiments for the above Office, in addition there is co-operative experimental work carried on for other divisions of the United States Department of Agriculture and for the New Mexico State Experiment Station. The primary work of the Station is testing out various rotations and tillage methods which may be best adapted to this section. The co-operative work consists of securing soil moisture and climatological data in co-operation with the Office of Biophysical Investigations; varietal tests and dates and rates of planting grain sorghums for the Office of Cereal Investigations; varietal tests of sorghos, millets and cowpeas for the Office of Forage Crop Investigations; varietal tests of corn for the Office of Corn Investigations; varietal tests of cotton for the Office of Cotton Breeding Investigations, and taking weather observations for the U. S. Weather Bureau. Co-operative steer feeding and hog pasture experiments are being conducted with the State Experiment Station. It is the intention to publish, at an early date, a bulletin giving the results secured in the steer feeding investigations. Some experimental work with fruit trees and ornamental shrubs and trees is also being conducted.

METHOD OF EXPERIMENTATION.

These crop experiments are conducted on plats either one-tenth or one-twentieth acre in size. All plats are 33 feet wide and are either 66 feet or 132 feet long, depending on the area. There were 146 one-tenth acre plats de-

voted to the work of the Office of Dry Land Agriculture and 29 one-tenth and 88 one-twentieth acre plats devoted to the work of co-operators during the season of 1916. Each plat planted to row crops has ten rows spaced 44 inches apart. The spacing of the plants in the rows varies with the crop grown and the experiment being conducted. For all drilled crops the rows are 8 inches apart.

A number of one-acre fields are used for co-operative hog pasture experiments. The remaining land is devoted to raising crops for the Station live stock and for feeding tests.

Since all of these crop tests are conducted on small areas of land, the farming operations are necessarily more expensive than is the case with crops grown on larger units, but it is the aim of the Station to give no more and no better treatment to the crops than a farmer could afford to give.

Fig. 2.—Tucumcarl Field Station Plat Field, fall of 1915.

General Factors That Should Be Considered

Locating a Farm.

The following suggestions relative to locating a farm may be of some use to new settlers as they aim to present some of the more salient points to be considered.

The choice as to distance from town depends largely upon the type of farming that is to be practiced. If livestock farming is to be undertaken, distance amounts to but little, whereas if the crops are to be marketed direct it is essential that one locate within easy reach of markets.

In eastern New Mexico soil types vary greatly—in many instances two or more distinct types of soils will be found quite close together. Most of the farmers who are doing well in this section prefer a sandy rather than a clayey soil, as in the past it has been noted that better and surer crops were raised on sandy soils than on those containing more clay. The depth of the soil should be considered as well as the type, for the soil acts as a reservoir for water and it is evident that a deep soil will hold much more water than will a shallow one. Nearly all of our sandy types of soils are underlain by a clay or other relatively impervious subsoil. In cases of this kind it will be found best to select soils the subsoil of which is at least two feet below the surface. Experience shows that shallow soils are to be avoided. Before deciding on a piece of land it should be ascertained if the prospects for securing water are good. The well should be the first thing to be considered and only after water has been secured should buildings be erected. Whenever possible, buildings should be placed in close proximity to the water supply.

As the section becomes more settled schools will be

established closer together than is now practicable, but even now it is no great distance from any farm to a good school, and good high schools are to be found in almost any of the larger towns.

In regard to selecting a healthful location, probably the most important things to be considered in this climate are sources of uncontaminated water and a reasonably high and well-drained place for the residence and barns.

LIMITING FACTORS IN CROP PRODUCTION.

Many of the limiting factors of crop production found in other agricultural communities are also to be found in this section. Among the more important ones may be mentioned the following:

Moisture: Moisture is generally stated to be the principal limiting factor in crop production in this section, and this being true, the farm practices should be outlined to conserve and utilize as much of the available moisture as possible.

Sand: On the sandy areas of New Mexico much soil-blowing and soil-washing occur unless special effort is made for their prevention. When a crop is young the drifting or washing of the soil will sometimes cover and smother it. In the tillage operations on sandy lands it is therefore necessary to bear in mind the prevention of blowing and washing whenever possible.

Pests: New Mexico has her share of weeds and since weeds use much moisture they should be kept in check, in order that the available moisture can be saved for the crops.

Rabbits, prairie dogs and other rodents are sometimes injurious. In favorable years rabbits will not bother most field crops, but in dry years some method of combating them is necessary. Where possible a rabbit

drive is probably the best method of getting rid of jack rabbits. With the cottontail it will be necessary to resort to trapping, shooting or poisoning. Prairie dogs and other rodents should be exterminated by poisoning, shooting or other suitable methods.

In the dry-farm districts there are few insects which are of economic importance. The corn-ear worms, the grain aphids, and the grasshoppers are probably the most common.

Migratory birds, chiefly bobolinks and blackbirds, are occasionally bothersome to such crops as grain sorghums, as they often reduce the grain yields as much as 50 per cent through their depredations. These birds molest the crops from the time the grain is forming until maturity, and present a menace difficult to control.

Plant Diseases: The plant diseases of importance are the smuts of the small grains, of broomcorn and other sorghums, and of corn. Treating the seed of small grains by soaking for ten minutes in a solution of 1 pound of formalin to 40 gallons of water will, as a rule, be quite effective in preventing this disease. Corn smut cannot be controlled but may be checked by planting only on land on which no corn smut has been allowed to mature. The loose kernel smut and kernel covered smut in sorghums also may be controlled by soaking the seed used for planting in the formalin solution for thirty minutes.

Tillage: Too much tillage as well as too little tillage may be injurious to crops, in addition to increasing the relative cost of raising them. The number of cultivations which should be given will depend largely upon the season, the weediness of the land, the previous crop and the methods by which it was handled.

General System of Farming: Good farming is as necessary here as elsewhere. "Good farming," says Prof. E. C. Chilcott, of the United States Department of Agriculture, "means practicing the best methods of

producing the largest crops at the lowest relative cost of production and leaving the soil in the best condition for the production of subsequent crops." Slovenly methods are sure to fail in New Mexico, as well as elsewhere.

Seed: Last but not least of the more important limiting factors of crop production is seed. Clean, viable and unbroken seed, free from disease, must be planted to insure a good crop.

TILLAGE BEFORE PLANTING.

Breaking Sod Land: The common practice for breaking sod land is to use a small turning plow and plow from 3 to 4 inches deep. When the first plowing is done in the previous summer or fall, the land can be backset a little deeper than first plowed some months before planting, in order that the ground may be weathered and worked down to a good seed bed. On sandy land or land poorly sodded, a disk plow will be found most satisfactory, especially when the ground is dry, but where the sod is dense as in short-grass land, a better job will be done with a flat breaker of either mouldboard or rod type. The latter is the more common type in this section. Sometimes it is the practice to list sod land. This practice is to be condemned, however, as a very poor seed bed is procured by this method unless the land be extremely sandy.

If the land be broken and backset some months before planting season, it will be found a good practice to allow the soil to lie rough until within six or eight weeks of planting time, in order to prevent run-off from rains, to hold the snow and to expose as much surface of the soil as possible to the weathering agencies. From six to eight weeks before planting season the ground should be double disked with a weighted disk harrow having the disks set fairly straight to cut and fine the sod. Then two to three weeks before planting this operation should be repeated. Unless weeds come up thickly, the ground will be in good shape for planting. If weeds appear they should be erad-

icated before planting is done, as it is much easier and cheaper to clean land of weeds before than after a crop is planted.

Breaking Old Land: If time permits, it will be found to be a good plan to disk as soon after harvest as possible land that is to be plowed or listed. It will then work much easier and a better job can be done. This disking has the added advantage of killing many of the late weeds and thus aiding in the preparation of a clean seed bed for the following season.

Many authorities advocate plowing or listing at some definite time of the year, but it has been the observation of the writers, both at the Field Station and on private farms, that the date of plowing is not of so much importance as the doing of a good job when it is done. Our suggestions would be to plow old land for spring and summer crops during late fall, winter or early spring, and for the small winter grains as soon after harvest as possible. Early plowing should be done about 8 inches deep, whereas later plowing may be shallower. Listing should be done much deeper than is the general custom—6 to 8 inches having been found to be a very satisfactory depth.

Some writers recommend the summer fallow, but neither at Tucumcari nor at any other of the twenty-three stations in the Great Plains Area operated by the Office of Dry Land Agriculture has this practice been found the most profitable. Summer fallowing land is not practiced to any extent in eastern New Mexico and is not to be generally recommended. It may be said that alternate cropping, i. e., summer fallowing land every other year, would not be profitable. It might sometimes be advisable, however, to fallow land one year out of four or five, but no satisfactory records are available which show even this frequency of fallowing to be profitable.

Seed Bed Preparation: For sandy land, if the ground

has been plowed from four to six months before planting season, a single disking two or three weeks before planting, with weights on the disk harrow, will in most cases and in most years be found sufficient to put old ground in good shape for planting. If weeds are likely to be bothersome it may sometimes be advisable to set the disks wide, weight the implement and then double-disk the land before planting. If the ground has been listed instead of plowed, leveling with the lister cultivator will fit it for planting, or row crops may be planted without other preparation by splitting the ridges with a lister. This will not only place the seed in moist soil but will cover nearly all weeds.

One of the principal things to guard against on a sandy soil is getting the surface too fine and smooth. For this reason a smoothing harrow is not recommended, for unless great care is taken in both the time and the method of using the harrow, the surface of sandy soils will be fined so that it will blow readily.

On heavier soils much the same methods should be pursued, but ordinarily the spring work should be started two to three weeks earlier than on the sandy types of soil, and possibly one or more diskings in addition to that advised for the sandy types should be given. A spike-tooth or other smoothing harrow will sometimes be found to be useful on the heavier soils even though their use is not generally advisable on the lighter soils.

PLANTING.

Time for Planting, Early vs. Late: Early planting—from September 30 to November 1—is recommended for fall and winter grains, as the plants will then make sufficient growth to guard against winter freezing and soil-blowing. Early planting will also be found advisable in the fight against plant lice or “green bugs,” which are sometimes injurious to small grains during mild winters.

For spring grain crops, early planting—about March 1—is recommended. For summer crops, such as milo, kafir, sorghum, cowpeas, broomcorn, corn and Mexican beans, late planting is to be recommended almost without exception. The 15th day of May should be about the average date for planting at places with the same elevation as Tucumcari. By this date danger of frost will be over, many of the early weeds may have been eradicated, and the condition of the soil will usually be found to be good for germinating seeds. Late planted crops will not make growth enough before the usual summer rains to exhaust the water stored in the soil.

Listing: On sandy areas in this section listing is one of the best methods of preparing land and for planting crops. By listing, more land can be handled in a given length of time and it can be handled at less expense per acre than by practically any other method. Listing is the surest preventive of soil-blowing and soil-washing. The greater percentage of successful farmers in this section use a lister for both preparation of the land and for planting. Single listing in the fall, winter or early spring and splitting the ridges at planting time has been found to be both cheap and profitable. By planting with a lister the seed can be placed in moist earth, which is essential in securing a stand. The lister furrow also affords some protection to young plants.

Flat Planting: If the ground is broken with a plow and later worked down and planted "flat," it is recommended that disk furrow openers be obtained and used on the planter. By using these furrow openers, seed may be placed in moist soil without covering it too deeply, and the roots will be out of the way of the cultivator shovels and where they will be less exposed to damage by hot sun and winds. After planting, the soil is left in ridges and will seldom blow if in the right condition. If the soil should blow it is usually a simple operation to stop it by running the furrow openers between the rows

with the same machine, throwing the planting mechanism out of gear. This will leave the surface of the land corrugated and only a very stiff wind will start it blowing.

Single or Two-row Implements: Wherever sufficient horsepower is available two-row tools should be used in preference to single-row tools, as much more work can then be done by one man. Dry farming should be a process of making a minimum amount of work per man per year cover as large an acreage as possible without material decrease in either quality or timeliness of the work.

Drilling: Drilling, of course, is the only advisable method of planting small grains and millets. At Tucumcari these crops are planted in drills 8 inches apart. Other crops, such as sorghums, beans and corn, should generally be planted in rows and cultivated. If the latter crops are planted in drills or broadcasted, too many plants to the acre will result. In very dry years they will soon use up the available moisture supply and will perish, while if planted thinly in rows they will stool and sucker and produce large crops in good years, and will have a chance to make fair crops in dry years.

Depth to Place Seed: In dry-farming sections as a general rule the seed may be covered more deeply than in more humid regions. The depth to plant depends largely upon the soil moisture conditions and the crop planted. Seed should always be placed in moist soil. Corn, cowpeas, peanuts and other large seeds may be placed as deeply as 4 to 5 inches, but the optimum depth will be about 3 inches. Medium sized seeds, as the sorghums and the small grains, may be placed as deeply as 3 to 4 inches, but the optimum depth will be about 2 inches. Millet, alfalfa and other small seeds, and cotton should be scarcely more than covered, and with these, therefore, it is usually difficult to secure a stand unless they are planted during a rainy period, as the surface soil dries out very rapidly.

Rate to Plant: Crops in this section should be planted much thinner than in more humid regions. Most planting is done too thickly. If corn has one stalk every 30 inches, grain sorghums one stalk to 14 inches, feed sorghums and broomcorn one stalk to 7 inches, cowpeas and beans one plant to 7 inches, and in all cases the rows 44 inches apart, the crops will be quite thick enough for average years. Rye or wheat may be planted at the rate of about three-fourths bushel to the acre, oats about one and one-half bushels per acre, and alfalfa or millet about 12 pounds per acre. If alfalfa is planted in rows 36 inches to 42 inches apart (and this is the better method), 3 to 5 pounds of seed per acre will be sufficient.

TILLAGE AFTER PLANTING.

Purpose of Tillage: The principal reasons for cultivation after planting or intertillage of a growing crop in this section are to destroy weeds, to check or prevent soil-blowing or soil-washing, to level listed land and, by maintenance of a loose, open surface, to facilitate the penetration of water and prevent run-off.

Weeds: Perhaps the most important reason for cultivating is for the purpose of destroying weeds. Weeds use as much water per pound of dry matter produced as do most crops. Water is one of the most important of the limiting factors of plant growth and should be conserved in every possible way. All weeds should be kept cultivated out of a crop. A heavy growth of weeds and good yields of crops are not produced together. A surface cultivation will kill the ordinary weeds as well as a deep cultivation, and without breaking off the roots of the crop plants. Select shovels or sweeps for the cultivator, having in mind both the eradication of the weeds and the breaking up of the crust into a dirt mulch. "Wing" sweeps will do well in any but trashy and heavy or stony soils.

Storing Moisture: By keeping the ground moderate-

ly rough through cultivation, the soil is made receptive to precipitation and run-off prevented.

Breaking Crust: Often it will be necessary to break the crust after rains so that seed previously planted can emerge. Any tool that will scratch the soil sufficiently to break the crust in the row over the seed will suffice. Sometimes driving the planter over the row and allowing the shoe or runner to drag lightly will do the work.

Leveling Listed Land: Wherever crops are planted with a lister, it is essential that the land be leveled by cultivation before harvest time in order to have a smooth surface for the binder and wagons when harvesting and hauling in the crop.

Checking Soil-Blowing and Soil-Washing: Cultivation of the right kind will check soil-blowing if there are either clods or moist dirt below the surface which can be brought to the surface by the cultivating implement. The principles of checking soil-blowing and soil-washing are quite simple. On land with steep slopes, the soil should always be worked across the slope. Where no serious soil-washing occurs, the soil should always be worked as nearly at right angles to the direction of the prevailing winds as is practicable. The surface of the soil should be left in a roughened or furrowed condition at all times. A rough soil will not blow, except during the severest wind storms, or unless other "blow-soil" is carried upon the roughened surface by wind or other agency. If "blow-spots" are noticed in the fields, they should at once be disked or cultivated in order to check the area from spreading. In cultivating sandy land it should be remembered that a dust mulch should always be avoided. Listing is probably the surest and safest method of checking soil-blowing. If the ground is dry and deeply pulverized, even listing will often fail to check or prevent the soil from blowing.

If the soil surface is in a roughened condition, it is

receptive to any normal precipitation and there will be no run-off. If there is no run-off there will be no soil-washing. A rain will pack a soil having a dust mulch so that it quickly becomes non-receptive, and in many cases will wash badly. Sometimes the precipitation in this section falls so rapidly that any method used for checking washing will fail to prevent it entirely, but by practicing the methods discussed above much damage from soil-erosion will be avoided.

LAYING BY CROPS.

“Laying by” crops is the custom in nearly all agricultural districts. Since one of the principal reasons for cultivating crops is to eradicate weeds and since weeds grow well in this section up to frost, cultivation should be given late when practicable as well as early in the season. An injurious crust seldom forms late in the season, however, on any inter-tilled field that has been given sufficient cultivation to keep the weeds from growing. The late cultivation will help retain the moisture for the present season’s crops, and if the crop does not require the moisture, it can be stored or saved for the crop of the ensuing year.

EQUIPMENT AND POWER NEEDED BY A DRY LAND FARMER.

A good team is the basis of all operations on a dry land farm. Without a good team, one’s chances of success are lowered considerably.

Below are given lists of machinery or implements needed at different stages of the crop year, under the different methods of farming. Wherever sufficient power is available, large implements should always be purchased and used. Two-row implements should be given preference over single-row tools. Gang plows should be chosen in preference to single plows.

For Plowing: The implements necessary for the breaking of sod land have been discussed under the heading, "Breaking Sod Land." For breaking old land any good make of riding or walking plow is good. On old land where listing is practiced any reliable make of sulky lister having a tongue and a planting device will answer for both breaking and planting.

For Tillage Before Seeding: Where listing is practiced, no implement is needed other than the lister, for ordinary years. In cases, however, where the weeds secure such a start that the lister does not cover them when splitting the ridges in planting, it may be well to cultivate the ridges by running down the furrows with a "go-devil" or sled cultivator having short knives attached to each runner of the implement.

On flat planting a good disk harrow, and in some cases a smoothing harrow, will put the soil in condition for planting.

For Seeding: Where listing is done, the ordinary lister with planting attachment is all that is needed.

For planting row crops on plowed land either a lister or a two-row planter equipped with furrow openers will be suitable.

For millets, small grains, and in certain cases for alfalfa, any good make of disk drill, having from 10 to 14 disks spaced 8 inches apart, will do the work required.

For Tillage After Seeding: For listed crops nothing is better than an ordinary sled cultivator, or as it is commonly called, a "go-devil." This implement combines durability, serviceability and cheapness, and does fairly good work if properly handled.

For level planted crops, any good make of riding or walking cultivator can be used. As a rule it is thought best to equip the cultivator with four to six of any of the several styles of "sweeps" now found in general use in

this section. The size of sweeps to use depends on the width of the row. Sweeps are generally used in preference to shovels in eastern New Mexico.

For tree cultivation a disk harrow will be found essential.

In addition to the above it is desirable to have a one-horse cultivator or some other implement to use between and around the rows of trees.

Implements for Harvesting: For small grains, a binder, or a header and barges.

For millets, alfalfa, and Sudan grass, a mowing machine and horse rake, or in some cases a grain binder. A row binder will do good work with Sudan Grass where planted in rows and where it makes sufficient growth.

For standing row crops, a row binder or a sled harvester.

For cowpeas, beans, or peas, a regular bean harvester is needed. A serviceable sled cutter can be made at home.

For harvesting small areas of potatoes, peanuts, or other root crops, an ordinary walking plow will prove satisfactory. For large areas it will pay to have a potato digger which will do good work for all crops of this nature.

CROPS.

Whenever possible and practicable, row crops should be grown in preference to drilled crops, as has been stated. One principle of dry farming is to plant thinly.

The following lists of crops are necessarily brief and contain only those crops which have shown themselves to be suitable for the purpose mentioned. It should not be the aim of any one to grow all of the crops listed here. It will be better to raise not more than one or two crops

for each purpose. One of the most important things to be remembered is that the market demands a standard product grown in sufficient quantities to pay dealers to handle it. Many farmers, especially newcomers, do not know what crops to plant and so they try to grow a small quantity of each of several varieties, and when marketing these they often mix or offer them together to buyers, with the result that a low price is received. It will pay any grower to limit his efforts in growing crops to at least two or three of the leading varieties in each class.

Crops for Forage: **FREED or WHITE AMBER SORGO.** This is perhaps the earliest and surest of all forage sorghums tested. It is valuable for late planting, especially in years when other crops have failed. Its one drawback is that it is a relatively light yielder, but this is largely offset by its sureness.

Fig. 3.—Freed or White Amber Sorgho.
Tucumcari Field Station, 1914.

BLACK AMBER SORGO—RED AMBER SORGO.

These two varieties of amber sorgho are moderately early and for ordinary planting should be selected over the Freed, as either of them will outyield the Freed, in normal years. There is very little choice between the Black

and the Red Amber Sorgos—if anything, the Red Sorgo will be found to be slightly higher yielding.

Fig. 4.—Red Amber Sorgo.
Tucumcari Field Station, 1916.

ORANGE SORGO. The Orange Sorgos are valuable for forage but are later than the ambers and not quite as sure of making a crop. They are sometimes damaged by smut to a greater extent than the amber sorgos.

SUDAN GRASS. This is a promising hay crop where hay is wanted, but for feeding on the farm it has no particular advantage over the other sorghums, and it is a much lighter yielder. Sudan grass will generally outyield Millets and is a better drouth resister. It may be used successfully in summer as a grazing crop for hogs or other stock, and will furnish a large amount of green, succulent feed when used for this purpose.

COWPEAS. Cowpeas are very good forage plants,

having a feeding value but little lower than that of alfalfa. They have the advantage of leaving the ground in excellent condition for the succeeding crop. Crops following cowpeas nearly always yield higher than those following any other crop. Cowpeas should be grown in rows in this section. If land has a tendency to blow it should be listed as soon as possible after harvesting the cowpea crop, as otherwise the surface is left smooth and

Fig. 5.—“Whippoorwill” Cowpeas.
Tucumcari Field Station, 1916.

fine and is liable to blow. For hay the Whippoorwill variety is recommended, but for grain one of the earlier varieties such as Early Buff, Black-Eyed or New Era should be selected.

MILLET. German millet is the variety which has outyielded other varieties at the Field Station the past several years, but Turkestan Millet also seems to be very promising. Millet is a valuable hay or forage plant, especially for late season planting. The honors are quite evenly divided between it and one of the amber sorgos

for late season planting such as may be done on fields where other crops have failed.

Crops for Grain: On the higher elevations and in the more favorable districts of eastern New Mexico the small grains and corn will in some years do well, but results show that the yields are often light and will not always pay as a money crop. As will be noted from a study of the precipitation records given elsewhere in this bulletin, the greater part of the precipitation in normal years is distributed over the summer growing months, while the winters are usually dry. This alone is a strong argument in favor of growing and placing dependence upon the summer crops and "going light" on the small grain crops.

Fig. 6.—Dwarf Yellow Milo—showing the many heads.
Tucumcari Field Station, 1915.

Over the greater portion of the eastern part of the State farmers will do well to place their dependence upon such grain crops as DWARF YELLOW MILO, DWARF BLACK-HULLED KAFIR, and FETERITA. The Dwarf Milo has proven to be the highest yielding grain crop, but the roughage or forage from it is very poor.

Fig. 7.—Dwarf Black-hulled Kafir.
Tucumcarl Field Station, 1915.

Kafir roughage is very fair and although the grain yields are slightly below those of Milo, it is a much easier crop to harvest and many people grow it instead of Milo for these reasons. Feterita is a promising grain crop but as yet has shown itself to be no more valuable than either Kafir or Milo for this purpose.

Cash Crops: Nearly any of the grain crops mentioned under the previous heading will do well for cash crops, but it should be remembered that livestock probably bring higher cash returns than any other farm product, in addition to leaving most of the plant foods on the farm; therefore, grain crops, to bring the highest returns under ordinary conditions, should be fed to livestock.

Other suitable cash crops for our conditions are few in number and perhaps the NEW MEXICO PINTO BEAN and DWARF-STANDARD (Acme) BROOMCORN will be the best paying of these. The bean is a fair yielder in most years and will generally be found to be a profitable

crop to grow. Broomcorn is the more drouth resistant of the two and does well even in dry years. Crops use most water at the time of forming grain. Broomcorn has the

Fig. 8.—Dwarf-Standard (Acme) Broomcorn.
Tucumcari Field Station, 1914.

advantage over most other crops in that it does not have to form grain to be profitable. Rothgeb* says that the brush may be pulled at any time from the beginning of blooming until the seed is in the early dough stage. The exact time depends very largely upon the development of the fibre. When the natural pea-green color extends from the tip to the base and from the outside to the center of the head, the brush is ready for pulling. Broomcorn is usually a sure crop and a profitable one. It does, however, take more of an outlay of time, labor and cash to handle than do most dry farm crops. The stover from

*Adopted from U. S. D. A. Bulletin 768, entitled "Dwarf Broom Corns."

broomcorn will make fair roughness or forage for feed. If put into the silo at the time the heads are pulled, it will also make fairly good silage.

Crops for the Silo: The kafirs, in eastern New Mexico, fill the place held by corn in the central and eastern States. Silage made from one of the kafirs will generally be found to equal or excel that made from Indian corn. The **EARLY BLACK-HULLED KAFIR** is very good for the purpose. Other crops suitable for the silo include the **AMBER SORGOS**, **FETERITA** and **MILO**. Unless, however, the sweet sorghums are cut at the right stage of growth the silage made from them will be inferior in quality. Feterita and milo are considered by most authorities to make a silage somewhat inferior to kafir or cane, and should not be used for ensilage if better crops are available. Few trials of Sudan grass as a silage crop have been made, as yet, but very favorable reports have been made by the Oklahoma Experiment Station and others. Crops for silage should usually be cut when the grain is in the hard dough stage.

Pasture Crops: Pasture crops which are known to do well in this section are decidedly lacking. There is no pasture crop for general usage which is better than our native grasses, namely, Grama and Buffalo grass. These grasses are very slow in reseeding themselves and the seed is not procurable on the market. For this reason sod land should never be broken in this section unless one has a definite purpose in mind when doing so.

Crops which give promise of doing well for summer pasture for all classes of livestock are **RYE**, **PEARL MILLET**, **SUDAN GRASS** and **COWPEAS**. **WINTER RYE** and other **WINTER GRAINS** will make fair winter and spring pasture.

Crops for the First Year: The average settler who comes to this section will need to plant some crop the first year which will bring him a cash income. After suf-

ficient feed and grain crops for his own use have been planted, cash crops may be considered. If the ground is plowed and handled as recommended in this bulletin, or if some other suitable method of handling it is used, there will be no more difficulty in raising any of the crops recommended for this section, on sod land than on old land, provided that the normal amount of precipitation is received during the growing months.

Disposal of Crops: In selecting crops to grow it is very important that some consideration be given to their probable disposal. If straight crop farming, that is, selling the crops direct from the farm without the aid of livestock, is the plan, a different selection of crops should be planted than if livestock farming is to be followed. In the first instance cash crops would be largely grown, whereas in the second instance crops for feed, grain, silage and pasture would be given preference.

Possible Yields Under Dry Farm Conditions: Eastern New Mexico is not a section of 100 bushels of corn nor of 50 bushels of wheat to the acre. An average of from 10 to 15 bushels of corn and from 6 to 12 bushels of wheat may reasonably be expected. Yields of crops not particularly adapted to this climate and altitude will be found to be in much the same ratio. Any farmer practicing good farming should, under like conditions, be able to approximate closely, if not excel, the average yields of the staple crops as obtained at the Field Station and shown in tables on other pages of this bulletin. In eastern New Mexico the farmer must be content with relatively low average yields. This being the case, a larger acreage must be farmed to produce sufficient crops for the purpose desired. This is a region for extensive rather than for intensive farming operations.

Drouth Evasive vs. Drouth Resistant Crops: Many crops, generally considered to be drouth resistant, are really only drouth evasive. Crops such as the sorghums are real drouth resisters, being able to suspend growth

during protracted periods of dry weather, recovering and making fair yields when rain comes.

Crops such as the millets, instead of being drouth resisters are rather drouth evaders. They will not stand much dry weather during growth, but will make yields in relatively short periods of time if weather conditions are favorable. They thus evade drouth by maturing crops in short periods of favorable climatic conditions.

Selection and Management of Crops in Relation to Soil Moisture and Soil-Blowing: Many new settlers notice that wheat and other small grains are being successfully grown on some soils in some districts of eastern New Mexico, and being unfamiliar with the local conditions, they sometimes assume that the small grains will grow well in any part of this section. It has been the experience at the Field Station, and of many farmers, that most of the soils of the lower elevations are too light or sandy in character for the small grains. One of the difficulties experienced on such soils is that during the windy months of the year—and this is the growing season of the small grains—the soil will blow to such an extent that the small plants are either cut off, covered up, or severely burned by the blowing sand.

Nearly any of the common row crops suitable for dry land conditions may be grown even on the sandiest soils, provided that tillage operations are conducted with the end in view of keeping the surface of the soil rough or furrowed, that is, resistant to the effects of the wind, at all times until the crops are high enough to protect themselves. After such crops as cowpeas or beans have been harvested the land should be plowed or listed, as the soil is left in such condition after these crops that it will blow very easily. On heavy soils these precautions will be unnecessary.

Soil Moisture Not All Available to Growing Crops: Not all of the moisture in the soil is available for use by

crops. Although the roots of the more important field crops have been found from four to six feet deep, in some years of heavy rainfall the water will penetrate below the reach of the roots if surface run-off is prevented, and will then be unavailable to the growing crops. At the Field Station the first four feet have been found to retain in storage an average of about 13.5 per cent of water. Again, it has been ascertained that the water content below about 6.5 per cent is not available to crops.

CROP ROTATION, PRINCIPLES AND PRACTICE.

Effect of Different Crops Upon the Fertility of the Soil: Crops are generally considered to be exhaustive, intermediate, or restorative in character according to the effect they have upon the fertility of the soil. In this section the effect that various crops have upon the moisture of the soil is probably of more importance than their effect upon fertility. Such crops as small grains are generally considered to be exhaustive of fertility and to draw heavily upon the moisture content. Sorghums are considered to be neutral or intermediate upon the fertility of the soil, but they do draw more heavily than some other crops upon the moisture. Such crops as cowpeas, beans, peanuts and other legumes are restorative in character as regards fertility, and they do not seem to draw as heavily on the moisture supply as do most other types of crops.

Benefits of a Rotation: Among the more prominent benefits to be derived from practicing a rotation rather than a "hit and miss" system of farming may be mentioned the following: A rotation of crops will aid in controlling plant diseases, weeds and insect pests; it may provide for a balanced removal of plant foods, and, in some cases, it provides for a restoration of some plant foods to the soil. A proper rotation of crops will also help to systematize farming operations. In planning a rotation it should be the aim to include at least one cash

crop, at least one grain crop, and at least one feed crop. It should also be the aim to have at least one of these crops restorative in character; for instance, one legume, such as cowpeas or beans, should be included in every rotation. Following are given three three-year rotations which fill the above requirements:

First Suggestion: First year, Dwarf Kafir; second year, N. Mex. Pinto Beans; third year, Red Amber Sorgo.

Second Suggestion: First year, Dwarf Kafir; second year, Whippoorwill Cowpeas; third year, Acme Broomcorn.

Third Suggestion: First year, Dwarf Kafir; second year, N. Mex. Pinto Beans; third year, German Millet.

The cultivated land is divided into three parts and each crop is grown on one-third of the area each year. Each crop is grown on the same piece of land only one year in three. If it is thought desirable, milo or feterita might be substituted for kafir.

FINAL SUGGESTIONS.

Beautifying the Farmstead: With the exception of the "draws" and the "breaks," the greater portion of the eastern part of our State is almost treeless; nevertheless, as can be noted from what some settlers have done, it is possible to set out varieties of trees and shrubs which will not only grow but will do well if properly cared for. It has been stated that "until trees and other ornamental

Fig. 9.—Quay County Dry Farm Homes, near Tucumcari, N. M., With and Without Trees. Fall of 1916.

plantings have been made on the new place, the locality the people come from is still called 'back home,' but as soon as a good start has been made toward beautifying the farmstead, a different aspect is soon developed and the new place is now called 'home.' " Besides adding to the attractiveness of any place, trees and shrubs also greatly enhance the value of the farm and will amply repay one for all the time, labor and other expense involved.

Ornamental Trees and Shrubs: There are many promising trees for this section, but the trees mentioned

Fig. 10.—Black Locust Trees at Tucumcari Field Station, September, 1916. Left-hand row transplanted April, 1915; right-hand row transplanted April, 1916. Never watered.

below do well under drouthy conditions, and the recommendations will be limited to these until further tests and observations have been made. Varieties of cottonwood, the ailanthus or Tree of Heaven, the Russian mulberry, the black locust and such native trees as the hackberry and the soapberry are on our list. The better varieties of the peach make as good or better growth than do other

trees, and although they will bear fruit on an average of only one year out of four or five they will make attractive trees for shade and ornamental purposes.

Among desirable and easily grown shrubs and hedge plants may be mentioned Bois d'Arc or Osage orange, salt cedar or tamarix, the Russian olive and the California privet.

Fruit Trees: Eastern New Mexico is not a natural fruit district, in the general sense of the term, but it will pay every settler to set out a small family orchard having a carefully selected assortment of fruits. The following varieties of fruit trees make a good list and can be recommended:—

APPLES. Jonathan, King David, Arkansas Black, Winesap, Early Harvest and Red June.

PEACHES. Texas King, Alexander, Salway and Elberta.

PLUMS. Jefferson, Yellow Egg, French and German Prunes, Wild Goose and Green Gage.

CHERRIES. Montmorency, Early Richmond and Compass.

PEARS. Bartlett and Kieffer.

QUINCE. Orange and Champion.

Small fruits will do well in this section but not enough work has been done with them at the Field Station or elsewhere in this section for us to make a recommendation of varieties.

Preparation of Land for Trees: Land for trees should be plowed at least six months before the probable date of planting, but it will be still better if the plowing has been done as long as ten months or a year before planting. Better still if the land has been under cultivation for a period of years.

At the Field Station the method used which has given the best results has been to plow the ground several months before planting, as advised. Then a dead furrow is plowed for the tree row, after which a disk harrow, with the disks set to cut wide and deep, is run up and down in this dead furrow until a ditch from 2 to 2½ feet deep at the center and as wide as the disk harrow has been made. The holes are then dug and the trees planted in the bottom of these ditches. This method will do equally well for shade or orchard trees. By using this method the rain water is carried to the trees and practically no run-off occurs. Orchard ground is plowed each year, plowing in one direction one year and at right angles to this direction the next. The orchard should be plowed as deep as possible without disturbing the root systems of the trees. The dirt is always thrown away from the trees with the plow and to the trees with the cultivator or disk. In plowing, a back-furrow is left between the tree rows. By plowing and cultivating in this manner a basin is gradually formed about each tree and this insures for each tree most of the moisture which falls within its area. The principles underlying the cultivation of crops hold equally true for trees.

Distance for Setting Trees: The distance to plant or set trees depends largely upon the preference of the person having the work done and the variety planted. It is necessary, however, to allow plenty of room for each tree in order that sufficient moisture may be secured for it. Again, too great a distance should not be allowed between trees, as it not only mars the sightliness of the place but also makes extra land to tend from which there is no income. At the Field Station we have found that for single rows of shade trees the trees do very well when set at a distance of from 16 to 20 feet apart in the row.

For such orchard trees as peaches, cherries, plums and pears, about 20 feet should be left between the trees; while apples should be set about 25 feet apart. In this

section, where the trees never make a very rank growth, these distances will be found sufficient, in most cases.

Time for Setting Trees: If the trees are to be watered they may be transplanted at the most convenient time of late fall, winter or early spring. If, however, the natural rainfall of the region is to be depended upon, it will nearly always be found best to set the trees out even as late as the middle of April. At least some rain is almost always certain to fall in April and it will be found that the ground will usually be in good condition for setting trees during this month.

Presentation and Discussion of Crop and Climatic Data as Secured at the Tucumcari Field Station

The following portion of this bulletin will be devoted to a presentation of tables showing the results of work done at the Tucumcari Field Station since its establishment; to tables giving such climatic data as are available, and to a discussion of the tables.

The different lines of work at the Tucumcari Field Station have been carried on from three to five years, and the results obtained are more or less indicative of what might be expected with the same crops under like conditions and with the same limiting factors.

It might be stated at this time that the greater the number of years the experimental work is carried on the more conclusive and valuable the results.

CLIMATIC DATA.

Eastern New Mexico is a region of fluctuating annual and monthly rainfall, variable temperatures, high evaporation and a fairly high average wind velocity. These factors are all of great importance in their effect on crop production. Detailed data are presented in Tables I to VI and are discussed in the following pages.

Precipitation: Table I shows that the normal or average annual precipitation received at Tucumcari covering a 12-year period is 16.21 inches. The table also indicates that there is often a departure in the amount received above and below the monthly and the yearly average or normal. It is believed that this precipitation record, which covers several years, will prove of value if properly considered when planning or carrying on farming operations in this region.

Fig. 11.

*AVERAGE MONTHLY PRECIPITATION-1905-16, INC.
TUCUMCARI, NEW MEXICO.*

The bulk of precipitation in eastern New Mexico falls in the form of local showers during the spring and summer months. Frequently these showers are light in character and cover only a small area and consequently do little good. Again they may be very heavy and fall in a correspondingly short period, which often causes a loss of much moisture by run-off. Considerable loss of moisture also occurs through evaporation; this explains partly why all of the precipitation is not available for the use of the crop. Therefore, the best possible methods should be employed to conserve as much of the moisture as possible, in order that it may be available for crop growth.

Figure 11 shows graphically the average monthly precipitation received at Tucumcari for the 12-year period from 1905 to 1916, inclusive. The figure also shows that the months of April, July and August have the heaviest average rainfall. Over 70 per cent. of the annual precipitation falls between April 1 and October 1. This information is important, as it shows that the bulk of the precipitation comes during the summer season, which is the time it is needed the most by the summer tilled crops. By referring to Table I an idea can be secured of the monthly and annual precipitation received for each of the years indicated.

TABLE I.—PRECIPITATION RECORDS, TUCUMCARI, NEW MEXICO.
(In inches.)

YEAR	January	February	March	April	May	June	July	August	September	October	November	December	Seasonal, April to September	Annual	Departure from Normal Annual
1905	.53	1.15	2.96	2.10	2.25	2.50	4.07	1.01	2.50	Trace	4.00	1.00	14.43	24.07	+7.86
1906	.70	.70	.05	1.79	1.00	.46	4.21	2.92	.33	.62	1.66	1.61	10.71	16.05	— .16
1907	.24	.00	.00	2.31	2.30	3.36	2.56	3.92	.08	1.43	.75*	.80	14.53	17.75*	+1.54
1908	.20	.90	.00	1.60	.24	.44	3.45	1.78	1.03	.93	.98	Trace	8.54	11.55	—4.66
1909	Trace	Trace	1.72	.48	.97	2.42	2.03	1.04	.85	1.90	1.59	.20	7.79	13.20	—3.01
1910	.09	.04	.09	.76	.16	.26	1.77	5.88	.49	.45	.22	.15	9.32	10.36	—5.85
1911	.13	1.70	.17	.68	.92	1.13	2.90	5.01	2.75	1.89	.40	.74	13.39	18.42	+2.21
1912	.00	2.40	.15	1.01	1.50	1.57	3.11	3.74	1.16	1.10	.00	.13	12.09	14.87	—1.34
1913	.28	.51	.16	4.51	1.11	2.80	.42	1.71	.94	.51	1.49	2.51	11.49	16.95	+ .74
1914	.30	.40	.50	2.52	5.24	2.81	3.90	1.06	.72	3.48	Trace	1.31	16.25	22.24	+6.03
1915	.66	.98	.90	4.00	1.59	.71	3.13	2.28	2.94	.67	Trace	.27	14.65	18.13	+1.92
1916	.70	.00	.09	1.55	.56	.63	.98	4.43	.56	.78	.29	.32	8.71	10.89	—5.32
Average	.32	.73	.57	1.94	1.49	1.59	2.71	2.90	1.20	1.06	.95	.75	11.83	16.21, normal	

* Incomplete.

Records to and including 1912 are from U. S. Weather Bureau records; those after 1912 are from observations made at the Field Station.

Precipitation from October 1 to June 30 is 9.4 inches, average for the twelve years.

Temperature: The eastern part of the State is a region where considerable variation in daily temperature often occurs. This condition is due to the elevation of the country and to the dry atmosphere. During the summer the temperature often rises above the 100° mark, while in the winter it may drop below zero.

The high temperatures that often prevail for a period of several days during the summer have a serious influence on crop growth by causing rapid transpiration from the plants. This makes it important that the crops grown should be limited to those that are adapted to the section. It should be mentioned here that the "typical hot winds" of the Corn Belt area of the United States very seldom occur in this part of eastern New Mexico. The region is also subject to late spring frosts. These frosts are usually preceded by periods of very warm days which often cause fruit trees to bloom out prematurely. It is due to this fact that some varieties of fruit are uncertain in bearing crops of fruit in this district. These warm periods in the spring often cause the farmers to plant their crops too early, with the result that they are often killed by frost or have to be replanted on account of injury.

In Table II are given the mean temperatures from 1905 to 1916, inclusive, as recorded at Tucumcari. The term "mean temperature," when used in stating temperature for any one month or year, indicates the average of highest and lowest daily temperatures for the particular period considered. By consulting the table, comparisons may be made of the mean temperatures for any month or year. The right-hand column gives the mean annual temperature, while the lower row of figures gives the averages of the mean temperatures for each month and the average of the mean annual temperatures for all years included in this table.

TABLE II.—MEAN TEMPERATURES, TUCUMCARI, NEW MEXICO.

YEAR	January	February	March	April	May	June	July	August	September	October	November	December	Seasonal, April to September	Annual
1905	37	31	53	54	66	77	76	78	72	57	47	34	71	57
1906	39	40	44	57	66	76	75	75	71	57	41	45	70	57
1907	45	49	58	56	62	72	79	80	73	Lacking		42	70	*
1908	44	44	56	57	64	78	77	77	71	59	46	43	71	60
1909	46	45	48	57	64	77	81	79	71	60	53	33	72	60
1910	43	40	57	61	66	79	82	77	73	61	52	41	73	61
1911	47	41	53	59	68	78	78	79	75	57	45	33	73	59
1912	38	37	45	55	66	71	80	77	66	60	48	37	69	57
1913	37	36	46	57	68	71	79	79	64	54	50	33	70	56
1914	44	40	47	56	64	76	76	76	73	58	49	32	70	58
1915	34	42	40	58	63	74	76	73	70	59	49	41	69	57
1916	38	46	54	55	67	77	80	76	69	57	43	36	71	58
Average	41	41	50	57	65	76	78	77	71	58†	48†	38	71	58†

* Incomplete.

† Eleven-year average.

Records to and including 1912 are from the U. S. Weather Bureau records; those after 1912 are from observations made at the Field Station.

Table III gives the highest and the lowest temperatures recorded for each of the years given in the table. The lowest temperature for the period was 11 degrees below zero in 1905, while the highest temperature is shown to be 105 degrees, which was reached in each of the years 1909, 1910, 1911, 1913 and 1915. On account of the dryness of the atmosphere and elevation of the country these high temperatures are kept from being very oppressive.

TABLE III.—HIGH AND LOW TEMPERATURES, TUCUMCARI, NEW MEXICO.

Year	Highest Temperature, degrees	Date	Lowest Temperature, degrees	Date
1905	101	July 12	—11	February 13
1906	100	June 30	— 1	November 20
1907	104	June 29	11	December 18
1908	103	June 21	10	January 16
1909	105	July 11	— 3	December 18
1910	105	June 8	— 3	February 17
1911	105	August 21	— 8	January 3
1912	104	July 9	— 3	January 2
1913	105	July 13	— 7	January 8
1914	99	June 26	4	February 6
1915	105	July 11	0	January 16
1916	104	July 3	3	November 13

Records to and including 1912 from U. S. Weather Bureau records; those after 1912 were made at the Field Station.

Table IV gives the date of the last spring frost and the first fall frost, also the number of days between frosts for each year included in the table. The year 1908 contained 168 frost-free days, while the year 1912 had a frost-free period of 204 days. These two years cover the extremes for the longest and the shortest "frost-free

periods'' for the years indicated in the table. The average length of the frost-free period is 188 days. This table

TABLE IV.—FROST DATES, TUCUMCARI, NEW MEXICO.

Year	Last Spring Frost	First Fall Frost	Frost-free Period; days.
1905	April.....24	October .....15	174
1906	April..... 2	October .....22	203
1907	April.....30	(Lacking)	*
1908	May 6	October .....21	168
1909	May 1	November ....16	199
1910	April..... 5	October .....21	199
1911	April.....15	October .....21	189
1912	April..... 2	October .....23	204
1913	April.....24	October .....19	178
1914	April.....18	October .....13	178
1915	May 6	November ....10	188
1916	April.....14	October .....19	188
Average length of frost-free period,			188‡

* Incomplete.

‡ Average of eleven years.

Records to and including 1912 from U. S. Weather Bureau records; those after 1912 were made at the Field Station.

shows that, while in most years the last frost comes during April, it has been recorded as late as May 6. This makes it apparent that planting of crops before the month of May is rather a risky proposition. The first frost recorded in the fall occurred on October 13, 1914. The two dates of May 6 and October 13 mark the minimum possible growing period for the district, based on the frost records.

Evaporation: At the Tucumcari Field Station a steel tank two feet deep and six feet in diameter is kept filled with water, within three or four inches of the top. Daily measurements from April to September, inclusive, are made of the amount of evaporation from this free water surface.

The dryness of the air, the high summer temperature and the almost incessant winds all cause a relatively high monthly and seasonal evaporation in the Tucumcari district. Table V gives the monthly evaporation from April 1 to October 1, for the years 1913 to 1916, inclusive.

This table also shows that the evaporation ranges from 49.9 inches to 58.9 inches, with an average for the six months included in each year of record of 54 inches, or $3\frac{1}{2}$ times the normal yearly rainfall.

TABLE V.—EVAPORATION FROM FREE WATER SURFACE,
TUCUMCARI, NEW MEXICO.

Year	April	May	June	July	August	September	Total
	Inches	Inches	Inches	Inches	Inches	Inches	Inches
1913	7.216	10.345	8.716	11.833	10.138	6.438	54.686
1914	7.046	7.286	9.875	8.078	8.962	8.673	49.920
1915	5.554	9.912	11.239	10.023	8.406	7.369	52.503
1916	6.853	11.317	12.729	11.506	8.879	7.617	58.901
Average	6.667	9.715	10.640	10.360	9.096	7.524	54.003

All records taken at the Field Station.

Were it not for the fact that the evaporation of moisture from the soil is much less than from the free water surface, growing of crops in this region would be an impossibility. Most of the evaporation occurs from the first few inches of the soil, and while the soil is still wet after rains the evaporation is very rapid on hot days during the summer.

During periods when evaporation is high, heavy demand is made upon the growing plants for moisture. In order to meet this requirement the crops planted should be hardy and adapted to such conditions; therefore, such crops as milo, kafir, sorghum, feterita and Sudan grass

are recommended for this section. These crops have the ability to suspend or stop growth for a short period of time, though they may seem to burn badly. If rain is not delayed for too long a time the crops will spring into new growth after a few good showers, and if not burned too severely will often produce fair yields. This is what makes them valuable crops for eastern New Mexico.

Wind Velocity: The eastern part of New Mexico, as well as other parts of the State, has considerable wind movement. This movement is so great at times that frequently sandy soils blow badly and in the spring of the year serious damage is often done to the young crops. The plants may be either cut off at the surface of the ground, covered badly, or blown completely out.

As has been stated, the wind plays an important part in causing rapid evaporation from the surface of the soil during the early spring and summer. Transpiration from the leaves of the plants during warm and windy periods is no doubt very heavy.

TABLE VI.—AVERAGE HOURLY WIND VELOCITY, TUCUMCARI, NEW MEXICO.

Year	April	May	June	July	August	September	Average
	Miles	Miles	Miles	Miles	Miles	Miles	Miles
1913	6.7	7.3	7.2	6.6	5.2	5.5	6.4
1914	9.3	7.4	7.1	3.2	3.9	5.0	6.0
1915	6.3	7.1	7.1	6.1	4.3	5.6	6.1
1916	7.6	7.8	7.6	5.5	5.5	4.9	6.5
Average	7.5	7.4	7.3	5.4	4.7	5.3	6.3

All records taken at the Field Station.

The months of March, April, and May include the part of the year having the greatest wind movement, although this windy period may sometimes extend to the

middle of June. Often the soil is dried out so rapidly after planting that a good germination and stand is not secured, necessitating a replanting of the crop. Table VI gives the average wind velocity in miles per hour for each of the months from April 1 to September 30, inclusive. The anemometer or wind gauge used in taking the wind velocity is placed at a height of two feet above the ground in an unsheltered place.

CROP DATA.

In the following tables presenting yields of crops under various tests at the Tucumcari Field Station, kafirs are given in bushels (60 lbs.) per acre; milo and all other grain sorghums in bushels of 58 pounds per acre; forage sorghums, Sudan grass, millet and cowpeas are given in pounds of hay per acre; broomcorn yields are totals of "cleaned brush" per acre in pounds; beans are given in pounds of beans per acre; cotton is given in pounds of seed-cotton per acre, and corn, potatoes, wheat, oats, barley and rye are given in bushels (U. S. Standard) per acre.

Table VII is a presentation of the yields per acre of crops obtained under the various cultural methods in use at the Tucumcari Field Station. In this table it is shown that the highest yields were secured on the summer tilled plats with all crops except cotton and cowpeas. It should be remembered, however, that the increases in yields are small and not high enough to pay for the increased cost of production under this method. As has already been stated, summer tillage or alternate cropping has not proven to be the most profitable with any crop at the Dry Land Field Stations.

Fall plowing has given higher yields than spring plowing, subsoiling or listing, except with sorghum, broomcorn, corn, spring wheat and oats. In some cases the difference is so small as to make it immaterial, so far

as yields are concerned, as to whether spring or fall plowing is used.

TABLE VII.—YIELDS OF CROPS, IN POUNDS OR BUSHEL PER ACRE, OBTAINED UNDER DIFFERENT CULTURAL METHODS AT THE TUCUMCARI FIELD STATION, FOR THE YEARS 1914 TO 1916, INCLUSIVE.

Crop	Cultural Method							Av'ge*
	Fall Plowed	Spring Plowed	Subsoiled	Listed	Disked	Summer Tilled	Manured Tillage	
Milo	40.1	34.5	28.2	23.2		45.4 ‡	43.2	37.9
Kafir	30.8	29.9	32.1	28.9		39.1		31.6
Sorgo (d)....	5300	5520	4887	4245		6040		5108
Broom-corn (e)...	534	588	550	568		628		573
Sudan grass		2360a						2360a
Millet		2254						2254
Cowpeas	3587b	3004c				3340a		3049
Beans		655						655
Cotton	601	558	439	400		517	593	520
Corn	22.2	23.5				26.9		23.2
Win. Wheat(f)	2.7	2.3				3.1		2.7
Winter Rye..	3.5a							3.5a
Spring Wheat	7.5	8.2			6.8	8.6		7.9
Oats	11.9	13.8			11.9	17.1		13.1
Barley		5.7			5.4			5.6

* The final averages given are not necessarily the averages of the other figures given in the table, but are the averages of the yearly averages for each year that the various crops were grown.

‡ 6 plats in 1914-15; 7 in 1916.

a 1 year's record, 1916.

b 1 plat each 1914-15; 2 in 1916.

c 7 plats 1914-15; 11 in 1916.

d Freed in 1914-15; Red Amber in 1916.

e Dwarf in 1914-15; Dwarf Standard in 1916.

f Kharkov in 1915; Turkey Red in 1914 and 1916.

Subsoiling has not proven profitable when compared with other cultural methods used, kafir being the only

crop to show an increased yield over either spring or fall plowing.

Fairly good yields with all crops have been obtained on listed land.

The results with broomcorn show a slightly higher yield on fall plowed than on listed land, but the difference in yield is small.

In summing up the yields with the various crops under the different cultural methods used at this Field Station, subsoiling and summer fallowing have not proven relatively profitable. Fall and spring plowing and listing are indicated as the methods to use in preparing the land. Which one to use will depend on the plan of cropping to be followed, the nature of the land, and the seasonal conditions existing during the fall, winter and spring.

The figures given in the last column are the average yields from all plats of each crop grown at the Field Station. They are not the averages of the average yields as shown in the table.

The question often arises as to the advisability of planting sorghum in drilled rows or rows closer together

TABLE VIII.—YIELDS OF SORGO PLANTED IN ROWS OF VARYING WIDTHS, 1914 TO 1916, INCLUSIVE.

Width Rows; inches	Year			Average
	1914	1915	1916	
	Pounds	Pounds	Pounds	Pounds
8	5100	3820	840	3253
16	4300	4980	840	3373
24	4840	5400	1160	3800
32	5020	4700	1200	3680
44	5093 a	4600	1400	3698

a Average of rotations and tillage plats.

Freed sorgo grown in 1914 and 1915. Red Amber sorgo grown in 1916.

than the ordinary width used. In 1914 an experiment was started with sorghum planted in rows 8 inches, 16 inches, 24 inches, 32 inches and 44 inches apart, respectively. In 1914 and 1915 Freed sorghum was used for this work. In 1916 Red Amber sorghum was used. Table VIII, giving the results of these tests, shows that the yields vary with the different methods in certain years. The results indicate that the highest yields have been obtained with the crops planted in 24-, 32- and 44-inch rows.

Table IX shows the yield obtained with Mexican June Corn planted at different dates. While corn is not considered one of the staple crops in the Tucumcari district, the results obtained show that probably the best yields can be obtained by planting this variety of corn between May 1 and June 10.

TABLE IX.—YIELDS OF MEXICAN JUNE CORN OBTAINED UNDER SEVERAL DATES OF PLANTING, 1914 TO 1916, INCLUSIVE.

Y E A R								
1914			1915			1916		
Date	Yield		Date	Yield		Date	Yield	
	Stover	Grain		Stover	Grain		Stover	Grain
	Pounds	Bush'ls		Pounds	Bush'ls		Pounds	Bush'ls
May 4	3662*	32.4*	April 3	1240	25.7	April 6	520	Fodder
						April 15	920	Fodder
			April 21	1840	33.6	April 29	1360	Fodder
			May 13	1660	30.2	May 13	1020	11.7
						May 27	790	8.7
June 8	4640	25.8	June 4	4440	32.0	June 10	1240	6.9
			June 18	4480	29.7	June 24	2755	8.6
July 7	5960	15.6						

* Average of tillage and rotation plats.

Considerable difference of opinion exists as to the best time for planting such crops as dwarf milo. Table X gives the yields secured with this crop when planted on different dates. From the work done it is believed that

the average date of planting this crop should range between May 10 and June 10, the time depending to some extent upon the seasonal conditions.

TABLE X.—YIELDS OF DWARF YELLOW MILO OBTAINED UNDER SEVERAL DATES OF PLANTING, 1915 AND 1916.

YEAR					
1915			1916		
Date	Yield		Date	Yield	
	Stover	Grain		Stover	Grain
	Pounds	Bushels		Pounds	Bushels
			April 6.....	965	8.9
			April 15.....	1380	9.3
			April 29.....	1500	12.8
May 7	2045	23.4	May 13	1715	10.4
May 21	2133	23.9	May 27.....	2540	18.3
June 4	2368	25.4	June 10.....	1820	14.1
			June 24.....	2850	16.4

Table XI shows the effect of the previous crop on the yields of the several crops obtained on land cropped continuously and on land where the crops have been grown in rotation with other crops.

It is noted from the table that milo grown after milo and sorghum after sorghum have made lighter yields than where these crops have been included in a rotation. Milo made higher yields when grown after cowpeas than after cotton. Sorghum made higher yields after cowpeas than on land continuously cropped. Millet after sorghum made higher yields than following beans or winter wheat. Cowpeas made higher yields following cotton and milo than after millet. Cotton grown after milo made higher yields than following cowpeas or cotton.

The yields with corn show that very little difference was obtained on plats where corn followed corn and on

TABLE XI.—YIELDS IN POUNDS OR BUSHELS PER ACRE OF CROPS OBTAINED FOLLOWING THE SAME OR OTHER CROPS, AT THE TUCUMCARI FIELD STATION DURING THE YEARS 1914 TO 1916, INCLUSIVE.

Crop	Previous Crop																	
	Milo	Kafir	Sorgo	Broomcorn	Sudan Grass	Millet	Cowpeas	Beans	Cotton	Corn	Winter Wheat	Winter Rye	Spring Wheat	Oats	Barley	Summer Tilled	Manured, Summer Tilled	Average
Milo	27.4						38.6		36.0							45.4b	43.2	37.9
Kafir		30.2	4673				6353									39.1		31.6
Sorgo (d)																6040		5108
Broomcorn (e)				562												628		573
Sudan Grass												2360a						2360a
Millet			2500					2213			2047							2254
Cowpeas																		
Beans						2873	3880a		3333		679					3340a		3049
Cotton		1310ac			4400ac	631	499		499									655
Corn	571									22.8						517	593	520
Winter Wheat (f)											2.5		23.0	22.6	22.9	26.9	23.2	
Winter Rye																3.1		2.7
Spring Wheat													6.6	8.6	12.8	8.6		3.5a
Oats							3.5a			8.1			12.1	17.1	5.7	17.1		7.9
Barley										13.3								13.1
										5.4								5.6

a 1916 yield only—one year.

b 6 plats. in 1914 and 1915; 7 plats 1916.

c Following kafir, yield was lowered by drifting sand,

Following Sudan grass the topography is such that water ran to the plat from rains, making conditions more favorable in 1916.

d Freed sorgo in 1914 and 1915; Red Amber in 1916
e Dwarf broomcorn in 1914 and 1915; dwarf standard
in 1916.

f Kharkov in 1915; Turkey Red in 1914 and 1916,

plats where corn had been grown in rotation with other crops. The effect of the previous crop on the yields obtained with the small grains has been small.

With a few exceptions higher yields were secured on summer fallowed land than on land previously cropped, but the increased cost of production under this method does not make it a relatively profitable system to follow. The figures given in the last column are the average yields from all plats of each crop grown at the Field Station. They are not the averages of the average yields as shown in this table.

Variety Testing: Numerous varieties of crops are constantly being recommended or advertised as being suitable for growing in certain districts. In order to get some definite information on this subject quite a number of varieties of various crops have been planted each year since 1912. The varieties tested and the yields secured with each will be found in Table XII.

TABLE XII.—YIELDS PER ACRE OBTAINED ON PLATS DEVOTED TO VARIETY TESTING FROM 1912 TO 1916, INCLUSIVE.

CROP	YEAR					No. Years	Aver- age
	1912	1913	1914	1915	1916		
Grain Sorghums—yields in bu. per acre; kafir 60 lbs. to bu.; others 58 lbs.							
Feterita		15.3	32.2	22.3	12.2	4	20.5
Dwarf Feterita					19.7	1	19.7
Dwarf Blackhull Kafir..	22.0	4.1*	39.5*	38.9	13.3	5	23.6
Standard Kafir					7.4	1	7.4
Early Kafir	20.6	4.5	30.1	29.5	13.3	5	19.6
Red Kafir				31.7	8.3	2	20.0
Brown Kaoliang	15.8	8.3	19.1	14.4		4	14.4
Standard Milo	25.7	5.6	37.5	16.9	12.3	5	19.6
Dwarf Milo	22.7	12.9	48.8*	49.4*	13.0	5	29.4
White Milo			37.9	18.6	13.0	3	23.2
Durra X Kafir	22.0	7.7	26.2			3	18.6
White Durra	18.4	4.1	26.1			3	16.2
Sudan Durra	21.8	7.0	35.1			3	21.3
Dwarf Hegari					15.1	1	15.1
Forage Sorghums—yields in lbs. hay per acre.							
Gooseneck				14720		1	14720
Freed	5420*	1740	5093*	5640	2940	5	4167
Red Amber		2080	7010	8400	4561	4	5513
Black Amber		1675	6120	8520		3	5438
Orange			6993	8200	9740	3	8311
Honey			12263	11780	12621	3	12221
Sumac			12048	12060	13140	3	12416
Tennessee Redtop			8363			1	8363
Darso				7420	3280	2	5350
Milo X Amber					3341	1	3341
McLean					7181	1	7181
Minnesota Amber					4641	1	4641
Dwarf Ashburne					10600	1	10600
Collier					5421	1	5421
Dakota Amber ..					3281	1	3281
Whooper					4281	1	4281
Shrock Kafir				5460	6500	2	5980
Sudan Grass			2638	4960	1240	3	2946
Early Blackhull Kafir...	6432	2699	5580	6000	1680	5	4478
Millets—yields in lbs. hay per acre.							
German	3820*	980*	3773*	3420	1041	5	2607
Common		640	2520	2880	980	4	1755
Siberian			2220	2940		2	2580
Turkestan					2040	1	2040
Kursk			1750	2400	381	3	1510
Japanese				2280		1	2280
Pearl				3780	4600	2	4190
White Proso	2720	720	1740	2000		4	1795
Black Proso	920	460	1360	1740		4	1120
Cowpeas—yields in lbs. hay per acre.							
New Era		1150		2560	3000	3	2237
Taylor				2040	2760	2	2400
Monetta				2040	2660	2	2350
Early Buff			2840	2160	1380	3	2127
Groit		1200	3000	2060	2781	4	2260
Blackeyed		992	3180	2700		3	2291
Logan					2500	1	2500
Iron			3168	2140	3181	3	2830
Brabham	1960	1200	3420	2000	3561	5	2423
Whippoorwill	2010	2500	3298*	2598*	3861	5	2853

* Average of rotation and tillage plats for that year.

TABLE XII, CONTINUED.—YIELDS PER ACRE OBTAINED ON PLATS DEVOTED TO VARIETY TESTING FROM 1912 TO 1916, INCLUSIVE.

CROP	YEAR					No. Years	Average
	1912	1913	1914	1915	1916		
Broomcorn —yields in pounds cleaned brush per acre.							
Dwarf	400	215	665*	628*	400	5	462
Dwarf-Standard	500	90	770	820	500	5	536
Standard					240	1	240
Beans —yields in lbs. beans per acre.							
White Tepary			1200	860		2	1030
Brown Tepary			1010	933		2	972
White Navy			538	143		2	341
New Mexico Pinto	860*	13*	976*	633*	354*	5	567
California Pinks			63	45		2	54
Red Kidney.....			425	73		2	249
Bayo			300	33		2	167
Cotton —yields in lbs. "seed-cotton" per acre.							
Durango	320	50	318	180		4	217
Mitchell's Improved King		125	543	413		3	360
Columbia	100	100	294	118		4	153
Early King	338	280	826*	388*	342*	5	435
Trice	850	150	574	515		4	522
Lewis		125	338			2	232
Acala	200	113				2	157
Burnett	730	150				2	440
Triumph	550	25				2	288
Shankhigh	600	25				2	313
Lanquin	400	50				2	225
Corn —yields in bu. corn per acre. (U. S. Standard.)							
Mexican June	26.1	0.0	32.4*	30.2	5.5*	5	18.8
Reid's Yellow Dent.....	.3	0.0	20.5	33.2		4	13.5
Hickory King			15.2	22.5		2	18.9
Silver Mine			23.7	21.6		2	22.7
Pima			29.5	28.4		2	29.0
Hopi		0.0	20.5	31.2		3	17.2
Stockton		0.0	22.8	31.9		3	18.2
Navajo			19.6	20.8		2	20.2
Australian White Flint..	0.0	0.0	18.8	18.1		4	9.2
Chinese			10.0	12.5		2	11.3
Peanuts —yields in lbs. per acre.							
Valencia			1135	1333		2	1234
Virginia Bunch			1095	1425		2	1260
Spanish	500		1160	1358		3	1006
Irish Potatoes —(Ordinary treatment) yields in bu. (60 lbs.) per acre.							
Early Ohio			10.0	95.0	1.7	3	35.6
Irish Cobbler			11.1	60.0	7.5	3	26.2
Green Mountain			7.8	29.2	10.8	3	15.9
Rural N. Y. No. 2			2.8	37.5	15.0	3	18.4
Pearl			5.0	68.4	11.7	3	28.4
Early Six Weeks			19.2			1	19.2
Burbank			13.3			1	13.3
Triumph				29.2	2.9	2	16.1
Irish Potatoes —(Covered at emergence with about 6 in. of straw.) yields in bu. (60 lbs.) per acre.							
Early Ohio				133.4	13.3	2	73.4
Irish Cobbler				47.5	18.3	2	32.9
Green Mountain				53.4	30.8	2	42.1
Rural N. Y. No. 2				59.2	21.7	2	40.5
Pearl				50.0	5.8	2	27.9
Triumph				12.5	.4	2	6.5

* Average of rotation and tillage plats for that year.

GRAIN SORGHUMS. The average yields obtained with the varieties of grain sorghums show that dwarf milo, white milo, dwarf blackhull kafir, feterita, and possibly red kafir are the leading grain sorghums that can be recommended for eastern New Mexico. Of these varieties it is probable that dwarf milo, dwarf blackhull kafir and feterita are the most dependable.

Fig. 12.—“Heading” Dwarf Yellow Milo in 1915, Tucumcari Field Station; showing common method of harvesting for grain. Requires only pocket-knives, barge and team. Average in fair years, about a ton a day per man.

FORAGE SORGHUMS. Nineteen varieties of forage sorghums have been grown and tested from one to five years.

The yields secured show that honey and sumac have made the highest average yields during a three-year test. Red Amber, Freed and Black Amber have been tried from three to five years and while the yields with these varieties have not been high they have produced fair crops and are among the most dependable varieties. Some of the varieties have been tried only one year; therefore, sufficient time has not elapsed to tell what the average yields for these varieties will be. Sudan grass, while not giving a

high average yield for the three years tested, is the best crop to grow for hay. Early blackhull kafir, on account of the quality of the forage and amount of grain produced, is a valuable crop to grow, especially for silage.

MILLETS. The yields secured with the nine varieties tested indicate that some of them will produce good yields during favorable seasons and are valuable as catch crops.

COWPEAS. Ten varieties of cowpeas have been tested at the Station. From the yields secured it is noted that the Whippoorwill, Iron, Brabham and Taylor have produced the highest average yields.

Fig. 13.—Homemade Cowpea-Bean Harvester. In use at Tucumcari Field Station. (The blocks behind are only for holding the implement off the ground to show knives.)

BROOMCORN. Broomcorn is ranked among the important cash crops for the eastern part of New Mexico. The dwarf and dwarf standard have produced the highest yields in variety tests and are probably the best varieties to grow in this section.

BEANS. Of the varieties tested at the Station the New Mexico Pinto beans and the White and Brown Tepary beans have produced the highest average yields. The New Mexico Pinto bean is the most important variety grown in the State.

COTTON. Several varieties of cotton have been tested each year since the Station was started. Though cotton is not generally grown in eastern New Mexico at the present time, some idea may be had by a study of the yields obtained as to the possibilities of the crop for this section.

CORN. While some of the varieties of corn have made fair yields for two or more years, it is not believed that corn will rank in importance with milo and kafir through a series of years when both the grain and the stover produced are taken into consideration.

Fig. 14.—Red Amber Sorgo from 1-10 Acre. Whippoorwill Cowpeas to left. Alfalfa in cocks at back. Corn and Milo further back. Other shocks Red Amber Sorgo to right and rear. Tucumcari Field Station, 1916.

PEANUTS. Results secured with two years' testing indicate that peanuts will probably do fairly well on the

sandy soils in this region. The greatest difficulty in producing a crop will be the depredations of rabbits. Unless the crop is protected by a rabbit-proof fence or unless they are grown on a large scale, peanuts will not be a profitable crop to grow.

POTATOES. Several varieties of Irish potatoes have been grown at the Station. One lot received the ordinary treatment of planting and cultivating while the other was covered with straw about the time the plants were coming up. Some difference in yields was obtained with the two methods, but it is indicated that more work will have to be done before definite conclusions can be drawn. It is generally considered, and these results seem to indicate, that potatoes are not a profitable crop to grow. A small area should be planted, however, for home use each year.

Successful Dry Farming

To make a success of dry farming the farmer should make free use of all reliable literature on the subject; he should study the methods of successful farmers, and then govern his own farming practices accordingly.

In eastern New Mexico good grain crops even of milo and kafir are by no means always certain. Past experience has shown that in the best years large grain crops and good feed crops may be raised by almost any method of farming. During the worst years nothing but a fodder crop may usually be grown, while in normal years profitable crops are assured only by practicing the best known adaptable methods of farming.

Dry farming, as practically every other type of farming nowadays, usually requires, for best results, considerable capital; for the purchase of the necessary farming implements, stock, and sufficient of the necessities of life not only for the first year, but also to tide over at least another year. Without at least sufficient capital or credit to tide over the first two years, the chances for success will be very materially reduced.

A survey of the methods practiced by successful settlers will show that in almost every case livestock has been the basis of their success. This is a stock farming country and although an occasional successful crop farmer may be found he is the exception rather than the rule. Many well informed persons state that there is no better stock breeding section than this. Due to our comparatively mild climate and open winters, a very high percentage of calves and other young stock are raised. No prospective settler will go wrong if he follows the lead of other successful settlers and uses livestock as the nucleus around which to build all other farming operations.

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**New Mexico College of Agriculture
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AGRICULTURAL EXPERIMENT STATION

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NEW MEXICO PINTO BEAN FIELD, SAN MIGUEL COUNTY.

New Mexico Beans

By **FABIAN GARCIA**

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NEW MEXICO BEANS

Introduction

In this bulletin will be found articles written by a number of the county agricultural agents of their respective counties: Bernalillo, Torrance, San Miguel, Colfax, and Union. These articles give information regarding bean culture in the counties mentioned, local conditions taken into consideration.

While beans have been grown in New Mexico for probably the past three centuries, not until the past few years has much interest been taken in this crop. The bean has been, and is at the present time, one of the most staple foods of the native population. This crop is getting to be an important one in the irrigated as well as in the dry-farming communities. According to the United States Census Report for 1910,* 5,147,580 pounds of beans were raised in New Mexico in 1909, valued at \$232,023. During the past four years the output has been very materially increased and for 1916, New Mexico was reported as fourth among the States in the production of beans. According to the United States Department of Agriculture Crop Report for December, 1916,** New Mexico produced in 1914, 1915, and 1916, 16,320,000, 22,080,000, and 22,500,000 pounds, valued at \$615,000, \$828,000, and \$1,488,000, respectively. From this it will be seen that the increase in production, as well as in value, of the New Mexico bean crop, since 1910, has been marked. About 90 per cent to 95 per cent of the crop is of the New Mexico Pinto variety.

Freeman of Arizona, in Bulletin No. 68, speaking of the economic value of the bean in the United States,

*United States Census Report for 1910.

**These figures have been computed from the United States Department of Agriculture Monthly Crop Report for December, 1916.

quotes Tracy* as follows: "Next to the potato the bean is by far the most important vegetable of this country. Being sold in the United States under more than 400 varietal names and having at least 185 distinct types, it easily stands first among the vegetables in the number of varieties." The New Mexico varieties of beans are among the most drouth resistant vegetables grown in the State, being well adapted to our dry, hot climate. Few of the introduced varieties which have been tried have been so well adapted to the New Mexico conditions, particularly in the drier and warmer valleys. This agrees with Professor Thornber** of Arizona, who is authority for the statement that "only a small percentage of the species or varieties developed in sections having decidedly different climates from that of Arizona may be successfully cultivated here." This may be applied to New Mexico, as well, since the climates of both States are quite similar.

This suggests the importance of utilizing and improving many of our native varieties of vegetables, instead of trying to adapt varieties of other origin. We find in the cultivated districts of New Mexico a number of varieties, not only of vegetables but of grains and other crops, which, through the course of cultivation and unconscious selection by the growers, have become adapted to our dry, hot conditions. If these varieties were improved, no doubt they would produce, in many cases, crops considerably larger and of better quality than at present.

"The Mexican Frijole Bean."

We frequently see articles printed in newspapers, and sometimes even in semi-scientific literature, and hear people—especially those from the East—discussing the Mexican "frijole" bean. From information obtained

*American Varieties of Garden Beans, W. W. Tracy, Jr., U. S. Department of Agriculture, Bulletin No. 109 (1907).

**G. F. Freeman, Arizona Bulletin No. 68.

from such sources, it would appear that this so-called Mexican "frijole" bean was some new species or some extraordinary vegetable. There seems to be an erroneous idea of what this bean is. "Frijole," no doubt, has been derived from the Spanish word frijol, which is the term used for the botanical species of the *Phaseolus* (Linn.); just as in English the word bean is used for the different species of the same genus. We speak of "frijol amarillo" or "frijol blanco," meaning yellow or white bean.

Varieties.

While in the past this crop was not raised on a sufficiently large scale to be shipped out, it has always been grown for home use. No doubt, in the course of so many years of cultivation and through unconscious selection, varieties which have adapted themselves to New Mexico conditions have been produced; and today, when the bean crop in the State is assuming such important proportions, there are one or two important native varieties.

The New Mexico Pinto bean has been known to the native bean growers and to the first settlers as the *Rosillo* bean, and this is today the principal commercial variety that is being grown in New Mexico. It is very drouth resistant, requiring a comparatively small amount of moisture to mature it; it is of large size, a good yielder, and very palatable. In the Twenty-fourth Annual Report of the New Mexico Agricultural Experiment Station this variety is mentioned as the *Rosillo* bean and as being of a white and grayish color. It is the largest of the native varieties now being grown and is peculiarly marked. While the name *Pinto* has now been adopted, its markings are of a splotchy nature; in other words, the outlines between the two colors are very irregular. It is irregularly marked with olive drab to greenish etches. The cream ground color has a slight pinkish tinge. Strictly speaking, the Spanish word "pinto" gives the idea of markings of more regular outline than those on this bean.

FIG. 1.—Beans in Exhibit at New Mexico State Fair, 1916. 1, New Mexico Pinto; 2, Mixed Seed; 3, Ancient Yellow; 4, Garden Brown; 5, Bolita; 6, Navy.

The other variety that has been generally planted and is at the present time of more or less importance is the Bayo. This is slightly earlier than the New Mexico Pinto and seems to be preferred by many of the native farmers for irrigated land. It is almost as large as the New Mexico Pinto, but is of a more solid color, being almost a tan, though varying to a light yellowish. A larger variation of the Bayo is found in some of the northern counties. Another variety that was formerly used quite extensively is the one that we now propose to name the "Ancient Yellow." This is of a solid yellow color and is a little smaller than the Bayo. It is, on the whole, a little earlier than the other two varieties. In the lower and warmer valleys two crops from this variety are often raised during the year.

A fourth variety, which has been grown to some extent during recent years, is the one known as the California Pink; this being one of the commercial varieties raised in California. This is slightly larger than the Ancient Yellow and a little smaller than the Bayo. It resembles the latter somewhat, but is of a dark pinkish color. This bean is not quite so well adapted to New Mexico conditions, particularly for the irrigated districts. It is considerably later in ripening, frequently makes too much vine and the yields have been rather small. Because of its tendency to produce a rather large vine and ripen late, sometimes the bean beetle reduces the crop. The Tepary, which is a comparatively new variety in New Mexico, is now attracting some attention. It is an exceedingly hardy bean and will stand considerable drouth. It produces a larger vine and yields well, but shatters badly. The bean as yet has not been used very extensively for culinary purposes and does not cook quite as readily as the other varieties. The vines are very prolific, producing a large number of small pods filled with quite small white beans. The Tepary is a little smaller than the navy bean and is of the same color.

At the Experiment Station many of the large number of introduced beans tried last year gave results that were not very satisfactory. The navy variety did fairly well. Apparently, the temperature was too high and the relative humidity too low. It is the intention to eliminate

FIG. 2.—Plants Selected for Improvement Work with the Ancient Yellow Bean.

such of the varieties as do not appear to be well adapted to New Mexico conditions and select seed from the more promising ones.

The following table will give an idea as to the comparative number of pods and beans that the Tepary, New Mexico Pinto, Ancient Yellow and Bayo varieties produced:—

TABLE I.

VARIETY	Number of Vines Observed	Total Number of Pods	Average Number of Pods per Vine	Total Number of Beans	Total Weight of Beans, ozs.	Average Number of Beans per Pod
Tepary	5	430	86	1481	9	3.4
Ancient Yellow	3	216	72	917	8	4.2
New Mexico Pinto	5	188	37	661	7	3.5
Bayo	5	166	33	630	7	3.8

It will be noted that the Tepary produced a larger number of pods and beans than any of the other varieties. The Ancient Yellow also produced a large number of pods. The New Mexico Pinto was third and the Bayo was last.

Soils.

Beans, like many other vegetables, can be grown on almost any kind of soil, provided special care is taken in the germination of the seed and cultivation of the crop. However, the best soil for this vegetable is of a light character, from a loam to a sandy loam. The adobe or hard clay soil is not so well suited to beans. If the crop is to be grown on the tighter soil it will require more care to get a good stand and in the cultivation of it. Beans belong to the leguminous or nitrogen gathering plants and may be grown on poorer soils than many other vegetables.

Methods of Planting.

It is very important to get a good stand, if a large yield is to be expected. Therefore, practically every bean planted should germinate. Under irrigation, frequently bean growers fail to get a good germination, while under dry farming conditions, lack of sufficient moisture often gives a similar result.

Under irrigation, at the present time, there are two methods of planting beans that are generally practiced: the native, or wet method, and the new, or dry method. There is a third method, which is not general and which might be called the furrow method.

New, or Dry, Method.

This method consists first in thoroughly plowing, harrowing and preparing the seed bed, then in drilling or planting the seed; next, in irrigating (usually flooding) to produce germination of the seed. In using this method in irrigated districts the seed may be planted with a drill, with a bean or corn planter, with a lister, or plowed in furrows. The important feature, however,

is the irrigation to produce germination. Care should be taken that the beans are not put in too deeply, or else a large percentage of them will not be able to break through the crust which is formed on the surface by the irrigation water.

It has been observed during the bean experiments which have been conducted at the Station that in addition to the crusting of the surface soil, as a rule, many weeds begin to germinate immediately after the ground is irrigated, and in most cases a large percentage of them will sprout ahead of the beans. By the time the latter

FIG.3.—Planting New Mexico Pinto Beans with a Corn Planter, Under Dry-farming Conditions.

are up so that the row can be seen the whole surface between the rows will be pretty well grown up with weeds; particularly if the ground has been allowed to become foul with them in previous years. This will make it necessary to begin cultivating the weeds out immediately; if allowed to grow for some time they will interfere with the proper development of the bean plant. It has been observed that, as a rule, it takes more hoeing and cultivating to produce the crop when it has been irrigated up, and usually it becomes necessary to irrigate the field

very soon after germination has taken place. This increases the number of irrigations to mature the crop.

This method can be used under dry-farming conditions, except that the moisture for the germination of the seed will have to come from the rains.

Native, or Wet, Method.

This method consists first in preparing the land for irrigation. The preparation consists in breaking down the old weeds, raking them up in piles and burning them, and in plowing up borders for the control of the water while irrigating the land. After this is done the land is irrigated to add the moisture necessary to produce germination when the seed is planted. As soon as the soil is dry enough so that the plow will scour, the land is plowed, usually with a small plow. The beans are planted in furrows and covered as the land is being plowed. The method usually followed in planting the seed is to have a man or boy follow behind the plow and drop the seed in the furrow. See Fig. 4.

FIG. 4.—Planting by the Native, or Wet, Method.

The seed may be dropped in hills or in a continuous row. The practice by the native farmers is to drop it in hills about a foot apart and, as a rule, the distance or width between the rows is three or four furrows. In practice it is found that the width between the rows varies considerably. This is due in part to the fact that those who do the plowing do not pay particular attention to this point. It is also found that the rows are not very straight. Due to the unevenness of the distance between the rows, it is somewhat difficult to cultivate the crop with bean cultivators.

An improvement along this line can be made by being more careful, having the rows straighter and the distance between uniform. The Station is at present investigating a gang plow that will plow the necessary width between the rows at one time and drop the seed in the furrow. This will perform the operation of plowing the land, dropping the seed and covering it at the same time, thus reducing the expense of the crop, for the reason that one man and team can do the work of three teams and four men. It will also tend to plant the seed at a more uniform depth, because all of the land will be plowed the same depth.

After the beans have been plowed under in the moist soil, the land is dragged with any kind of smoothing drag or an Acme harrow. The old practice is to use some sort of drag to smooth the soil and pack it. It is believed that the Acme harrow will perform the same functions as a drag and at the same time leave a mulch on the surface which should, to a large degree, reduce the evaporation from the moist soil.

In plowing the beans in, better germination may be had if they are not over 3 to 4 inches in depth, though fair results may be expected from a 5-inch depth. If planted over 5 inches deep, or as shallow as 1 inch, the germination may be poor. The crop may be planted in

rows 2 to 3 feet apart, and the seed should be dropped from 6 to 12 inches in the row. In the experiments conducted at the Station, the plats which were planted with beans 6 inches apart in the row gave the largest yields. (See Table 3.)

FIG. 5.—Planting Beans with a Single-row Planter.

In many ways the native, or wet, method, has advantages over the dry method. If the land is properly irrigated and plowed and the beans are put in in the right way, one may be able to get an almost perfect stand. Also fewer weeds come up, because the weed seeds which start to germinate when the land is irrigated will be destroyed when the beans are being plowed under. When the beans are planted in this way they seem to withstand considerable drouth, and do not need irrigation for a long time after they have come up. As a rule, they require less cultivation, hoeing, and irrigation than when planted by the dry method.

The native, or wet, method can be used under dry-farming conditions, and will usually give satisfactory results, if there is sufficient moisture in the soil for proper germination.

Furrow Method.

This method is not generally practiced, but if properly used it is quite likely that a good stand can be had. After the beans are planted in the dry soil, furrows are made between the rows with any kind of a furrower and the water is applied through these furrows. The moisture reaches the seed through percolation. In this way not much of a crust will form over the seed. It would take longer to irrigate, because the irrigating would have to be done very carefully and slowly.

Alkali.

While beans are very resistant to drouth and heat they are not so to alkali, and if the soil is heavily laden with any of the soluble salts, the stand is likely to be poor, though all of the other factors may have been favorable for germination. Figure 8 shows a strip in the middle of the plat with very few plants. This seems to be due to the excess of soluble salts in the soil.

Preparation of the Seed Bed.

Under dry-farming conditions, where there is no water for irrigation and where the farmer is dependent on the rainfall, bean growers should exert every effort to conserve all of the moisture possible, taking advantage of all of the natural conditions and planting the beans at the time when they can get the most good out of the moisture in the soil; provided, of course, it is not too late for the crop to mature.

This being the case it can readily be seen that, under dry-farming conditions, it is of the utmost importance to catch and conserve all the moisture possible in the winter and spring. Therefore, the dry farmer should give this matter his undivided attention. The practice

should be, wherever the soil and climatic conditions are favorable, for the land to be plowed in the fall, winter, or early spring, in order to catch as much of the moisture as possible.

It is considered at the present time that the fall or early winter plowing should be quite deep, probably from 8 to 10 inches, while the spring plowing should, as a rule, be somewhat shallower. Some farmers practice disking fall plowed land and leaving it in that condition through the winter. Others simply leave it in the rough condition. In the spring, the land, whether fall or spring plowed, should be disked and harrowed. It may also be smoothed before planting. Considerable care should be exercised in all of these operations in districts where the soil tends to drift and blow. In some of the dry farming districts bean growers list their beans in the spring.

Planting.

This crop may be planted with a lister, bean or corn planter, grain drill, or may be dropped by hand in the furrow. In a number of the bean growing sections, particularly among the native farmers, the beans are plowed in; that is to say, they are dropped in the furrow and covered over with a plow as the land is being plowed. Up to the present time there is considerable difference of opinion as to the best distance to plant, and because of this fact the planting is being done in rows 2, $2\frac{1}{2}$, 3, $3\frac{1}{2}$, and even 4 feet apart. Under dry farming, where the moisture is somewhat limited, it is well not to plant too thickly. Until more experimental work is done along this line it would be a difficult matter to say just what is the best distance to plant, but probably from 3 to $3\frac{1}{2}$ feet between the rows and from 10 to 20 pounds of seed per acre, would give as good results as any distance in most of the dry-farming districts. Under irrigation, thicker planting can be practiced, and the amount of seed that may be planted per acre varies from 25 to 35 pounds.

Time to Plant.

The date of planting varies with the locality and the altitude, and also with the moisture in the soil. For this reason, beans are being planted from early in the spring to late in July. The thing to keep in mind is that they must be planted early enough so that they will mature the crop. As a rule, under normal conditions, it will take about 90 days for most of the native varieties to ripen properly. By knowing about when the first killing frost may be expected in the fall, the grower will be able to know the approximate latest date that the planting may safely be done. However, everything considered, it would be better, if all the factors remain favorable, for the beans to be planted early. Aside from the earlier maturing of the crop, much of the damage that is often caused by the bean beetle, rust and fungus to the later plantings may be avoided. In the northeastern dry-farming districts of the State, the beans are planted from the 8th of May to about the 15th of July. In some of the north central districts, where the altitude varies from 4,400 to 8,000 feet, they are planted from the 15th of April to about the middle of July.

Irrigation.

Beans grown under irrigation will have to be irrigated to produce germination, either before or after they are planted. In practically all cases an additional irrigation will be required to mature the crop, and occasionally even two or three irrigations; depending on whether it is a dry or rainy season, and to some extent, upon the soil in which they are planted. As has already been stated, when the beans are irrigated up, it will usually be necessary to irrigate more frequently than when they have been planted according to the wet method.

The irrigation of the fields may be given in plats or furrows; the better plan is to cultivate first, setting the shovels of the cultivator so as to ridge the rows a little, thus leaving a furrow between the rows and running the

water down through these furrows. It is not necessary to apply large quantities of water; in fact, oftentimes a large amount of water at an irrigation may be detrimental to the plant.

FIG. 6.—Irrigating New Mexico Pinto Beans Planted by the Native Method.

Depth of Planting.

The matter of the germination of the seed is considered of great importance and of first consideration with all agricultural crops. Even the bean, with its great vitality, if not properly planted may give a poor germination. The question of the best methods to be used in growing beans must be considered. The Experiment Station has carried on investigations along the line of ascertaining at what depths under the different methods of growing beans the best germination may be had. In a general way, there are two methods of growing beans, as considered from the soil moisture factor. They are either planted in moist soil or in dry soil. If planted in dry soil, under irrigation they must be irrigated up. Under dry-farming conditions if there is not enough moisture in the soil, they must depend upon subsequent rain to bring them up. If planted in moist soil and if every-

TABLE 2.—SHOWING PERCENTAGE GERMINATION UNDER DIFFERENT DEPTHS AND METHODS OF PLANTING.

VARIETY	Row No.	Planted in Wet or Dry Soil	Depth Planted; Inches	1914			1915			Summary	
				Beans Planted	No. Ger- minated	No. Failed to Germinate	Beans Planted	No. Ger- minated	No. Failed to Germinate	Total Germination	Total Failures
College Yellow	1	Wet	1	180	157	23	200	30	170	187	103
	2	Wet	1	180	154	26	200	162	38	316	64
	3	Wet	3	180	141	39	200	188	12	329	61
	4	Wet	4	180	144	36	200	187	13	331	49
	5	Wet	5	180	129	51	200	181	19	310	70
	6	Dry	1	180	132	48	200	155	45	287	93
	7	Dry	2	180	143	37	200	155	45	288	76
	8	Dry	3	180	127	53	200	158	42	285	78
	9	Dry	4	180	121	59	200	143	57	287	75
	10	Dry	4	180	119	61	200	137	63	287	72
	11	Dry	5	180	80	110	200	43	157	158	42
Bryo	12	Wet	1	180	124	56	200	59	141	73	307
	13	Wet	2	180	119	61	200	54	146	183	197
	14	Wet	3	180	105	75	200	134	66	253	137
	15	Wet	4	180	94	86	200	190	10	295	85
	16	Wet	5	180	100	80	200	194	6	288	76
	17	Dry	1	180	64	116	200	187	13	287	93
	18	Dry	2	180	62	118	200	132	68	196	184
	19	Dry	3	180	44	136	200	143	57	205	175
	20	Dry	4	180	50	130	200	168	32	212	168
	21	Dry	5	180	32	148	200	75	125	125	255
	22	Wet	1	180	160	20	200	65	135	97	283
N. M. Pinto	23	Wet	2	180	155	25	200	97	173	187	103
	24	Wet	3	180	146	34	200	50	150	205	175
	25	Wet	4	180	138	42	200	179	21	325	55
	26	Wet	5	180	121	59	200	168	32	306	74
	27	Dry	1	180	83	97	200	181	19	302	78
	28	Dry	2	180	86	94	200	123	77	206	174
	29	Dry	3	180	68	112	200	162	38	248	132
	30	Dry	4	180	40	140	200	131	69	190	131
		Dry	5	180	34	146	200	135	65	175	205
		Dry		180			200	58	142	92	288
		Dry		180			200				

TABLE 2—(Continued).

VARIETY	Row No.	Planted in Wet or Dry Soil	Depth Planted; Inches	1914			1915			Summary		
				Beans Planted	No. Ger- minated	No. Failed to Germinate	Beans Planted	No. Ger- minated	No. Failed to Germinate	Total Germination	Total Failures	Percentage Germination
California Pink	1	Wet	1	180	162	18	200	132	68	294	96	77
"	2	Wet	2	180	154	26	200	171	29	325	55	86
"	3	Wet	3	180	139	41	200	171	29	310	70	82
"	4	Wet	4	180	133	47	200	156	44	289	91	76
"	5	Wet	5	180	138	42	200	83	117	221	159	58
"	6	Dry	1	180	72	108	200	433	67	205	475	54
"	7	Dry	2	180	113	67	200	143	57	256	124	67
"	8	Dry	3	180	84	96	200	141	59	225	155	59
"	9	Dry	4	180	33	147	200	79	121	112	268	29
"	10	Dry	5	180	35	145	200	21	179	56	324	15
Tepary	11	Wet	1	180	151	29	200	106	94	257	123	68
"	12	Wet	2	180	149	31	200	154	46	303	77	80
"	13	Wet	3	180	141	39	200	191	9	332	48	87
"	14	Wet	4	180	140	40	200	166	34	306	74	81
"	15	Wet	5	180	140	40	200	167	33	267	113	70
"	16	Dry	1	180	128	52	200	103	97	231	149	61
"	17	Dry	2	180	105	75	200	145	55	250	130	66
"	18	Dry	3	180	74	106	200	133	67	207	173	54
"	19	Dry	4	180	41	139	200	56	144	97	933	26
"	20	Dry	5	180	33	147	200	29	171	62	318	16

thing is favorable, germination will take place in about eight to ten days.

In order to have sufficient moisture in the soil, under irrigation it will be necessary to irrigate the land a few days before, or after planting. Under dry-farming conditions, the winter and spring moisture will have to be conserved, or it may be necessary to wait for summer rains. At the Station, as a rule, the best germination was obtained from planting in moist soil. The poorest germination was obtained from planting in dry soil and irrigating the beans up.

FIG. 7.—Result of Planting Too Deep; the Plant Cannot Get Through the Soil.

A glance at table 2 will bring this point out quite clearly. In these experiments the plantings were made 1, 2, 3, 4 and 5 inches in depth in the moist and dry soil. Another feature that is shown by this table is that the best germination was obtained in the moist soil from the 3- and 4-inch depths, though fairly satisfactory germination was obtained from the 5-inch, and in some cases from the 2-inch depth. The 1-inch depth in almost every case gave a very poor germination. This seems to be explained by the fact that the surface soil dried very quickly after the seed was planted. In the case of the dry soil it is noticed that, as a rule, with all of the varieties tested, the best germination was obtained from the 1, 2, or 3 inch depth; while the 4 and 5 inch depths gave, usually, very poor germination.

This brings out the point that if the beans are to be irrigated up they should not be planted deeper than 3 inches, preferably 1 or 2 inches. On

the other hand, if they are planted in moist soil it would be better to plant them 3 to 4, or possibly 5, inches in depth.

Cultivation.

The cultivation of the bean is comparatively simple; it consists principally of tillage by means of a cultivator, keeping a soil mulch as much as possible; and on lands that are weedy, hoeing the weeds from between the plants in the rows. Under irrigation, these operations may be a little more expensive than under dry farming, and in addition, from one to three irrigations are required to mature the crop. Under dry farming, there is very little hand work done, for the reason that there are comparatively few weeds. The number of cultivations will vary somewhat, according to the methods used in planting and with different soils and different altitudes; though as a general rule, it will be advisable to cultivate just as often as the operation will be of any material benefit to the crop. In practice, however, from one to four cultivations are given.

Some growers go over the ground with a harrow from one to four times after the beans have been planted. In following this practice, care should be had that the harrowing of the land is not delayed too long after the planting; otherwise the harrow teeth or spikes may destroy many of the beans that are coming up. If the soil is in good moisture condition and is quite warm, beans usually germinate in about eight to ten days; consequently, if the harrow is to be used the harrowing should be done very shortly after the beans are planted.

The five-shovel, one-horse cultivator is being used to advantage; particularly in the smaller fields. In some of the dry-farming districts, as well as in the irrigated districts, many of the native farmers do very little cultivating by machinery. The hoe is the tool that is most used; however, on a large scale this kind of work would

not be economical. The use of machinery for the cultivation of the bean should be encouraged as much as possible.

1

2

FIG. 8.—1, Irrigated Up. Notice the large number of weeds that came up with the beans. 2, Planted in Moist Soil, after Irrigation. Much freer from weeds. A strip of alkali soil crosses the plats near the center, the plants being much smaller where there is any considerable amount of the alkali.

Harvesting.

Beans may be harvested by hand pulling, by plowing them, or with a bean harvester. The bean harvester is the best and most economical way of harvesting, and is being used quite extensively in a number of the north-eastern bean growing districts, though a large percentage of the crop is still being pulled by hand. When a harvester is used, the beans are usually gathered in piles or rows in the field; but when pulled by hand they are generally placed in small piles. The harvesting should be done when the majority of the pods are ripe. Sometimes, because of late rains or late irrigation, the plant continues to grow and to produce beans. In such cases the beans ripen somewhat irregularly, and if one waits for the last pods to ripen, it will be found that the greater part of the crop is too ripe and many of the beans are

likely to shatter. The native farmers follow the practice of pulling the bean plants during the earlier part of the day, while they are still moist with dew, and in this way prevent the shattering of the pods.

Threshing.

As this crop in New Mexico has never been, until very recently, of much importance commercially, in most cases the threshing has been done by the old method; which consists of flailing the beans out or trampling them out with horses, mules, or even goats, and then depending on the wind to clean them. However, in more recent years the bean thresher is finding its way into the bean fields of New Mexico, and no doubt in a very short time it will replace the old method almost entirely. In the old method, the threshing floor was an important factor. This usually consisted of a dry, hard portion of the field, swept very clean, where the beans were piled for threshing. (See Fig. 13.)

FIG. 9.—Unloading on the Floor of a Threshing Yard New Mexico
Pinto Beans Raised under Dry-farming Conditions.

Yields.

The yield varies considerably, as would naturally be expected, on account of the variation in the amount of

moisture, amount of seed planted to the acre, soil, and variety. At the Experiment Station, under irrigation, it has been found that the yield may vary from 200 to 2,000 pounds to the acre; while under dry-farming conditions, occasionally farmers average from 800 to 1,200 pounds, though the average yield per acre is usually 400 to 500 pounds.

TESTS.

While the bean has been grown for many years by the native farmers, very few actual data derived from investigations have been available. In order to be able to furnish farmers with such data, the Experiment Station has been carrying on bean experiments since 1912. In the spring of 1912, four acres of sandy to loamy soil were used in experiments with the Bayo and Pinto varieties. These four acres were planted at different dates, to ascertain what effect different times of planting might have upon the yield and maturity of the crop. Acre I was planted on May 13, Acre II on May 24, Acre III on June 3, and Acre IV on June 13. Each of these acres was divided into eight $\frac{1}{8}$ -acre divisions. By referring to Table 3 it will be noticed that plats 1, 2, 3, and 8 in all of the four acres were planted to the Bayo bean. Plats 4, 5, 6, and 7 were planted to the New Mexico Pinto. In carrying out these experiments it was also arranged to try the different methods of growing beans, and plats 1, 2, 5, and 6 were planted according to the native, or wet, method, while plats 7 and 8 were planted according to the new, or dry, method. Plats 3 and 4 were broadcast and plowed under.

Plats 1, 2, 3, 4, 5, and 6 of Acre I were irrigated on May 8. The land was dry enough so that the beans could be plowed in on May 13. Plats 7 and 8 were planted on the same date and were flooded to produce germination on May 15. In planting plats 7 and 8 according to the dry method, after the land had been thoroughly plowed

TABLE 3.—SHOWING YIELDS AND DATES OF HARVESTING UNDER DIFFERENT DATES OF PLANTING, DIFFERENT METHODS OF PLANTING, AND DIFFERENT AMOUNTS OF SEED PER ACRE.

Variety	Plat No.	Area, acre	In Rows or Broadcast	Distance Apart, inches	Planted in Wet or Dry Soil	Acre I. Planted May 13				Acre II. Planted May 24				Acre III. Planted June 3				Acre IV. Planted June 13			
						Amount of Seed Planted, lbs.	Date Harvested	Yield, lbs.	Computed Yield per Acre, lbs.	Amount of Seed Planted, lbs.	Date Harvested	Yield, lbs.	Computed Yield per Acre, lbs.	Amount of Seed Planted, lbs.	Date Harvested	Yield, lbs.	Computed Yield per Acre, lbs.	Amount of Seed Planted, lbs.	Date Harvested	Yield, lbs.	Computed Yield per Acre, lbs.
Bayo ..	....	1 1/8	R	12x24	Wet	3	8-12	95	760	2 1/4	8-26	68	544	3	9-1	149	1192	3 1/2	9-6	110	880
Bayo ..	....	2 1/8	R	6x24	Wet	5 1/2	8-12	150	1200	4	8-26	140	1120	5 1/4	9-1	189	1512	4	9-6	139	1112
Bayo ..	....	3 1/8	B		Wet	3 1/2	8-9	84	672	4	8-26	88	704	4	9-1	123	984	4	9-6	91	728
Bayo ..	....	8 1/8	R	12x24	Dry	2 1/2	8-9	70	560	2 1/2	8-26	75	600	3 1/2	9-1	35	280	3 1/2	9-6	14	112
N. M. Pinto.	4	1/8	B		Wet	3 1/2	8-9	97	776	4	8-26	82	656	4	9-1	152	1216	4	9-6	80	640
N. M. Pinto.	5	1/8	R	12x24	Wet	2 3/4	8-9	85	680	2 1/2	8-26	74	592	3 3/4	9-1	156	1248	3 3/2	9-6	60	480
N. M. Pinto.	6	1/8	R	6x24	Wet	4	8-9	110	880	3 1/2	8-26	65	520	4 1/4	9-1	130	1040	5	9-6	140	1120
N. M. Pinto.	7	1/8	R	12x24	Dry	2 1/2	8-9	60	480	2 1/2	8-26	52	416	3 1/2	9-1	42	336	3 1/2	9-6	38	304
Per acre ..						27 1/4		751		25 1/4		644		30 3/4		976		31		672	

and leveled, furrows 3 to 5 inches in depth were made with a small plow and the seed dropped in the bottoms of them. The furrows were covered by running the Acme harrow over them.

The beans in plats 2 and 6 were dropped closer together in the furrow and it took from 4 to 5½ pounds to the plat. All the beans were harvested from August 9th to 12th. Plats 2 and 6 produced considerably more than any of the others. Plat 2 produced at the rate of 1200 pounds to the acre.

It will be noticed that plats 7 and 8, planted in the dry soil, gave the smallest crop.

The eight plats in Acre II were planted the same as those in Acre I. Plats 1, 2, 5, and 6 were plowed in according to the native method, while 7 and 8 were planted in the dry soil, and 3 and 4 were broadcast and plowed under. All of the plats were harvested on the 26th of August. The yield of the plats in this acre was a little less than that from the first acre. This was due, to some degree, to the fact that when the six wet plats were planted the soil had dried a little too much to produce the best germination possible. The plats were irrigated on May 20, and the beans were plowed under May 24. Plats 7 and 8 were irrigated on May 27. Aside from the soil having been a little too dry in the wet plats when the seed was planted, a heavy wind shortly after germination killed many of the plants. There was also a streak of alkali soil running through this strip, reducing the germination. (See Figure 8.)

Plats 1, 2, 3, 4, 5, and 6 in Acre III were irrigated May 29 and the beans plowed in June 3. Plats 7 and 8 were irrigated on June 6. The yield from all of the wet plats in this acre was quite good, while that from plats 7 and 8 was very small. The wet plats in Acre IV were irrigated on June 10, and the beans planted on June 13. Plats 7 and 8 were irrigated on June 19. It will be no-

ticed that the yield from this acre was just a little higher than that produced from Acre II, though plats 7 and 8 gave the lowest yields.

The yield results in this table show that the wet plats planted 6 x 24 inches gave, in all cases but one, the largest yield; while in the majority of cases the wet plats planted 12 x 24 inches gave a larger yield than the dry plats planted at the same distance. All of these plats were more or less affected by alkali salts, which tended to reduce the yield somewhat.

On the 20th of July the Bayo, New Mexico Pinto and Ancient Yellow were planted, to see how late beans could be planted and yet mature. These were harvested on October 8. The beans were not as plump nor as large as those from earlier plantings. During August and September there was considerable rain and the mildew affected many of the plants.

The beans tried in 1916 were planted on a piece of land that had grown a crop of corn in 1915. The corn received very little care and the middles grew up in weeds and grass. The soil, however, was of a good bean type. After the corn was harvested in the fall of 1915, the corn stalks were broken down, raked, and burned. On the last of April .97 inch of rain fell and this moistened the soil considerably. However, by the time the plats were laid off and prepared for planting, most of the moisture had evaporated. On May 11, plats 8 and 10 (see Table 4) were irrigated, to add moisture to the soil for germination of the seed. In five days the soil had dried enough so that it could be properly plowed. May 17 plats 8 and 10 were planted according to the native or wet method, to the Bayo and New Mexico Pinto beans, respectively. The beans were plowed under to a depth of from 3 to 5 inches. The soil had dried a little too much in spots and the germination in these dry spots was not very satisfactory. The beans were planted in furrows, 30 inches apart by 4 to 8 inches in the row.

On April 28 plats 1, 4, 7, and 9 were plowed, as a good many weeds were coming up. On May 18 the beans were planted 2 to 3 inches deep in these plats, with a garden hand drill (Planet Junior), in rows 30 inches apart and about 6 inches in the row. The soil was very dry and on May 23 the plats were flooded to produce germination. On June 9 plats 2, 3, 5, and 6 were irrigated to add moisture to the soil for germination. On June 13 plats 2 and 5 were planted according to the wet method and the beans were plowed in 4 inches deep. Plats 3 and 6 were planted on the same date by drilling the beans in the moist soil about 2 to 3 inches in depth. Before drilling the beans an Acme harrow was run over the irrigated soil to destroy the little weeds that had started to germinate, and to make a mulch over the field.

On June 14 plat 11 was irrigated and the New Mexico Pinto beans were plowed in on the 17th. The seed was covered about 4 inches deep. The soil in plats 2, 3, 5, 6, and 11 was in excellent moisture condition at the time of planting the seed and the germination was good. The following table will give the data on the time and method of planting, amount of seed used per plat, actual yield per plat and computed yield per acre. (Page 29.)

On May 18, the next day after plats 8 and 10 were planted, an Acme harrow was run over the plowed soil to level and mulch it. The same operation was performed in the cases of plats 2, 5 and 11 the next day after planting them.

The beans in plats 8 and 10 were up by the 27th of May, ten days after planting, while those in plats 1, 4, 7, and 9 were coming up by June 1, though the germination in plats 7 and 9 was noticeably slower.

On June 20 the beans in plats 2, 3, 5, and 6 were coming up nicely, although 5 and 6 were about a day ahead of 2 and 3. At this time no material difference

TABLE 4.—SHOWING YIELDS AND DATES OF HARVESTING UNDER DIFFERENT METHODS AND DATES OF PLANTING.

VARIETY	Number of Plat	Area; acre	Method of Planting	Planted in Wet or Dry Soil	Date Planted	Beans Planted; lbs.	Date Harvested	Yield in Pounds	
								Actual	Computed per Acre
College Yellow ..	1	.125	Drilled	Dry	May 18	3½	Aug. 26	115	920
" ..	2	.063	Plowed in	Wet	June 13	1¾	Sept. 1	84	1333
" ..	3	.063	Drilled	Wet	June 13	1¾	Sept. 1	60	952
Tepary	4	.126	Drilled	Dry	May 18	3½	Sept. 1	215	1707
"	5	.063	Plowed in	Wet	June 13	1¾	Sept. 6	128	2032
"	6	.063	Drilled	Wet	June 13	1¾	Sept. 6	115	1825
Bayo	7	.126	Drilled	Dry	May 18	3½	Aug. 29	113	897
"	8	.126	Plowed in	Wet	May 17	3½	Aug. 29	132	1048
N. M. Pinto.....	9	.126	Drilled	Dry	May 18	3½	Sept. 1	121	960
" ..	10	.063	Plowed in	Wet	May 17	1¾	Sept. 1	61	968
" ..	11	.063	Plowed in	Wet	June 17	1¾	Sept. 9	70	1111

1916

was observed in the stand between the plats plowed under and those drilled after irrigation.

On June 22, the vines in plats 1, 4, 7, and 9 were needing water and were irrigated the second time. They were again irrigated on August 2. These plats, which were planted in the dry soil, were irrigated three times; once to produce germination of the seed and twice to mature the crop. Plats 8 and 10, which were planted according to the wet method, were irrigated but once, on August 1, to mature the crop. The same thing was true of plats 2, 3, 5, 6, and 11, which were irrigated once, on August 2, to mature the crop.

The Ancient Yellow in plat 1 started to bloom July 5 and by the 18th there were many pods large enough to gather as green beans. The Tepary, in plat 5, and the Bayo in plats 7 and 8, were blooming by July 6, and these had pods large enough to pick by the 19th; while the New Mexico Pinto in plats 9 and 10 was starting to bloom by July 8, and the pods were large enough to pick by the 22nd. On July 24 the Ancient Yellow in plats 2 and 3 were starting to bloom and by August 8 it had pods large enough to pick. The Tepary in plats 5 and 6 did not start to bloom until July 26 and the beans were large enough to pick by August 8. The New Mexico Pinto in plat 11 was blooming by July 29 and by the 11th of August it had pods large enough to pick. On the whole, the Ancient Yellow was a little earlier than the other varieties. It took from 11 to 15 days for the pods to become large enough for use as green beans.

The method of planting had no material effect on the blooming of the plants, the maturing of the pods, or the ripening of the crop, but it did have on the yield.

By referring to the columns on actual and estimated yields, given in the table, it will be noticed that the plats planted according to the native or wet method gave the largest crop, while the plats drilled in the moist soil gave

also a better yield than the plats in which the beans were planted in the dry soil and irrigated to produce germination. It was also noticed that, on the whole, the stand was not quite as good on the plats planted in the dry soil and then irrigated up. These plats also required more irrigation, cultivation and hoeings, because more weeds came up in the middles than was the case with the plats in which the beans were plowed under after irrigation. The plats in which the beans were drilled in the moist soil had more weeds than those in which the seed was plowed under, though they required no more irrigation.

The results of these experiments indicate that the best way to plant beans under irrigation is to irrigate the land first and either plow them in or drill them in the moist soil. Planting in the dry soil and irrigating the beans up tends to pack the soil and thus prevent the best germination possible, encourages weeds to come up immediately, and requires more frequent subsequent irrigations, hoeings and cultivations. If the beans are planted in the dry soil and have to be irrigated up, great care should be taken not to plant them too deeply; otherwise, many of them will not be able to break through the crust formed by the flooding of the land. If they are to be irrigated up, the best germination can be had when the planting is done from 1 to 3 inches in depth. Planting deeper than this will reduce the stand very materially.

The young bean plant cannot come through a hard soil very easily, if it is planted too deeply. It comes up in a doubled-up shape, as is shown in Figure 10. Even if the seed is not buried too deeply, if the soil is hard, the cotyledons may occasionally break off and remain below the surface. If the plant does this it is not very likely that it will grow.

If the ground has been irrigated to get it moistened for germination of the seed, the beans can be covered

FIG. 10.—Illustrating Habit of Germination. 1, Breaking through the hard soil. 2, Just through the soil.

3, Plant well started. 4, A plant that has been seriously injured by the baking of the surface soil.

3 to 4, or even 5, inches deep, if planted according to the native or wet method; and 2 to 3 inches if they are drilled in. It is not advisable to cover them too shallow, as the top soil soon loses its moisture, and the seed may not even germinate, or if they do the plants will soon begin to suffer for the lack of water. The deeper they are, the better, provided they can come through the soil. The plants will develop a good deep root system and will require less irrigation and less moisture, either under irrigation or dry farming.

Approximate Cost of Growing Beans per Acre by the Wet Method.

Preparing the land for irrigation	\$.40
Irrigating before planting	.15
Plowing at planting	2.00
Dropping seed	.70
Dragging land after plowing	.20
One cultivation	.50
One hoeing	1.65
One irrigation	.20
Pulling beans by hand	1.80
<hr/>	
Total	\$7.60

In this estimate the cost of the seed, the threshing, the sacking, and grading of the crop are not included. In case an extra cultivation, hoeing or irrigation is given the field, it will add that much to the cost of production.

In planting according to the dry method the cost of preparing the land for irrigation, plowing, irrigating, planting the seed, and pulling the beans by hand will be about the same as with the wet method. The cost of hoeing, cultivations, and the irrigating of the field will be greater.

Under dry farming conditions, where the bean grower will not have to prepare his land for irrigation or irrigate it for germination of the seed, and where there is no subsequent irrigation for the crop and very little hoeing, the cost of production is, no doubt, less than under irrigation.

Seed Selection.

The matter of seed selection cannot be too strongly emphasized. Good seed is one of the most important factors in the production of a good, profitable crop. New Mexico farmers, as a rule, have not given this feature as much consideration as it deserves, and until more attention is devoted to this point, mixed and inferior crops may be expected. At this time, when the farmers have so much competition on the market, the question of seed selection is of still greater importance, in order to produce strictly pure products of standard varieties. The New Mexico farmer is not exempt from the necessity of practicing seed selection. This is not only true of all agricultural crops, but of the bean crop as well.

The New Mexico Pinto bean, which is so well adapted to the climatic and soil conditions of the State, has been grown for so many years under dry farming and under irrigation without the proper selection of seed, that there

FIG. 11.—Selecting New Mexico Pinto Bean Seed for Planting.

are found rather marked differences as regards size and color markings. *The bean growers, therefore, should give considerable attention to the elimination of variations which do not come up to the best standard of the*

Pinto bean. The planting of this bean without paying any attention to the careful selection of the seed should be discouraged. In all cases good plump beans of uniform size and color of the type should be selected and planted.

Nutritive Value.

The bean is a leguminous plant and is, therefore, quite rich in protein. The native varieties—Bayo, Ancient Yellow, and New Mexico Pinto—are rich in proteid, cook easily, and are very palatable. The Tepary bean is not quite as rich in proteid, does not cook quite as readily as the native varieties, and is hardly so palatable. The following figures show the percentages of proteid obtained by analyses made recently by Dr. L. A. Higley of the Department of Chemistry:—

Ancient Yellow	21.88%	proteid
New Mexico Pinto	21.88%	proteid
Bayo	23.19%	proteid
Tepary	19.69%	proteid
Navy	21.44%	proteid
Black Eye	19.69%	proteid

These figures are on the wet basis.

Consumption.

The consumption of the New Mexico beans has increased very materially during the past two or three years. While this is true, very few, if any, of the restaurants and hotels have beans on their bills of fare. If these establishments could be induced to use more of them, putting them on their bills of fare, the consumption of the New Mexico beans would increase considerably more.

There are many ways of cooking the native beans. The following is a good method, used by the Spanish-Americans, of cooking the New Mexico Pinto bean:—

Take 1 pint of the New Mexico Pinto beans. Wash clean. Put them in a graniteware or other suitable cooking vessel. Pour 3 pints of boiling water over them and place on the stove to cook. Get them to boiling as soon

as possible, and keep boiling until done. Do not let the water boil below the surface of the beans, but keep it above by adding hot water to the vessel from time to time, possibly every three-quarters of an hour to an hour, depending on the heat. If the water boils down the beans are liable to burn. Keep the vessel covered while boiling, but allow escape for the steam. Never add cold water to the vessel while the beans are cooking. Keep up a steady heat until they are boiled soft. It will take about two and a half to three and a fourth hours to cook them well; the older the beans the longer it will take them to cook. When about done, add the necessary amount of salt.

When the beans are done they may be served immediately, or they can be partially mashed and fried in a small amount of lard, the lard being as hot as possible before the beans are poured into it. The frying makes them more palatable.

PESTS.

Perhaps the bean beetle is the most common pest that the bean grower has to fight, though some trouble is experienced from the cutworms, also from rust and mildew. Professor Merrill of the Biological Department has prepared the following article on the bean pests:—

“The Bean Lady-Bird, or Bean Beetle, as it is commonly called, is the most important insect enemy of the bean in New Mexico. It is about one-fourth inch in length, hemispherical in shape, orange brown in color, with sixteen black spots on the wing covers. The other members of this family of beetles are beneficial and should be recognized as such.

“The adult bean beetles hibernate, emerging late in spring and laying clusters of eggs on the under side of the bean leaf. Several hundred eggs may be laid by one female. In a few days the yellow, spiny larvae hatch and begin to eat the tissue from the under side of the leaf, leaving only the white skeleton of the leaf. Most of the damage is done by the adult beetles in eating holes in the leaves.

“Beans planted as early as possible in the season usually mature a crop before the beetles get very numerous. Late plant-

ings suffer greatly from the attacks of the increased numbers in the later generations. Early planting is better, also, in regard to prevention of bean rust.

"Spraying for the bean beetle may be practiced successfully as a preventive measure. Experiments indicate that the adults will pass sprayed fields and lay their eggs upon fields unsprayed. The spraying, then, should be done first before the eggs are laid. The farmer will have to decide for himself the exact date. A first spraying is not effective if done when already a full brood of young are hatched. If the first spray is put on at the time suggested, usually there is no need for a second. Care should be taken to spray the under side of the leaf, for there the eggs are laid and there the young hatch and begin to eat. For large fields a sprayer with row attachment throwing a fine spray should be used.

"As a spray, use powdered arsenate of lead at the rate of 2 to 2½ pounds to 50 gallons of water. As a partial preventive of rust, at a small cost, bordeaux mixture may be substituted for the water."

Cutworms.

"Cutworms are the naked, greenish or dusky larvae of a number of species of dusky-winged moths that fly at night for the most part. In the spring of 1914 there was a great number of one species of moth of this group prevalent very generally over New Mexico.

"The usual life history is as follows: The eggs laid by the moths in late summer hatch into small caterpillars, or 'cutworms,' which lie concealed just beneath the surface of the ground near tender parts of plants. They feed mostly at night. Later cold weather and lack of food necessitate hibernation in the soil or under rubbish, weed piles, etc. In the spring, feeding is resumed again. The damage is more noticeable at that time for the cutworms are fair sized, hungry, and vegetation is scarce. After a time the caterpillars reach their full size, go into the soil to pupate, and later emerge as moths to lay more eggs for later generations. Alfalfa fields harbor enormous numbers of these cutworms.

"Control: Many moths may be caught at night by placing a light above a tub of water. This will not reduce the number of cutworms much, as the females do not fly far before laying the eggs. It will reduce the nuisance of having the moths in such numbers about the house. Water standing 6 or 8 hours on an irrigated field should kill many of the cutworms in the soil. A reliable remedy is the poisoned bait made as follows: Mix 1 pound of Paris green with 25 pounds of dry bran. Add 2 or 3 quarts of molasses to 5 or 6 gallons of water and stir the mixture thor-

oughly into the poisoned bran. Let this stand for several hours before using. In infested fields scatter broadcast, in the evening, pieces of this bait the size of two or three fingers together. In gardens, strew the pieces along the bases of the plants being attacked. In this dry climate the application may have to be repeated to give best results."

Rust of Beans.

"This fungous disease of the bean is marked, first, by a tendency toward yellowing of the leaves and, later, by the production of spots on the under sides of the leaves yielding the dusty red rust. The destruction of the foliage by this disease is apt to cause a too early maturing of the beans and a consequent loss in yield. The rust usually appears late in the season and is most injurious if the season be moist.

"The old leaves and vines hold the fungus over from one year to the next. Such should be burned after the crop is off, so as to reduce the chances for infection the next year.

"Among varieties of beans there is difference as to the susceptibility to the rust. From observations the New Mexico Pinto bean, Tepary, and navy beans are less affected by the rust than most others grown in the State.

"Aside from trying to get resistant varieties, control of the disease is mostly along preventive lines. Early planting tends to mature the crop before the rust may become injurious. If Bordeaux mixture is used in combination with the lead arsenate for the bean beetle, it will help some to prevent infection. When once the rust appears there is as yet no remedy for the affected plants."

Powdery Mildew of Beans.

"This disease appears first on the leaves as whitish spots of the dense threads of the fungus. The spots may run together in some cases and cover the leaf, and even stem and pods. It is more apt to be injurious late in the season in moist weather. Attack by this disease is not as often disastrous as is attack by the rust. The same recommendations apply, in general, as to prevention. Dusting the plants thoroughly with flowers of sulphur will usually control this fungus if applied promptly on appearance of spots.

"It is well, as a matter of precaution against all bean diseases, to insist, when buying, on getting seed from disease free fields, if possible, and to select seed from disease free plants when using home grown seed."

The following articles were prepared by the county agricultural agents in several of the principal bean growing counties of New Mexico:—

BERNALILLO COUNTY.

Introduction.

Beans have been grown in this County, which is slightly north and west of the central part of the State, since its early history, and are one of the principal foods of the Spanish-American people. However, it has never been considered a money crop. They are grown in both the valley and mountainous districts, principally the latter. The New Mexico Pinto bean is the leading variety, though the Bayo is sometimes grown, because of its quick maturing habit. The area devoted to bean culture in this County would probably not exceed one thousand acres. They are grown on a majority of the farms, on small areas. Seed selection is seldom or never practiced, and as a consequence the varieties are very badly mixed.

Seasonal Conditions.

The elevation of the Rio Grande Valley in the County is approximately 4,950 feet. The mountainous districts, in the eastern portion of the County, are considerably higher. The average date of the last killing frost, in the spring, is April 18; an occasional killing frost has occurred as late as May 15. The average date of the first killing frost in the fall is October 19. Some have been reported as early as September 17. The annual rainfall averages 7.51 inches, nearly fifty per cent of which occurs during June, July and August; the remainder being equally distributed throughout the other nine months. The readings from which these data were compiled were taken in the vicinity of Albuquerque, and will hardly apply to the higher altitudes, where much winter snow falls. The table below shows the monthly and seasonal temperatures and precipitations.

Planting.

Very little attention is given to the preparation of a proper seed bed. The most successful planters fall plow, and harrow several times during the winter and spring. A good seed bed for the catching and holding of winter moisture is necessary in the dry farming districts, but is not considered so essential where irrigation is practiced. The land on which beans are to be grown is generally irrigated a few days in advance of the planting season, and as soon as it is ready to plow the seed is scattered broadcast by hand or dropped in the furrows. Thus at one operation the seed bed is prepared and the seed planted. The field is then gone over with a heavy log or drag, which tends to firm and smooth the soil. Borders are laid out with a plow and reinforced with

NEW MEXICO BEANS.

NORMAL MONTHLY, SEASONAL, AND ANNUAL TEMPERATURE AND PRECIPITATION AT ALBUQUERQUE, BERNALILLO COUNTY, N. M.

MONTH	TEMPERATURE			PRECIPITATION			
	Mean	Absolute Maximum	Absolute Minimum	Mean	Total Amount for the Driest Year	Total Amount for the Wettest Year	Snow, Average Depth
	Deg. F.	Deg. F.	Deg. F.	Inches	Inches	Inches	Inches
December	34.4	69	3	0.40	0.84	2.93	1.8
January	33.8	70	-4	0.40	0.32	1.00	2.0
February	39.3	78	-10	0.24	Trace	Trace	1.7
Winter	35.8			1.04	1.16	3.93	5.5
March	47.2	89	12	0.21	Trace	Trace	0.7
April	55.7	89	13	0.53	.00	4.20	Trace
May	64.7	95	30	0.39	0.23	.00	0.0
Spring*	55.9			1.13	0.23	4.20	0.7
June	73.4	104	37	0.76	Trace	1.37	0.0
July	77.1	104	44	1.16	1.20	0.22	0.0
August	75.3	99	45	1.30	0.70	0.72	0.0
Summer	75.3			3.22	1.90	2.31	0.0
September	67.8	97	30	0.88	0.55	0.59	0.0
October	56.6	85	24	0.73	Trace	.00	0.4
November	43.3	76	7	0.51	1.10	4.70	0.6
Fall	55.9			2.12	1.65	5.29	1.0
Year	55.7	104	-10	7.51	4.94	15.73	7.2

the hoe. The seed is generally covered four to six inches deep. Seldom are the fields watered before the beans germinate, as this packs the soil and causes a poor stand.

In the dry-farming districts in the County the methods of planting are the same as previously described, excepting that they do not irrigate or make borders. The seeding rate is not definitely known, but varies between twenty and forty pounds to the acre, according to the ideas of the planter. The principal planting dates are early spring and midsummer. Much of the acreage is planted from June 1 to July 15.

Cultivation.

Seldom are horse tools used for cultivating beans, as few of the bean growers possess such implements; this would also be

impossible where the beans are planted broadcast. The fields are usually gone over twice and the weeds pulled by hand or chopped with the hoe. This is all the cultivation that is given. They are irrigated one to three times, according to the seasonal conditions, but generally when the vines are about half grown and again when in full bloom. They are always flooded, and if the water is very silty they are either not irrigated at all or a very light application is made. This is because the vines are often killed by being covered or allowed to stand for any considerable length of time in muddy water.

Harvesting and Threshing.

The harvesting is all done by hand, in this County. Usually the plants are pulled in the early morning, when wet with dew, as the beans do not shatter badly excepting when very dry. Seldom are they pulled until all the pods are well matured; they are then thrown in small piles about the field. The next day they are hauled to the threshing yards and piled. This yard is a hard spot of earth from which has been swept all the loose dirt. If there is any considerable quantity the beans are tramped out with animals, principally horses and goats. If the acreage is small they are beaten out with a flail. They are cleaned by winding, and sacked. No fanning machines are used. An occasional field is threshed and cleaned with a small grain thresher.

During the past few years great damage has resulted to the crop from the work of the bean beetle.

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COLFAX COUNTY.

At the present time the New Mexico Pinto bean is not grown very extensively in Colfax County, but it is reasonably safe to predict that it will become one of the most important crops in a surprisingly short time. The growing demand for this variety of bean, together with its excellent adaptability here, due to its drouth resistant and high yielding qualities, is attracting the active interest of many farmers. In addition to the advantages referred to above, it is a very profitable money crop, and at the same time fits in well with the crops grown in the County, as a part of a crop rotation.

This crop is grown on both irrigated and dry land, on lands which are classified as plains lands. The plains areas of this County vary in altitude from 5,700 to 7,000 feet.

The crop is usually planted the last of May to the middle of June. This usually insures against damage from the last killing

frost, which seldom comes later than the 15th of May. In some instances, however, killing frosts have come as late as the 6th of June. The first killing frost in the fall usually occurs about the first of October, but may occur any time after the 20th of September.

This crop is planted on spring plowed land by most of the farmers, which practice is attributable to the fact that late planting allows the farmers ample time to prepare the seed bed, the fall plowed land being used for other crops which require earlier planting. So far it is not definitely known which is the better, spring plowed or fall plowed land.

On account of their drouth resistance, beans are often planted on sod land; in which case no cultivation is practiced. However, much better yields are obtained on older land, where cultivation is possible.

In plowing land for beans, most of the farmers plow from four to six inches deep. It is difficult to say what depth of plowing is best, as no tests have been made. However, land which has been seeded to small grain crops the preceding year should be plowed at least six inches deep preparatory to the planting of beans. The land should be plowed as early as possible in the spring, in order to assure the formation of a good seed bed. The land plowed each day should be harrowed the same day, in order to conserve the moisture and because the soil works up much better than if allowed to dry. If rains pack the soil sufficiently to form a crust the field should be harrowed to form a mulch; thus conserving the moisture.

The amount of seed planted per acre varies from 12 to 75 pounds. Twelve to fifteen pounds per acre is ample on dry land, and from 15 to 20 pounds is being planted on irrigated land in this County. Observations made in a great many fields indicate that a large proportion of the farmers are seeding too heavily, which usually results in lower yields, poorer quality and waste of seed.

Beans are planted by means of bean or corn planters, at a depth of from 3 to 4 inches in rows from 24 to 36 inches apart. Where the proper amount of seed is sown, plants are from 12 to 18 inches apart in the rows.

The bean crop responds very readily to cultivation, but many of the farmers do not practice cultivation thoroughly enough. The effect of thorough cultivation was very apparent in 1916. On account of the dry weather, many farmers became discouraged and discontinued the cultivation of bean fields. In many cases where cultivation was discontinued, absolute failure resulted, or

else very low yields were obtained. Where cultivation was persistently practiced yields from three to six times as large were obtained. Bean fields should be cultivated from three to five times, depending upon conditions of rainfall, soil, and weed growth.

Harvesting usually begins about the first week in September, but the greater portion of the crop is harvested after the 15th of September.

The bean crop in Colfax County has not been very large up to the present time, and but few of the farmers have harvesting machinery. Most of the growers pull the beans by hand and thresh them by tramping out with stock. But the acreage of this crop is rapidly increasing and modern harvesting machinery will soon be in use.

The bean lady-bird beetle does considerable damage to the bean crop here. Up to the present time but very little has been done toward its control.

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SAN MIGUEL COUNTY.

The farmers of San Miguel County have realized that the best and most profitable cash crop to be grown at present, under dry-farming conditions, is beans. About half of the entire area of the dry-farming land under cultivation is being planted to beans; or in other words, half of all crops in the dry-farming district is beans.

Altitude. The altitude at which beans are grown in the County ranges from 4,400 feet in the low lands to 8,000 feet in the mountain districts. They seem to do best at an altitude of about 5,500 feet.

Rainfall. The rainfall in the County varies from 14 inches, on the low lands, to 22 inches in the mountains. The precipitation comes during the fall and winter in the form of snow and in the form of rain about the middle of spring. The rainy season starts again about the 15th of July. Fortunately for the bean grower, the rain comes during the growing period of the crop.

Soils. There are many kinds of soil in which beans can be grown, but the most common are loam, sandy loam, clay and sandy clay. The best yields have been secured from the sandy clay soil. Such soil can be plowed from ten to twelve inches deep very successfully. It is rich and has the power of retaining the moisture for long periods.

Seed Bed. The preparation of the seed bed is one of the most important determining factors in the production of a good crop of

beans. It has been clearly demonstrated that the best crops are raised where the seed bed has been prepared most thoroughly. There are farmers who have different methods of preparing the seed bed for beans, but the following is the one from which they have had best results in dry farming in this County:—

- 1st. Fall plow from eight to ten inches deep.
- 2nd. Disk and leave the land open through the winter.
- 3rd. Double disk in the spring about four inches deep.
- 4th. Smooth with tooth harrow.

Allow the land to settle for about three weeks; the longer the better, provided the time of planting is not retarded. The same method of preparing the seed bed is followed by those who do their first plowing in the spring, except that they do not plow over 6 inches deep. Disk about 4 inches deep, smooth with tooth harrow and allow the land to settle until planting time. This method is not as good as the first, but at present is the one practiced by the majority of the farmers.

Time to Plant. The time of planting varies in the County with the different altitudes. Usually in the higher altitudes the best time to plant is about the last of April, as soon as the danger of spring frost is over. Care should be taken not to plant too early. If the beans are nipped by frost, they will be stunted and the chances for a good yield will be poor. In the lower altitudes beans are planted from the 15th of April to about the middle of July; or sometimes even a little later.

Planting. Two methods of planting are practiced: hand and machine planting. The former is the system that the majority of the native farmers have followed heretofore. It consists of having a boy or man follow the first furrow, dropping two or three beans about every ten or fifteen inches. The same plow goes over a second time, covering the beans in the furrow. Two more rounds with the plow and another row of beans is planted. The distance at which the beans are planted varies with the size of the plow that is used. The average distance between the rows is from twenty-four to thirty-six inches, and about twelve inches in the row.

There are two methods of planting with the machine. One is drilling the beans from eight to twelve inches in the row, the rows being from thirty-six to forty-two inches apart. The other is the check method, which consists in adjusting the corn planter so as to drop from three to six beans every thirty-six inches in the row, the rows being thirty-six inches apart. In this way the beans are planted at the same distance each way. The cultivator can be used both ways and no hand hoeing is necessary.

Seeding. As a general rule, farmers have planted twice as much seed as they should. The native farmers, particularly, plant a comparatively large amount of seed per acre, because they use no machine in planting and the distance between the rows varies

FIG 12.—Selected New Mexico Pinto Beans for Seed.

with the size of plow used. However, much less seed is being planted at the present time than has been in the past. It takes from twenty-five to thirty pounds of beans per acre when planted by hand; from fifteen to eighteen pounds are used in drilling with a corn planter, and about twelve pounds per acre when the planting is done by the check method.

Seed Selection is one of the very important factors in improving the quality of the beans raised in San Miguel County. If beans of uniform type and color are desired, seed with the same uniformity must be planted. To do this, if one does not have pure seed, the common New Mexico Pinto beans may be sorted, leaving only those of uniform type and color. Splendid results have been attained by selecting the seed.

Varieties. There are three predominating varieties of beans grown in this County. Mixed with these varieties, sixteen different kinds of beans are found.

Mexican Beans. The term "Mexican bean" is very indefinite, and should never be used without a modifier. If we say Mexican Bayo beans, Yellow Mexican beans, or Pinto Mexican beans, a particular kind of bean is identified and all who know the bean will understand the term. In the past, considerable confusion has been caused by buyers' not stating which variety of Mexican bean was desired.

New Mexico Pinto Beans. This is now the recognized commercial name for the so-called Mexican Pintos or Rosillos. It should be borne in mind that there is a vast difference between the New Mexico Pintos and the Mexican Pintos. The latter may be of two or three colors: mottled, black and white, yellow and white, pink, purple, tan, blue, red or any other color. New Mexico Pinto beans are of a cream ground color, mottled with dark tan or olive drab. Beans with stripes, half white and black, almost entirely dark, or red, should never be classed as New Mexico Pintos; which latter are a native production of the State. It is a heavy yielder and drouth resistant. Over 95% of all beans grown on the dry farms of San Miguel County are of this type.

Other Beans. The other 5% of beans raised in this County are the Bayo, the Little Navy, the Large Navy and the Lady White; also the Ancient Yellow. The California Pinks are beginning to be raised. These beans grow almost as well as the New Mexico Pintos, but are considered hardly so desirable for dry farming.

Harvesting begins about the 20th of September and ceases after the first frost, about the latter part of October. Most of the beans are pulled by hand. A man can pull about an acre a day. Many of the farmers are beginning to use the bean cutter, which is similar to a cultivator, having two sharp knives which run about two inches under the surface of the ground, at an angle with the rows of about 45 degrees. The beans remain standing until they are gathered in small shocks, which afterward are hauled to the stack. Land from which beans have been cut by machine remains in very good condition for fall plowing, since a good mulch has been formed on top of the soil by the cutter. A man and team should be able to cut not less than five acres per day.

Threshing. About 95% of the beans threshed in San Miguel County at present are threshed by horses or mules. The common way is to build a yard consisting of a level floor, especially prepared by puddling and leveling. On this yard the beans are stacked four or five feet high and two or more horses are driven over the beans until the threshing is completed. The cleaning is done by the wind. Another way is by piling up the beans and riding over them with a disc harrow. Another method is by the use of a machine having cylinders especially made for beans and peas. There are very few of these machines in the County at present.

Yields. The average yield per acre is about 400 pounds, in a good year; however, it is not uncommon to find farmers who are

FIG. 13.—Old, Native Method of Threshing Beans, which is Giving Way to the Modern Threshing Machine.

averaging from 800 to 1,000 pounds per acre. Some of these farmers have not only done this one year, but for the past several years. They plow in the fall, and do not spare horse flesh in the preparation of the seed bed. The following is the approximate cost of production per acre, with an average yield, on a 40-acre basis:—

Cost of Producing an Acre of Beans under Dry-Farming Conditions.

	Non-selected	Selected
Fall plowing	\$1.50	\$2.00
Double Disking	.70	.70
Double Disking in spring, three times		1.50
Smoothing, harrowed	.50	.50
Seed, 15 lbs., at 7c.....	1.05	1.05
Planting	.50	.50
Cultivations, two.....	1.00	Three 1.50
Weeding, one	.50	Two 1.00
Cutting or pulling	.75	1.00
Threshing, 10 cts. per hundredweight	.40	.80
Sacks, 4, at 15 cts.	.60	8 at 15c 1.20
Interest and taxes, \$10 per acre.....	1.00	1.00
	<hr/> \$8.50	<hr/> \$12.75
Gross returns, 400 lbs., at 4 cts.....	16.00	800 lbs, at 4c 32.00
	<hr/>	<hr/>
Profit	\$ 7.50	\$19.25

Insects. The most troublesome insect that the bean growers have in San Miguel County is the spotted bean beetle. They seem

to appear on old land first. Small areas are infested the first year, and they gradually spread over the entire field. Fortunately, we have had no great losses from this insect, so far.

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TORRANCE COUNTY.

This County is near the center of the State. The altitude where beans are grown averages about 6,500 feet, and the average annual precipitation for the County is approximately 16.5 inches. The average precipitation for April is 1.35 inch; May, .69 inch; June, 1.12 inch; July, 3.33 inches; August, 2.52 inches; September, 1.39 inch; or a total of 10.40 inches for the growing season. The average date of the last killing frost in the spring is May 10; of the first killing frost in the fall, October 4; the average length of the growing season being 147 days.

The southwesterly winds, which are common during the months of March and April, are perhaps the most discouraging feature of the climate. Comparatively high velocities are reached, resulting in the loss of soil moisture and at times in serious drifting of the surface soil, where best cultural methods are not employed. Inasmuch as the moisture in the ground, rather than timely rains, is depended on to germinate the seed, these winds become a pertinent reason for the adoption of good tillage practices.

Preparation of Seed Bed and Planting Methods. Experience in Torrance County has shown that flat breaking of the ground in the fall is preferable to the same operation in the spring or to spring listing. The land being left in the rough, opportunity is afforded for the storage of all possible winter moisture. This also prevents, to a very marked degree, the spring drifting of the soil; and seems to be the only practical method of controlling the cutworm, the losses from which are great. Listing in the early spring has the advantage of checking drifting of the soil, but fails in the matter of insect control and winter conservation of moisture. Fall listing has decided advantage over spring listing, but approximately only one-third of the ground is covered and from the point of cutworm control is not altogether desirable. Insofar as area is concerned, the three methods are at present about equally represented.

Shortly before planting, the ground is either disked or harrowed down to a plain surface. The seed is then planted with either a lister planter or corn planter. Where spring listing is

practiced, the seed is dropped in the bottom of the furrow, either at the time of listing or later. There is little choice between the lister planter and the corn planter, except that the former permits of a subsequent covering of the weeds in the row with greater facility. The practice of harrowing one or more times after planting is very desirable in destroying weeds before the crop appears above the surface of the ground. This is more practical where the crop has been planted on a smooth surface.

Time and Method of Planting and Amount of Seed Used. The seed is usually planted about May 10, as the danger of frost is then not serious and advantage must be taken of the moisture in the ground, for germination. If plantings are made later, the advantage of less danger of frost is offset by moisture losses.

The depth of planting depends on the nearness of germinating moisture to the surface. It is seldom possible or desirable to plant at a less depth than four inches, and successful plantings have been reported at a depth of eight inches. It is hardly likely that extremely deep planting is desirable, except where absolutely necessary. There is also great danger that poor germination will result where the seed is planted at a depth under four inches, in this County.

Ordinarily, from 12 to 20 pounds of seed per acre is used. Best results are usually obtained by planting about 16 pounds in 36- to 40-inch rows.

Cultivations and Implements. In ordinary practice, the crop is given four cultivations with a shovel cultivator. This seems to be about the proper number for weed control and for moisture conservation. The first cultivations, which approximate two inches, are later gradually extended to a depth of four to five inches. These cultivations are usually periodic until the first real moisture is received. The date of this first beneficial rainfall varies from about July 1 to July 25. Subsequent cultivations follow irregularly and as conditions permit. In the early cultivations the sweep, which skims near the surface, is largely used, and is only replaced by the shovel when the size of the weeds will no longer permit of its use. Ordinarily one hoeing is given the crop towards the end of the growing season. This operation is usually light and consists in eradicating an occasional large weed, if prior cultivations have been improperly carried out.

Date and Method of Harvesting. Harvesting usually occurs between the latter part of August and the middle of September, and the time for this operation is largely determined by the date of planting. In this operation, the regular bean harvester is used to a limited extent, and for the most part, the farmers depend

upon homemade sweeps, which they use in connection with cultivators, corn planters or sleds. The capacity of these machines varies from one to two rows, and in most cases they have a pulling action, rather than a cutting one. The blades of these machines operate at about two inches beneath the surface. Some little hand pulling is still practiced, but this method is seldom followed in Torrance County, except where weeds have made the use of harvesting implements impossible. Where machinery is not available, the moldboard is sometimes removed from a turning plow and this implement used. Unless care is exercised in harvesting, the vines become filled with dirt, which is difficult to remove from the seed and in addition, makes threshing disagreeable work.

Preparation for Market. Two machines are ordinarily used in the threshing operation. A special bean huller, which has as a feature a slow moving cylinder followed by a faster moving one, has proved generally satisfactory. In other cases, the regular small grain threshing machine is slowed down and part of the teeth removed from the concaves, to avoid cracking. Some little threshing by the use of animals is still practiced in the mountain districts. Following the use of any of these methods, it has been found necessary to reclean, by passing the beans through a fanning mill. These fanning mills are usually located near a railroad at the larger centers, where the final operation of weighing and sacking to an even hundred pounds and of loading on the cars are carried out. No grading, except that performed by the fanning mill, is at present practiced, though there is no question about the desirability of such an operation.

Markets. Several local buyers are found within the County who make the marketing of beans their chief occupation following the harvesting season. They deal directly with the farmer and assume any further risks of transporting the beans to commission merchants, who are located principally in the following centers: Detroit, Chicago, St. Louis, Kansas City, Joplin, Memphis, New Orleans, Dallas, Fort Worth, and El Paso. In the case of one or two of these commission merchants, representatives have been sent to deal directly with either the local buyers or the farmers. In ordinary practice, the local buyer assumes the cost of re-cleaning and proper bagging. Where this work is contracted, the farmer pays five cents per hundredweight for re-cleaning and bagging, furnishes the sacks and loses the weight of the inferior beans, dust and chaff resulting from the operation.

Yields, Prices Received and Cost of Production. The highest yield thus far reported, on a fair sized area, in Torrance County, is 1900 pounds per acre. Yields between 1,000 and 1,400 pounds

are not uncommon, under dry-farming conditions; but the average is much less, as shown by the table below:—

Year	Average Yield	Average Price Received	Approximate Cost of Production, per acre	Approximate Total Area, acres	Approximate Total Yield, lbs.
1915	400 lbs.	\$4.00 per cwt.	\$8.15	10,000	4,000,000
1916	533 lbs.	6.50 per cwt.	9.00	15,000	8,000,000

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UNION COUNTY.

Union County lies in the northeastern corner of the State, Colfax and San Miguel Counties being contiguous on the west and southwest, respectively. It is a high rolling plateau, sloping gradually to the east; the altitude varying from 4,000 to 6,500 feet above sea level. The average annual precipitation is about 16 inches, and falls mostly during the growing season, April, May, June, July, August and September; the months of heaviest rainfall being July and August. The growing season is usually from about May 1 to October 1. The soils are mainly of the heavy clay, clay loam, silt, sandy loam and sandy types. High winds are of frequent occurrence, and soil blowing is quite general, at times.

Beans grow on all the different types of soil and from the lowest to the highest elevations. However, they are more generally grown at the lower altitudes, as the season is longer and late frosts are less frequent. Here they are one of the principal crops grown, and are, at the present time, the main money crop for the farmer. They work in well as a rotation crop, and the acreage is being rapidly increased. During 1915 there were 100 carloads shipped from the County, and about 150 carloads were sold in 1916.

Soil. While beans do well on all the different types of soil in Union County, the sandy loam soils, with the general methods of farming, give the best results. However, the heavier or "tight" lands give just as large a yield where the land is plowed deep in the fall, winter or early spring, and a good firm seed bed established.

Preparation of Land. The land should be thoroughly prepared, by plowing or listing. Fall preparation of land is preferable and should be done to a good depth, 6 to 10 inches, and left rough through the winter. If plowed or listed in the spring, the plowing or listing should be done as early as possible. Double listing is to be recommended over single listing. The ground should be harrowed as early in the spring as possible, to level it, fill the air spaces and form a soil mulch. If the soil is cloddy and does not work into a fine firm seed bed, a weighted disk harrow with the blades set straight should be run over it. The ground should be harrowed often enough to maintain the soil mulch and keep the weeds in check, until time of planting.

Planting. Beans may be planted with a lister, a two-row corn planter or a grain drill. The two-row planter with special plates is the popular machine for planting beans in this County. The rows are usually from three to three and a half feet apart, the seeding being done at the rate of from 10 to 18 pounds per acre. On new or sod land the practice of double rowing, planting the rows twenty-one inches apart, is followed to some extent. This makes cultivating and harvesting difficult, necessitating hand labor to a large extent. It is doubtful if the yields justify the increased labor and cost of production.

The planting is usually done from two to three inches deep. The deep planting in moist soil, so that germination will take place promptly, is the best practice. Where the planting is shallow, the soil dries out around the beans and they must lie in the ground until there is rain to bring them up.

The season for planting extends over a long period, from May 1 to July 15. As frost sometimes occurs as late in the spring as May 15 and as early in the fall as October 1, and as it takes from 80 to 90 days for the crop to mature, the medium dates for planting—May 15 to June 15—are to be recommended.

Cultural Methods. After the beans have been planted three or four days and before they are up, the ground should be harrowed with a spike tooth harrow to kill any weeds that may be starting. Harrowing should not be done when the beans are breaking through the ground, as many of them would be broken off and killed. They should be harrowed once or twice more while they are small. After they are too tall to harrow—five or six inches in height—they should be cultivated shallow, with a small shovel or sweep cultivator. The last cultivation should not be close to the plants, as they are easily injured. The cultivations should be given often enough to maintain a soil mulch and keep the weeds in check.

Harvesting. Beans are harvested by hand pulling, by plowing them out and with the bean harvester. The last method is the one generally used in this County, and is the best method. The harvesters are home and factory made, and harvest two rows at once, raking them together. Some machines have a buncher attachment and bunch the two rows in small piles at the same operation. The cutting part of the harvester consists of a long blade set at an angle to the row and run about an inch and a half under the surface of the ground, cutting off the roots.

Beans should be harvested when a majority of the pods are ripe. If harvest is delayed for all the pods to ripen, many of those that were first to mature will shatter and be lost. On account of the different dates of seeding, harvesting extends over a long period; usually beginning the last of August and continuing well into the middle of October. The beans are generally stacked in long narrow stacks, and covered with bundles of sorghum or grass to keep them dry. They are threshed with a bean thresher, in nearly every case; though a few flail them out, where the distance from threshers is too great to bring them in.

FIG. 14.—A Type of Bean Harvester Used Extensively in the Dry-farming Sections,

Yields. The yields vary from 250 to 1,000 pounds to the acre; the average yield for the County being about 400 pounds. The low yields are due to poor preparation of seed beds, poor stands, lack of proper cultivation, and to insufficient moisture. Beans do not require a large supply of moisture to make good yields. They withstand drouth very well, but a drouth during the blossoming period lowers the yield by blighting the blossoms.

Variety. The New Mexico Pinto is the principal bean grown in Union County, about 99% of the beans grown being of this variety. Some navy, Tepary, Red Kidney and California Pinks are grown and fair yields obtained.

Diseases and Insects. The bean is free from disease, with the exception of a rust that has occurred to a small extent some years. There are several insects that do considerable damage to the crop: the cutworm, black and spotted beetles and some worm that works in the stem. It enters the stem near the surface of the ground and kills the plant.

Price. The price of beans varies from 3 to 7 cents per pound; the average for the past five years being about 3½ cents. The beans are usually sold to local warehouse men and merchants.

ORREN BEATY,

County Agricultural Agent,

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SUMMARY.

1. Beans have been grown in New Mexico, probably, since the first European explorers settled in this territory.

2. Due, no doubt, to the long period of cultivation and the unconscious selection by the growers, varieties have been produced which are well adapted to New Mexico conditions. Some of these are the New Mexico Pinto, the Bayo and the "Ancient Yellow."

3. At the present time the *New Mexico Pinto* is being grown in almost all of the agricultural districts where beans are grown; both under irrigation and dry-farming conditions. Probably ninety to ninety-five per cent of the 22,500,000 pounds raised in 1916 were of this variety.

4. Beans can be grown successfully under irrigation and under dry-farming conditions, provided atten-

tion is given to the proper cultivation and the proper amount of moisture for the crop.

5. The planting may be done in either dry or moist soil. The moisture in the soil may be had by irrigating the ground, under irrigation, or by conserving the winter or spring moisture, under dry farming. Under dry-farming conditions, if there is not sufficient moisture in the soil when the seed is planted, the grower must depend upon subsequent rains for the germination of the seed.

6. Under irrigation, according to the experimental data secured at the Station, it seems that better germination, and consequently, better stands, can be had by first irrigating the ground and planting the seed in moist soil, than by planting in dry soil and "irrigating up."

7. The results at the Experiment Station from the different depths of planting indicate that if the beans are planted in moist soil, best germination can be had at three to four inches, but that satisfactory germination can also be had from a 2- or 5-inch depth. A very poor germination was obtained from a depth of 1 inch.

8. When the beans were planted in dry soil and irrigated up, the best germination was obtained from 1- to 3-inch depths; very poor germination was obtained from the 4- and 5-inch depths.

9. The yield was larger from the plats that were planted in moist soil than from those planted in dry soil and then irrigated to produce germination.

10. It is advisable, wherever the local conditions favor the practice, to start the preparation of the seed bed in the fall. This will not only help materially in conserving the winter and spring moisture, under dry-farming conditions, but in destroying many eggs, larvae and insects that may become injurious to the plants in summer.

11. New Mexico bean growers need to pay considerably more attention to the matter of seed selection. In the varieties that are now being planted, many variations

are to be found. These variations are noted in the difference in size, and particularly in the coloring and markings of the individual beans. Good seed is fundamental in the growing of any crop, and too much emphasis cannot be placed at this time on the use of better seed beans in New Mexico.

12. All of the native varieties are quite drouth resistant, good yielders, palatable and nutritious. The little Tepary bean—judging from preliminary experimental work—does not seem to cook quite so readily as the New Mexico varieties; and on the whole, does not appear to be quite so palatable. Comparison of the analyses made also shows that it is a little lower in proteid than the New Mexico varieties. However, this bean has some excellent qualities that might be taken advantage of in plowing under as a fertilizing crop.

13 The New Mexico varieties tried at the Station will mature, in southern New Mexico, in eighty to ninety days.

14. The bean beetle, cutworms, and mildew are some of the pests that the bean grower may have to fight during the growing season.

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BULLETIN No. 106

April, 1917

**New Mexico College of Agriculture
and Mechanic Arts**

**Agricultural Experiment Station
State College, N. M.**

Fig. 1.
ADULT BEAN BEETLE.
Line at right shows natural size.
(Original).

THE BEAN BEETLE
(*Epilachna corrupta* Muls.)

By D. E. MERRILL

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BULLETIN NO. 106.

THE BEAN BEETLE

(*Epilachna corrupta* Muls.)

BY D. E. MERRILL

SUMMARY.

1. The bean beetle, *Epilachna corrupta* Muls., is the most injurious insect attacking the bean in New Mexico. Yearly damage is estimated in various localities from 5% to 100% of the crop. A conservative estimate puts the damage at close to 10% on the average. This species confines its attack to the bean.
2. Injury may be reduced to a minimum by cooperation in the use of preventive methods of control, firstly, and of remedial methods, secondly.
3. There are two broods of the bean beetle each year in the southern part of New Mexico where studies of the life history were made. The adults hibernate. In all stages the insect may be found upon the bean plant. On an average, the time necessary for the development from egg to adults is 25 days, approximately.
4. This species is definitely reported from New Mexico, Arizona, Colorado, Texas, Utah, and Mexico.

INTRODUCTION.

The bean beetle, (Fig. 1 and Fig. 2a) as the bean lady-bird is commonly called in New Mexico, has proven to be the most serious specific pest of the bean in the State. Since not much effort had been put forth previously to attempt its control, investigations were begun in 1913, at the Experiment Station, to learn the life history of this species and possibilities of control. Most of the life history work was done in 1914. Data obtained from personal observation of the bean beetle in many parts of the State by the writer serve to supplement some of the findings of the investigation proper.

Since the bean is one of the most important crops in the State, it is well for the grower to be acquainted with this pest so a probable source of damage may be avoided. This beetle, as far as can be learned, confines its attacks to the bean. For this reason its control should be made easier. The following pages set forth a consideration of the bean beetle as to habits and control, and give, also, the details of its life history as worked out at the Experiment Station. Notes are appended on the history and distribution of the species.

GENERAL DESCRIPTION OF ADULTS AND YOUNG.

The members of the lady-bird family, to which the bean beetle belongs, are, as a rule, very beneficial in that they destroy quantities of plant lice, scale insects, and soft bodied larvae of many kinds. They are sub-hemispherical in shape, variously colored and often spotted, so the casual observer often fails to distinguish this injurious species from the beneficial members of the family. Or, the latter may be confused with the former and so be held wrongly in disfavor. It should be remembered that the former is the only plant-eating member of the family in New Mexico.

The ground color of the bean beetle is brownish-orange. Eight black spots are found on each wing cover, three in a broken row across the front of the wing cover, a second row of three across the center, and a row of two, nearly parallel

a

c

d

b

Fig. 2. Full Grown Larva at a; Pupae at b; Adult at c; Egg Cluster at d. Natural Size. (Original).

Fig. 3. Bean Plant Destroyed by Larvae of the Bean Beetle. (Original).

to these, toward the tip. The length of the adult averages about one-fourth of an inch, this being larger than other members of the family common in the State. The tough outer wings cover and protect a delicate inner pair by means of which these insects fly very readily.

The larvae (Fig. 2a) or young, of the bean beetle are spiny, yellow, worm-like creatures, varying in size from less than 1-16 of an inch, when first hatched, to about 5-16 of an inch when growth is completed. Unless one has taken care to learn the facts, the adult beetle will not be noted in the bean patch as being the parent of these "worms" that eat so voraciously. The larvae have no wings at all so have to travel altogether on foot. When full grown the larva undergoes a further change into the pupa (Fig. 2b). The pupa is attached by one end to some object, is non-feeding, yellow in color, about the size of the adult, oval in outline, the free end being devoid of spines, the remains of the last larval skin being seen about the attached end. From this pupa comes the adult later.

NATURE AND EXTENT OF INJURY.

Injury to the bean plant occurs through having its leaves eaten outright or skeletonized (Fig. 3) by the adult beetles or their larvae. The adult beetles are not responsible for nearly as great a share of the injury as are their young. They usually feed by eating holes here and there entirely through the leaves, rarely the whole leaf being destroyed by them. As a rule they cling to the under side of the leaf and eat through to the upper side. The voracious larvae feed on the under side of the leaf, in colonies when they are young, but scattered later. (Fig. 6). When at all numerous they eat off the lower epidermis and all the green substance of the central layers of the leaf. In this way the upper epidermis and the veins remain as a whitish skeleton of the leaf. Part or all of the leaves on a plant may be damaged in this way and the feeding surface be so reduced that growth is too severely checked or stopped altogether. The young pods may be attacked, holes being scraped in their sides, or an occasional

flower eaten. Injury of this nature is not, as a rule, usual or very great.

The effect of the checking or stopping of the growth will vary with the age of the plant attacked. If the pods are well set at the beginning of the injury, the result is apt to be a hastening of maturity and a reduction in yield. If no pods are set, the plant may fail to yield at all. It may die at once or linger a while in a vain attempt to start new growth from the top, and still fail to recuperate or produce pods.

The extent of damage to the bean crop in any one year depends largely upon several conditions. It appears that late planted beans suffer most, the number of larvae increasing as the season advances. Usually a more severe infestation may be expected where the chances for hibernation of the adults have been made better by allowing weeds, crop remnants, or piles of rubbish to remain in or close to the field. Damage seems to be greater where beans have followed beans on the same ground year after year, there being a direct ratio between age of the field and extent of injury. In severe cases destruction of the crop may be total. A likely average estimate of damage is placed close to ten per cent of the annual crop.

In Torrance County, in 1916, the bean crop was estimated at 7,000,000 pounds, with a value of \$420,000. The annual loss caused by the bean beetle previous to this season was placed at \$26,000. Considering the 1916 crop at the advanced prices obtained, the loss by the previous estimate would be six and one-half per cent. Figuring at the prices formerly obtained for the crop, the per cent of loss would run much higher. Other bean growing localities suffer in like manner, in some the growing of beans being discouraged on account of the certain loss from the beetle.

TIME OF APPEARANCE.

Adult individuals of the bean beetle that have passed the winter successfully appear on the bean plants rather late. In the Mesilla Valley one finds them in small numbers after the first week in June. A week or so later they begin laying

eggs and the larvae appear soon after from these eggs. Serious damage may be expected in from three to four weeks after the beetles appear in the fields. Regardless of locality, inquiries from over the State seem to show that the maximum damage occurs between the first week in July and the first week in August. During this time the first brood of larvae reaches its maximum in numbers and size of the individuals and the second brood gets well started. Control measures should be applied, then, relatively early, for as we shall see, they are preventive rather than remedial in nature. A single female has been observed to produce 754 eggs in 40 days, and it is this rapid rate of increase that has to be forestalled.

HIBERNATION HABITS.

Reproduction continues in fall until failure of food supply or until sufficiently cold weather comes to prohibit egg-laying and destroy the larvae that are too immature to pupate. As a rule the individuals that have pupated will emerge, the cold not being suddenly severe enough to kill them.

Such adults as are left when the food supply is gone and cold weather is come, scatter to find suitable places for passing the winter in hibernation. If bunches of old vines, weeds, rubbish, or such be left in the field, the beetles will crawl down under them and perhaps partly bury themselves in the soft soil beneath. If such places are not handy the adults will fly to some other suitable and similar places where they may hide themselves away and remain dormant until late spring. They will hide usually as near as possible to the fields in which they found themselves at close of summer. They are late sleepers and do not emerge from hiding until assured that warm weather is certainly come to stay.

Cleaning up the fields in fall and winter, then, prevents hibernation there or kills the hibernating individuals.

FOOD PLANTS AND FEEDING HABITS.

So far as has been observed or reported, the bean beetle confines its feeding to the true beans. It has been taken on other plants but never found feeding. The writer conducted a

series of experiments in an attempt to get this insect to eat of other plants. A number of larvae and adults were confined in cages and given in succession fresh leaves of potato, tomato, chile pepper, lettuce, celery, cabbage, and cauliflower. None of the leaves were eaten and many of the insects died of starvation rather than eat. No variety of field or garden bean has been found to be free from attack, nor any particular difference observed as to susceptibility to attack.

Damage to morning glories and sweet potatoes by the bean beetle has been reported by casual observers. Where opportunity was given for judgment in such cases, the damage was found to be done by species of *Chelymorpha* or *Cassida*, which bear considerable superficial resemblance to the bean beetle and feed naturally on plants of the morning glory tribe.

The bean beetles do not appear to attack the very young bean plants to any considerable extent. Probably this is due in great measure to the smallness of the number of hibernating individuals. Moreover, they wander from plant to plant considerably, thus the damage is made less noticeable. The adults are not, however, very heavy feeders actually. The per cent of injury from them is small as compared to that from an equal number of larvae. When infesting new feeding grounds in summer the adults will fly to bean fields where the plants are older rather than to those where the plants are young. The extra cover for hiding among the larger plants may have something to do with their choice.

Although the adults usually eat entirely through the leaf they may occasionally merely scrape the surface as do the larvae. When the upper side of a leaf is turned down or when there is no other place to eat, the larvae will feed on the upper surface of the leaf.

CONTROL MEASURES.

PREVENTIVE.

From a study of the habits and life history of the bean beetle, there appear certain openings whereby damage may be

prevented in great measure by employment of cultural methods without dependence upon sprays, etc.

Clean Fields. Since the adults hibernate under piles of old vines, rubbish, etc., it follows that cleaning up and plowing deeply the fields, in fall and winter, will lessen the numbers that will survive hibernation.

Rotation. Since the hibernation will take place in the old fields, or as near to them as possible, rotation of crops, so as to remove the new fields as far as possible from the old, will lessen the chances of the adults finding the new fields in spring. It should be remembered that areas that have been in beans year after year are noted to be most damaged, regardless of planting time.

Planting Time. Much can be done in the way of prevention by attention to the time of planting. Climatic conditions influencing time of planting for various localities will have to be considered by each locality, as that is out of the scope of this bulletin. Under irrigation the planting time is not influenced by moisture needs. The hibernated beetles begin to feed very late. By planting the beans as early as possible in the spring, the crop will set and mature before the time of maximum injury, due to overlapping of the broods in midsummer and later. See Scheme I. If it were a question of smaller yield, possibly, from very early planting or of no crop from beetle injury, the choice would go to early planting.

Again, very *late* planting, if practiced *uniformly*, in a community, would so prolong the fasting period of the beetles that many would die before finding plants for egg-laying. However, late planted beans are more susceptible to bean rust and are liable to very serious reduction in yield from this, even if they escape the beetles.

By uniformly varying the planting time from early, over a series of years, to late, in one year next succeeding the series, the balance of the life cycle of the beetles may be upset and the increase of the beetles for that year lessened. The early planting would then be resorted to again.

From data secured from the County Agents of New Mexico and from Mr. A. G. Graham, County Agent of El Paso County, Texas, the following dates are given concerning the bean crop in relation to the bean beetle.

TABLE I.—DATES CONCERNING BEAN CROP IN RELATION TO THE BEAN BEETLE.

County	Earliest Date for Planting	Average Date for Planting	Average Date of Maximum Damage	Stage of Crop when Attacked	Average Date Maturing	Per Cent Injury
Bernalillo	4-1	5-1 to 15	7-15	**	8-1	30 to 70
Chaves	No data reported					
Colfax	5-1	5-10 to 6-10	In 7	†	9-10 to 10-1	Small to 100
Dona Ana * ...	4-1	5-10	7-15 to 8-15	†	8-1	10
Eddy †	5-1	7-1	.....	.....	9-late	.....
El Paso	4-15	5-15 to 6-1	8-1	††	8-15	20
San Miguel	5-20	6-20	8-25	§	9-20	90
Torrance	5-1	5-15	8-1	§§	8-1st wk.	10
Union	No data reported					

*Data obtained from Experiment Station. †Acreage very small, so data scanty.

** Approximately full grown. † Pods forming. †† Past blooming. §No definite stage. §§ Last flowers to string beans.

From the table above it is seen that the date of planting may be made from one to two weeks earlier at least. A gain of that much time at the crucial point of the infestation means a great deal, as shown by the rapidity of increase in the number of the insects at this time, as well as the rapid increase in size of the young, necessitating voracious feeding.

Trap Crop. Although opportunity has not been presented for any experiment with a trap crop in control of this species, it seems very reasonable to expect excellent results from using a late trap crop, consisting of a small patch of beans, to attract the adult beetles in late summer after the main crop of beans is harvested. When congregated on such

a patch the beetles could be killed in any convenient way, burning with straw, spraying with kerosene, etc.

Hand Picking. On a small patch of beans damage may be prevented by picking the adult beetles and eggs off the vines as they appear. In a large field this method would hardly be practicable.

Natural Enemies. The natural enemies of this species seem to be very few. They are protected from attack in the adult state by the repellent fluid secreted at the leg joints. In the summer's work on the life history of this species no parasites were found in any stages of the large number of insects handled. On a few occasions the writer has noted *Hippodamia convergens*, the convergent lady-bird, eating sparingly of the eggs. Dr. Gillette, of Colorado, reports "coccinellids eating eggs." Dr. Morrill, of Arizona, reports "an ant observed eating the eggs on one occasion."

REMEDIAL MEASURES.

Various sprays were tested on plats of beans of different areas. "Small plats" were approximately two rods square; "large plats" were approximately two rods by twenty rods. A few remedies were tried on areas of only a small number of plants.

Right angle, mist producing nozzles were used and the under sides of the leaves carefully reached.

Lead Arsenate Spray. On July 25, when adult beetles were first noted in the field powdered lead arsenate was applied on two large plats. On one it was used at the rate of 2 pounds to 50 gallons of water, on the other at the rate of 2½ pounds to 50 gallons of water. Three-fourths of the leaves had both sides fully covered, the remaining one-fourth being partly covered in varying degrees.

No damage was noted from the sprays. Most of the beetles left these plats at once. A few eggs were found deposited before spraying. If hatched on sprayed leaves the young were killed on first feeding. If on unsprayed leaves they fed safely. Where such food was sufficient to rear them

to the third or fourth stage, the young would refuse to eat of sprayed leaves and would hunt widely for unsprayed leaves. A number of adults and larvae of later stages were confined several days in a cage and kept supplied with fresh leaves taken from sprayed plants in the field. A few individuals died of starvation. Only one leaf showed any indication of being eaten and that had only one or two bites taken from its surface.

A few vines were sprayed with powdered lead arsenate at the rate of 5 pounds to 50 gallons of water. There was no damage to the plants but the protection afforded was no more effective.

Check Plat. A large plat adjacent to the plats above, left unsprayed, was badly injured by the beetles. Being attacked late, however, the beans matured a fair crop in spite of the injury.

Lead Arsenate—Dust. Powdered lead arsenate, 1 part. to 4 parts of powdered sulphur, was applied to a small plat with a hand dusting machine. The dust stuck well and was easily applied, somewhat more surface being covered with a given amount of arsenate than with the spray. Results, as far as control of the beetles was concerned, were about the same as with the spray.

Zinc Arsenite. A small plat was sprayed with zinc arsenite at the rate of 2 pounds to 50 gallons of water, with 2 pounds of stone lime added. Results were practically as in the first case above. There was a trifle more trouble in keeping the zinc arsenite in suspension and it did not seem to stick quite as well to the leaves as did the lead arsenate.

Sodium Arsenite. Sodium arsenite, 1 pound to 65 gallons of water plus 2 pints of sorghum molasses, was applied to a small plat. Every plant was either killed or damaged so it would not produce pods.

Blackleaf 40. Blackleaf 40, 1 pint to 100 gallons water plus 4 pounds of soap, was tried to test its effect on the larvae. Most of the larvae in the very young stages were killed if hit. Older larvae and adults were apparently uninjured.

Fig. 4. Attachment for Spraying Row Crops.

Combined Arsenate of Lead and Lime Sulphur. Tests were made on small areas as to the effect of a combined spray of commercial lime sulphur and arsenate of lead paste. The former was diluted at the rate of 1 part to 64 parts of water; the latter used at the rate of 3 pounds to 50 gallons of water. The two solutions were mixed half and half. On mixing, the resulting solution turned a bile green then almost black. Later it became a light yellow again. The bean leaves were spotted a dark green by the spray but no other effects were noted. The plants remained free from infestation for two weeks among others badly infested. Then the spray seemed to lose its power, for the beetles then attacked these plants.

Apparatus for Spraying. For a small area of beans almost any type of sprayer or duster will suffice. A fine spray is necessary for economical use of material and for efficient covering of the leaves. Angle nozzles should be used so the under sides of the leaves may be reached and thoroughly coated. For larger fields, row attachments, after the nature of the one in Figure 4 may be used. Such an attachment may be combined with hand or power machines. The nozzles should be set so as to spray inward and upward on each side of a row. The angle type of nozzle makes this easily done.

Studies of the Life History

INTRODUCTORY.

Before egg-laying could be noted in the field the hibernated adults used in these studies were secured. They were paired and kept for a few days in the laboratory on bean plants under chimney cages. When egg-laying began the pair were transferred each to a field cage of the type shown in Fig. 5. These cages were 12x12x16 inches. One type had a glass door, the top and other sides being of fine mesh wire. A second type had cheese cloth for the top, all the sides being of 16-mesh wire. These cages provided practically normal conditions for the adults and for the eggs and larvae until hatched.

Records on egg-laying, moults, etc., were made daily about nine o'clock in the morning. When a cluster of eggs was deposited, it was recorded by number and the same number was marked on the leaf bearing the eggs. This made taking of data on incubation possible without confusion. A few clusters at first were placed, leaf and all, singly, in 4-inch petri dishes for hatching. A small bit of cotton was kept moist in the dish to prevent excessive drying.

For individual records, larvae were placed singly, when hatched, in 4-inch petri dishes. Bean leaves were provided for food. They were kept fresh longer by a bit of moist cotton on the petiole. These leaves were changed as soon as unfit for food. Usually they lasted 24 hours and sometimes longer.

Where records only of the total developmental period were desired, large numbers of the same date transformations were kept in larger dishes. Supplementary data were secured from the field.

The term "hibernated" is used in reference to adults that have passed the previous winter in hibernation. The term

Fig. 5. Cages Used in Life History Studies, in Place Over Bean Plants in the Field. (Original).

"brood" is used to refer to eggs, larvae, pupae, or adults of any generation, e. g., "first-brood eggs" means the eggs laid by the "hibernated" adults, and producing the "first brood" of larvae, pupae and adults; "second brood" would be used to refer to members of the second generation in the same way.

THE ADULT.

DESCRIPTION.

The adult (Fig. 1) of *Epilachna corrupta* Muls. is oval in outline; orange brown, shining; pubescence very short, rather abundant. Elytra have each eight black spots: one humeral, one sutural sub-basal, one median sub-basal, three median, two sub-apical. Sterna and ventral surfaces of abdomen blackish. Length 7 to 8 mm. Female averages slightly larger than male. Prof. H. F. Wickham cites the original description of this species in "Species des Coleopteres trimeres securipalpes, Part II (No. 90), p. 815, 1851. Described from Mexico, collection of Chevrolat."

The color of fresh individuals is slightly lighter than normal, while individuals that have hibernated are much darker. There is considerable variation in the proportionate sizes of the black spots, so much that one can say, in general, only that the anterior spots average smaller. Some individuals show a coalescence of the sub-apical spots into one large spot.

The adult emerges through a longitudinal crack that appears in the mid-dorsal line of the pupal skin, extending from the under side of the anterior end back to the abdominal region. The head is first freed, then the feet, which are used to draw the emerging adult from the pupal skin. When first emerged the adult is a uniform light straw color, very soft, with wings and wing covers in crumpled masses against the thorax. It stands and crawls by turn, trying the while to move the wings. The latter gradually dry and expand, as they dry, to their final shape. The wings project backward at first from under the elytra. As they dry more completely they lose the yellow color, becoming nearly translucent with a yellowish brown tinge. Finally they fold under the elytra.

The anterior spots usually come out first on the elytra, then the median, and lastly the posterior, the ground color by then being the normal orange brown. The order of appearance of the spots may vary.

Usually the adults do not feed until about 24 hours after emergence. They begin to copulate the second day, and eggs may be produced in from four to six days after copulation.

From Table VI it will be seen that out of 169 adults reared from eggs, 45 were males and 124 females, a ratio of 1 to 2.75. This excess in numbers of the females is another factor in the rapid multiplication of this species.

TABLE II.—SHOWING LENGTH OF LIFE OF ADULTS.

Hibernated Adults				First Brood Adults			
No. Pair	Sex	Hatched	Died	No. Pair	Sex	Hatched	Died
I	Male	*	7-10	I	Female	7-11	8-14
	Female	*	7-20		Male	7-11	8-16
II	Male	*	7-24	II	Female	7-11	7-31
	Female	*	7-26		Male	7-11	†
IV	Male	*	8-7	IIa	Female	7-17	8-29
	Female	*	8-12		Male	7-17	†
				III	Female	7-11	8-17
					Male	7-17	8-17
				IV	Female	7-23	†
					Male	7-23	†

Of the first brood adults, Pairs I and II and female of Pair III were reared from first-brood larvae taken in the field; Pairs IIa and IV and male of III were reared from eggs secured from hibernated females used in the experiment.

* Probably August of previous year.

† Not recorded.

Reference to Table II shows the three hibernated adults dying between July 10 and August 12. As adults they had lived, then, between 11 and 12 months, at the least. The first-brood adults that were kept in captivity died, without

Fig. 6. Cluster of Eggs and Larvae of Bean Beetle in First Stage, Showing Tendency to Feed in "Herds". Slightly Enlarged. (Original).

hibernating, from 20 to 43 days after emerging. This does not mean necessarily that none of the first-brood adults hibernate. Fuller data would be needed to determine this point, but since none of these adults lived longer, indications are that probably most of the hibernating individuals are from the second brood.

CONCERNING EGGS AND EGG-LAYING.

Manner of Oviposition. To deposit the eggs, the female seeks a suitable spot on the under side of a leaf, stops and begins to work the tip of the abdomen up and down vigorously. In a few seconds the short ovipositor is protruded. This is then worked up and down, the egg being forced at the same time down the tube. Finally the tip of the egg touches the leaf, sticks firmly, the abdomen is raised high, freeing the egg from the ovipositor and leaving it attached to the leaf. A few preliminary movements are then made with the tip of the abdomen, to ascertain if nothing is in the way, and the process is repeated. The deposition of one egg requires from 30 to 70 seconds. Thus a large sized mass of 60 eggs would take 30 minutes to 1 hour and 10 minutes for placing.

Description of the Egg. An egg is light, clouded, yellow in color and of an oval shape, the attached end being slightly larger than the free end. In size it is 1.2 mm. long by .6 mm. wide. The surface is delicately sculptured. Infertile eggs may be told by their shrivelled appearance soon after being deposited.

Number of Eggs. As a rule the eggs are not placed contiguously in the mass, although in some instances they may touch each other. There is no definite arrangement of the eggs in a cluster, nor any definite shape to a cluster. (Figs. 2d and 6).

Table III shows that the number of eggs in a cluster is not constant. For 39 clusters counted, the average was 46 eggs per cluster. The lowest number was 7 and the highest 76. Among eight females observed in the life history studies, the maximum egg production for one female was 754 eggs.

in 14 clusters; the lowest was 93 eggs in 2 clusters. The average per female was 291 eggs.

The hibernated adults averaged higher in egg production than those of the first brood. The better protection afforded the individuals in captivity would probably balance any loss of productiveness through the slightly abnormal conditions under which the females were kept, so the above figures are fairly representative.

Length of the Egg-laying Period. Among the hibernated females whose egg records were kept, one produced her quota of 754 eggs, 14 clusters, in 40 days—1 cluster each 2.85 days. Reference to Table III shows the time elapsing between clusters varies from 1 to 10 days. A second female deposited 8 clusters in 17 days; a third 8 clusters in 28 days.

Among the first-brood females, one laid 6 clusters in 16 days; a second 3 clusters in 3 days; a third 4 in 13 days; a fourth 4 in 6 days; a fifth 2 in 2 days. Probably the egg-laying period for the first-brood females is longer than these figures show, under entirely natural conditions. The earliest of these females could begin to lay by the third week in July. The last record for eggs at the Experiment Station Horticultural Farm was on October 3. Larvae from eggs laid so late would likely not mature. This would give a possible 10 weeks period for egg laying by the first-brood females. However, the egg-laying period for any given female individual in this total time may be short. Scarcity of food in the latter part of the above time would restrict oviposition and shorten the average period, because most of the beans are harvested in this region before September.

The great length of the egg-laying period of the females of both broods causes an overlapping of the broods and a consequently huge number of the larvae are present in midsummer.

Incubation. The average time necessary for hatching is 5.8 days; the shortest time being 4 days and the longest time 9 days. (Table III).

Reference to Table III shows that of the eggs recorded approximately 75% hatched. In some cases every egg in a

cluster hatched; one record showed only 18% hatching. Everything considered, normally the per cent hatching is high. There was no discernible difference in the numbers hatching as between clusters on leaves in the field cages and on excised leaves in the laboratory.

TABLE III.—EGG AND INCUBATION RECORD.

Hibernated Female No. I.

No. of Cluster	No. in Cluster	Date Laid	Date Hatched	No. Hatched	Per Cent Hatched	No. Days Incubation
1	45	6-22	6-26	25	56	4
2	37	6-23	6-28	35	94+	5
3	60	6-25	7- 3	50	83+	7.5
4	48	6-29	Destroyed by accident			
5	11	6-30	7- 6	2	18+	6
6	10	7- 4	7-11	6	60	7
7	15	7- 6	7-12	7	46	6
8	11	7- 9	Destroyed by accident			
Total Ave.	237 30—				59	5.9

Hibernated Female No. II.

1	63	6-24	Destroyed by accident			
2	62	6-27	Destroyed by accident			
3	61	6-29	7- 5	45	74—	6
4	50	7- 6	7-12	50	100	5.5
5	56	7- 8	7-13	55	98+	5
6	60	7-13	7-22	20	33+	9
7	56	7-16	7-23	56	100	7
8	58	7-22	7-27	50	88—	5
Total Ave.	466 58+				82+	6.2

Hibernated Female No. IV.

1	59	6-21	6-29	4*		
2	55	6-22	6-27	30	54	5
3	60	6-25	Destroyed by accident			
4	61	6-27	7- 3	50	82	6
5	67	6-29	7- 5	35	52	5.5
6	57	7- 3	7- 7	57	100	4
7	58	7- 6	7-12	56	98+	6
8	60	7- 9	7-15	55	91	6
9	58	7-14	7-18	58	100	4
10	51	7-13	Destroyed by accident			
11	7	7-14	7-19	5	71+	5
12	50	7-16	7-23	50	100	7
13	50	7-21	7-27	45	90	6
14	62	7-31	Destroyed by accident			
Total Ave.	754 54—				83	5.4

*Allowed to stand in direct sun in dish. Not counted in incubation and hatching averages.

TABLE III. (Cont'd) EGG AND INCUBATION RECORD.

First Brood Female No. I.

No. of Cluster	No. in Cluster	Date Laid	Date Hatched	No. Hatched	Per Cent Hatched	No. Days Incubation
1	61	7-18	7-23	42	70—	5
2	62	7-20	7-25	58	93+	5
3	20	7-27	8- 2	15	75	6
4	58	7-28	8- 2	56	96+	5
5	10	7-28	8- 2	6	60	5
6	58	8- 3	8- 9	50	88—	6
Total	269					
Ave.	45—				80	5.3

First Brood Female No. II.

1	76	7-19	7-25	60	79—	6
2	50	7-21	7-28	40	80	7
3	45	7-22	7-27	40	89—	5
Total	171					
Ave.	57				83—	6

First Brood Female No. IIa.

1	32	Not kept for incubation record				
2	31					
3	39					
4	42					
Total	144					
Ave.	36					

First Brood Female No. III.

1	40	Not kept for incubation record				
2	45					
3	56					
4	59					
Total	200					
Ave.	50					

First Brood Female No. IV.

1	53	Not kept for incubation record				
2	40					
Total	93					
Ave.	46+					

Computation from Total Record.

	No Eggs in Cluster	No Eggs per female	Per Cent Hatching	Period Days Incubation
Maximum	76	754	100	9
Minimum	7	93	18	4
Average	46	291	75	5.8

THE LARVA.

Hatching. When the larva is ready to emerge it first chips out a hole in the free end of the egg. The head is forced through this opening. By more or less regular contraction and expansion of the whole body and by wriggings of the anterior part of the body, the front legs are next withdrawn from the egg, as the body is forced upward. Once out, the front legs

are used for grasping the side of the egg or any nearby surface, thus aiding in drawing the body out. As the other legs come out in turn they are used in like manner. The time consumed in this entire process varies from an hour and a half to two hours.

First Stage. When the yellowish larva first frees itself from the egg the spines are closely appressed. As the chitin dries, the spines become erect and are seen to be branched at and near the tip. Later the tips of the branches become darker. The larva is about 1.3 mm. long by .6 mm. wide. The body tapers sharply in the abdominal region and is recurved downward. There is a row of four spines across the front of the rather pronounced pro-thorax. On the rest of the body there are six longitudinal dorso-lateral rows, the spines of the outside rows being very small and very few.

The larvae remain for some hours congregated on the egg cluster after hatching before they go to feed. Then they move down to the surface of the leaf and feed together (Fig. 6) outward from the egg mass without leaving this leaf, if it is in condition to be eaten. Within 10 minutes after the larvae begin to feed the green color may be noticed in the digestive canal. By 20 minutes excreta were noted. When about ready for the first moult the larvae scatter and wander apart somewhat. The first stage of the first-brood larvae averaged 4.3 days in duration; of the second brood the period was 3 days for all the larvae used (Tables IV, V). The maximum time was 7 days and the minimum 3 days for first brood.

TABLE IV.—TRANSFORMATION RECORD OF FIRST BROOD LARVAE.

Larval Number	Date Eggs Deposited	Date Hatched	1st Molt	2nd Molt	3rd Molt	4th (Pupation) Molt	5th (Emergence) Molt	Sex	Larval Period; days	Developmental Period; days
1	6-22	6-26	6-29	*						
2	**	**	7- 2	7- 4	7- 8	7-13	7-18	Male	17	26
3	**	**	6-28	7- 3	7- 7	7-13	*			
4	**	**	6-30	*						
5	**	**	7- 3	7- 6	7-10	7-15	7-20	Female	19	28
6	**	**	7- 2	7- 4	7- 8	7-13	7-18	Female	17	26
7	**	**	7- 2	7- 4	7- 8	7-13	7-18	Female	17	26
8	**	**	7-29	Killed accidentally						
9	**	**	6-30	7- 4	7- 7	7-13	7-17	Male	17	25
10	**	**	6-29	7- 3	7- 6	7-13	7-17	Female	17	25
11	**	**	6-29	7- 2	7- 6	7-12	7-17	Female	16	25
12	**	**	6-29	7- 4	7- 7	7-13	7-18	Female	17	26
13	**	**	7- 2	7- 5	7-10	7-17	7-20	Male	21	28
14	**	**	7- 2	7- 5	7- 9	7-14	7-19	Male	18	27
15	**	**	*							
16	**	**	*							
17	**	**	6-30	7- 3	7- 6	7-12	7-17	Male	16	25
18	**	**	6-29	7- 3	7- 6	7-12	7-16	Female	16	24
19	**	**	6-29	7- 4	7- 7	7-13	7-17	Male	17	25
20	**	**	*							
21	**	**	6-30	7- 4	7- 7	7-13	7-17	Male	17	25
22	**	**	6-30	*						
23	**	**	*							
24	**	**	6-30	7- 4	7- 7	7-13	7-18	Female	17	26
25	6-27	7- 3	7- 7	7-10	7-13	7-19	7-24	Female	16	27
26	††	††	7- 7	7- 9	7-12	7-19	*		16	27
27	††	††	7- 7	7- 9	7-12	7-18	7-23	Female	15	26
28	††	††	7- 7	7- 9	7-12	7-18	7-23	Female	15	26
29	††	††	7- 8	7-11	7-14	*				
30	††	††	7- 6	7- 9	7-12	7-18	7-23	Female	15	26
			1st Stage	2nd Stage	3rd Stage	4th Stage	Pupal Stage			
†Average No. of days.			4.3	3.2	3.4	5.8	4.7		16.8	25.9
Maximum No. of days			7	5	5	7	5		21	28
Minimum No. of days			3	2	3	5	3		15	24

*Died.

**The first twenty-four larvae are all from the same cluster.

††The last six larvae are from a second cluster.

†The records of the individuals that completed their development were the only ones used in obtaining averages.

TABLE V.—TRANSFORMATION RECORD OF SECOND BROOD LARVAE.

Larval Number	Date Eggs Deposited	Date Hatched	1st Molt	2nd Molt	3rd Molt	4th (Pupation) Molt	5th (Emergence) Molt	Sex	Larval Period; days	Developmental Period; days
1	7-18	7-23	7-27	7-29	8-1	*				
2	**	**	7-26	7-28	7-31	8-7	8-12	Female	15	25
3	**	**	7-26	7-28	7-31	8-7	8-12	Female	15	25
4	**	**	7-26	7-29	8-2	8-7	8-12	Female	15	25
5	**	**	7-26	7-29	7-31	8-7	8-12	Female	15	25
6	**	**	7-26	7-28	7-31	8-7	8-12	Male	15	25
7	**	**	7-27	7-30	8-2	8-4	*			
8	**	**	7-26	7-28	7-31	8-8	8-12	Female	16	25
9	**	**	7-26	7-28	7-31	8-8	8-13	Female	16	26
10	**	**	7-27	*						
11	**	**	7-26	7-29	8-1	8-8	8-13	Female	16	26
12	**	**	7-26	7-29	7-31	8-7	8-12	Male	15	25
13	**	**	7-26	7-29	8-2	8-9	*			
14	**	**	7-26	7-29	8-1	8-9	*			
15	**	**	7-26	7-29	7-31	8-9	8-13	Female	17	26
16	**	**	7-26	7-28	8-2	8-8	8-13	Female	16	26
17	**	**	7-26	7-29	8-1	8-8	*			
18	**	**	7-26	7-29	8-1	8-9	*			
19	**	**	7-26	7-29	8-1	8-8	8-12	Female	16	25
20	**	**	7-26	7-29	7-31	8-7	8-12	Male	15	25
21	**	**	7-26	7-29	8-1	8-7	8-12	Female	15	25
22	**	**	7-26	7-29	8-2	*				
23	**	**	7-26	7-29	8-2	*				
24	**	**	7-26	7-29	8-2	*				
25	**	**	7-26	7-29	8-2	8-11	8-15	Female	19	28
26	**	**	7-27	*						
27	**	**	8-1	*						
28	**	**	7-26	7-29	8-1	8-8	*			
29	**	**	7-26	7-29	8-2	8-9	*			
30	**	**	7-26	7-29	8-2	*				
			1st Stage	2nd Stage	3rd Stage	4th Stage	Pupal Stage			
†Average No. of days			3	2.6	2.9	7.1	4.7		15.7	25.4
Maximum No. of days			3	3	4	9	5		19	28
Minimum No. of days			3	2	2	6	4		15	25

*Died.

**All 30 larvae from the same cluster of eggs.

†The records of the individuals that completed their development were the only ones used in obtaining the averages.

Second Stage. After the first molt the larva is 2 mm. long and the tip of the abdomen is slightly more curved than in the first stage. The spines are longer and more branched. The dark tips are not so pronounced. The rows of spines are the same in number but more distinct.

Moulting is effected as follows: The tip of the abdomen is stuck to the leaf; a longitudinal, median split comes in the thoracic region and the head is worked out; next the feet are freed. Clinging by the feet the larva then pulls itself out of the old skin.

The larvae are now able to travel well and hunt for suitable food. Tables IV and V show the duration of the second stage of the first-brood larvae to be 3.2 days; of the second-brood larvae 2.6 days. The maximum was 5 days and the minimum 2 days for first brood; and 3 and 2 days, respectively, for the second brood.

Third Stage. After the second moult the larva is 4 mm. long. The spines are longer, more branched from the sides, and dark tipped. The rows are now easily seen. In this stage the larva seems to be rather humpbacked, the highest and widest portion of the body being about the middle portion. The abdomen tapers sharply, the anterior end slightly, only.

From Tables IV and V the average duration of this stage is seen to be 3.4 days for the first-brood larvae and 2.9 days for the second-brood larvae. For first-brood maximum 5 days, minimum 3; for second brood, maximum 4 days and minimum 2.

Fourth Stage. At the beginning of the fourth stage the larva is 5.4 mm. long and it increases to nearly 1 cm. in length before the fourth moult. The chief difference between the larva in this stage and in the last is in the size.

Tables IV and V show this stage to last 5.8 days in the first brood; and 7.1 days in the second-brood larvae. For the first, maximum was 7 and minimum 5 days; for second brood, 9 and 6 days, respectively.

Since this stage is longest in time and the larvae are largest in size, it is during this period that the capabilities for damage are the greatest. Reports of damage usually come in when a maximum number of the larvae have reached this stage.

Near the end of this stage the larva stops feeding for about 24 hours, and wanders about considerably. Finally, having found a suitable place on stem, leaf, or pod, the tip of the abdomen is firmly glued to the surface, the skin cracks in the thoracic region in a mid-dorsal line, and is pushed back in a wrinkled, white mass to the fixed tip. This is the pupation moult. The black tips of the spines on the cast skin are very evident.

Duration of the Entire Larval Period. Tables IV and V show the entire larval period to average 16.8 days for the first brood, with a maximum of 21 days and a minimum of 15 days; for the second brood the average was 15.7 days, with a maximum of 19 and a minimum of 15 days. The longer fourth stage in the second brood almost compensates for the longer time for the earlier stages in the first brood.

The Pupa. The pupa (Fig. 2b) is yellow in color, about 7.5 mm. long by 4.5 mm. wide in the meso-thoracic region. Posteriorly it tapers rapidly to the tip; the anterior end is bluntly rounded. There are no spines on the pupa, indications of rows of tubercles representing the rows of spines. The abdominal segments are evident on the dorsal surface. Very fine, rather long, somewhat sparsely set hairs cover the whole surface. The pupal period averaged 4.7 days in either brood, with 5 days as a maximum in each. The minimum in the first brood was 3 days and in the second 4 days. (Tables IV, V).

Total Developmental Period. From Table IV and Table V the average total time from egg to adult is 25.9 days for the first brood and 25.4 days for the second brood. In Table VI are given the records of 169 larvae all hatched within the first two weeks in July and all transformed to adults before the end of the first week in August. They represent pretty well the middle of the season. Among these individuals the average time from egg to adult was 24.7 days, being slightly below the averages given in Tables IV and V. The shortest time for the transformations was 22 days and the longest time 28 days.

TABLE VI.—TOTAL DEVELOPMENTAL PERIOD AND RATIO OF MALES TO FEMALES.

No of Larvae Observed	Date Eggs Laid	Date Adults Emerged	Sex		Period of Development; days
			Males	Females	
6	6-27	7-23	3	3	26
2	6-27	7-24	1	1	27
3	6-27	7-25	0	3	28
3	6-29	7-23	1	2	24
1	6-29	7-24	0	1	25
1	6-29	7-25	0	1	26
17	7-3	7-25	6	11	22
19	7-3	7-26	2	17	23
5	7-3	7-27	0	5	24
8	7-6	7-30	3	5	24
17	7-6	7-31	5	12	25
33	7-6	8-1	5	28	26
16	7-6	8-2	8	8	27
6	7-8	7-31	0	6	23
22	7-8	8-1	8	14	24
6	7-8	8-2	2	4	25
4	7-8	8-3	1	3	26
169			45	124	Ave. 24.7
Ratio of males to females, 1 : 2.75					Min. 22
					Max. 28

SUMMARY OF THE LIFE HISTORY.

The studies of the life history of the bean beetle showed that there were two full generations per year. Further, 15 adults of the second generation, hatched about the middle of August, were placed in a screen cage over growing bean plants in the field. Careful observation failed to show any tendency toward copulation on the part of these individuals, nor were any eggs found at any time after in the cage. By the middle of October the vines were dead and two males and six females were still alive. By November 1 they had crawled down under the leaves in the cage to hibernate. Evidently there is no third generation. Dr. C. P. Gillette, in Colorado Agricultural Experiment Station Bulletin No. 19, 1892, reports only one generation in a year in that region.

The following approximate outline of the life history may be given for the Mesilla Valley, New Mexico, region:

1. Hibernated adults lay eggs from June 15 to August 1.

2. First-brood larvae found from June 19 to August 23.
3. First-brood pupae found from July 5 to August 28.
4. First-brood adults found from July 10 throughout the season. Some may hibernate.
5. Second-brood eggs found from July 16 to end of season.
6. Second-brood larvae found from July 20 to end of season.
7. Second-brood pupae found from August 5 to end of season.
8. Second-brood adults found from August 10—Hibernate.. May live a year or even slightly more.

This outline may be shown in schematic form as below. It will be seen in the scheme that there is a period between July 20 and August 23 when the two broods of larvae overlap. Reference to Table I shows again that this is the time for maximum injury from this species.

SCHEME I.—SHOWING OUTLINE OF LIFE HISTORY.

	January	February	March	April	May	June	July	August	September	October	November	December
1						15..	.....	...1				
2						19..	.....	..23				
3							5..	..28				
4							10.....		7 (?)			
5							16..	.....	.....7 (?)			
6							20..	.....	.....7 (?)			
7								5..	7 (?)			
8								8..	.....			

The figures in the left-hand column refer to the stages as numbered in outline above.

HISTORY AND DISTRIBUTION OF

Epilachna corrupta Muls.

The records of the bean beetle as a pest in New Mexico date far back. In *Insect Life*, 1889, Mr. J. F. Wielandy is quoted in a letter written from Springer, N. M., July 30, as follow: "Mr. William Kronig says he has known it (the bean beetle) for 40 years previous and it was just as bad then as now." That would take the record back to 1849. Mr. Kronig lived at Watrous, N. M., at the time. In *New Mexico Agricultural Experiment Station Bulletin No. 15*, p.13, 1895, Prof. T. D. A. Cockerell stated he took this species on beans at Santa Fe, N. M., July 5. In Bul. 21 from this Station a note from the San Juan County Sub-Station reported damage from this species in 1897.

It is present practically all over the State, ranging in vertical distribution from 3000 ft. to 7000 ft. As previously noted, this species was first described from Mexico in 1851. Professor Wickham concludes Mexico "is the home of the species, no doubt."

Answers to a questionnaire sent to states in the southern half of the United States and some farther north, give the following information as to the distribution of this species in the United States.

It is reported definitely in only five states: Arizona, Colorado, New Mexico, Texas, and Utah. In "*Injurious and Beneficial Insects of California*," Supplement to the *Monthly Bulletin of the California Horticultural Commission*, 1915, on page 219, *Epilachna corrupta* "is said to have been found in California." Mr. E. C. Van Dyke, Taxonomist of the California Agricultural Experiment Station, reported "it might possibly be established in the Imperial Valley," but there were no records. Dr. Morrill gives no records from that region of Arizona adjacent to this part of California.

Prof. J. W. Scott, University of Wyoming, reported an interesting item as follows: "No record in Wyoming.... It is possible, of course, for this insect to be present in Wyoming

without our having record of it—In our collection are specimens marked 'Epilachna corrupta, Fort Collins, 1890.' Fort Collins, Colorado, is 67 miles from here (Laramie) and about 2000 ft. lower. . . . Elevation of Laramie is 7100 ft."

In Colorado, Dr. C. P. Gillette, State Entomologist, reported it as "abundant in the foothill regions." Prof. Wickham gives the following locality records from his collection from Colorado: Colorado Springs, Fort Collins, Denver, Trinidad, Durango. He further furnished this note of records in this State: "Boulder, Golden, Buena Vista—Nat. Hist. Bul. State University of Iowa, V., p. 256, 1902."

Dr. A. W. Morrill, State Entomologist of Arizona, in Jour. Econ. Entomology, Vol. 6, No. 2, p. 193, recorded it as "observed or authoritatively reported from Thatcher, Clifton, McNeil, Prescott and Taylor, representing elevations from 2500 to 5500 ft. It is unknown in the Salt River Valley." The writer observed it in 1916 at Clifton and Safford, Arizona.

Mr. F. B. Paddock, State Entomologist of Texas, reported no records from the region about College Station. However, the writer has seen this species occurring abundantly in the El Paso Valley. Prof. Wickham cites specimens in his collection from Alpine, Texas.

Dr. E. G. Titus, of Utah, reported no record as yet but thought it might possibly occur in the southern part of the State. Mr. M. H. Swenk, of the Nebraska Station, reported in the collection there, specimens labeled "Ogden, Utah," without date or collector label.

Dr. Leonard Haseman, Entomologist of the Missouri Station, reports: "I find in our permanent collection three specimens without locality labels but apparently pinned here in our laboratory."

The following States reported negatively as to the occurrence of this species: Alabama, Arkansas, Florida, Iowa, Kansas, Louisiana, Oklahoma, Nebraska, Nevada, and South Carolina.

ACKNOWLEDGMENTS.

The author takes this means of expressing his gratitude to all who helped make this bulletin possible. Especial acknowledgment of favors is due the Horticultural Department for assistance with the spraying and for the loan of the experimental bean plats for control work; to the County Agricultural Agents of New Mexico, who furnished certain data from their respective localities in regard to the bean beetle; to the County Agricultural Agent of El Paso County, Texas, Mr. A. G. Graham, for furnishing similar data from his county; to all the Entomologists, who, on request, so kindly furnished data from their States on the status of the bean beetle; to the Deming Company, Salem, Ohio, for the loan of the photograph from which Fig. IV was made; to Prof. H. F. Wickham, State University of Iowa, for data on the distribution and reference to the original description of *Epilachna corrupta* Muls.

PRESERVATION REVIEW

11/04 _____

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