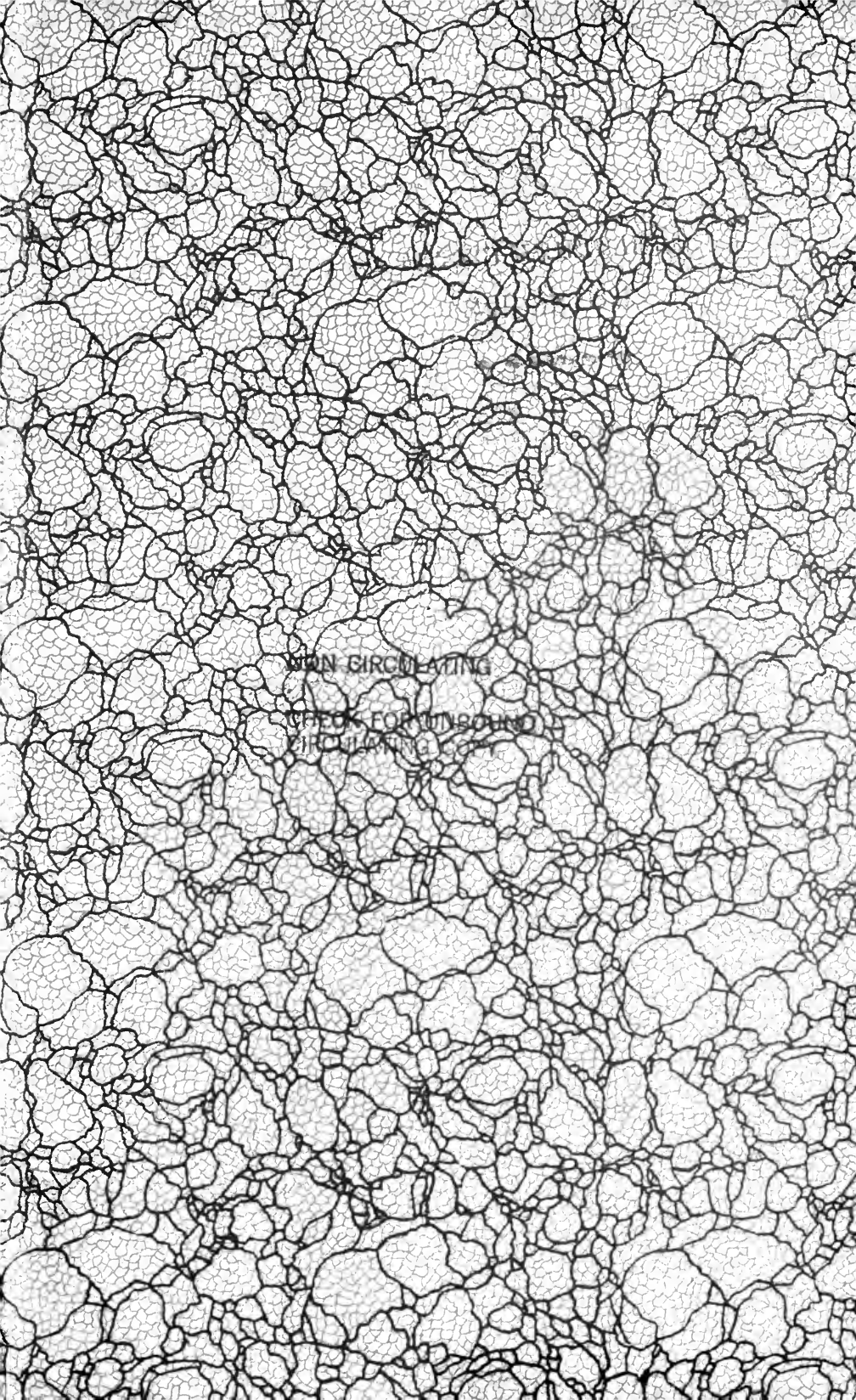
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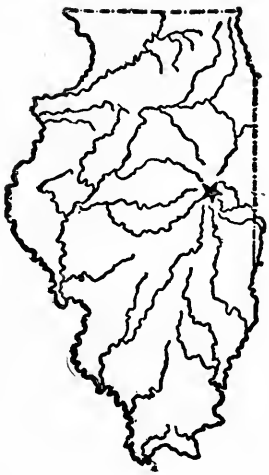
UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

BULLETIN No. 209

FERTILIZING CONSTITUENTS EXCRETED BY TWO-YEAR-OLD STEERS

By H. S. GRINDLEY, H. W. MUMFORD, A. D. EMMETT, AND SLEETER BULL



URBANA, ILLINOIS, JUNE, 1918

Contents of Bulletin No. 209

FERTILIZING CONSTITUENTS EXCRETED BY TWO-YEAR-OLD STEERS

By H. S. GRINDLEY, H. W. MUMFORD, A. D. EMMETT, AND SLEETER BULL[1]

This bulletin is one of a series[2] reporting the findings of an investigation in regard to the effect of variations in the character and amount of feed consumed upon the nutrition of steers. It gives the results relating to the fertilizing constituents of the excreta, including (1) the amounts of nitrogen, phosphorus, and organic matter excreted, (2) the manner of excretion, i. e., whether via the feces or the urine, and (3) the commercial value of the fertilizing elements of the excreta.

Inasmuch as no bedding was used in this experiment, its fertilizing value is not considered in the general discussion of the results. It should be borne in mind, however, that ordinary bedding, such as straw, does contain considerable fertilizing value which should be added to the commercial value of the excreta proper. For a discussion of the manurial value of bedding the reader is referred to other sources.[3]

THE EXPERIMENT

The Animals.—The animals used were eight two-year-old high-grade Hereford steers, grading as choice feeders and weighing from 800 to 1,000 pounds. These animals were selected from the same herd. From birth to the time of purchase they had been treated very much alike. During a period of about two months preliminary to the experiment they were kept in paved lots with access to open sheds, and during the experiment proper, which lasted from May 27, 1908, to February 10, 1909, a period of thirty-seven weeks, they were kept in digestion and metabolism stalls.

Rations and Feeds.—During the first month of the period preliminary to the experiment the ration consisted of corn silage, clover hay, and alfalfa hay. At the beginning of the second month ground corn was added to the ration, and the feeding of alfalfa was discontinued. Four days later the feeding of corn silage was discontinued.

[1]The authors take pleasure in acknowledging their great indebtedness to Professors L. D. Hall and H. O. Allison for their generous and helpful cooperation and assistance in the planning and conducting of this investigation.

[2]See Ill. Agr. Exp. Sta. Buls. 172 and 197.

[3]Hopkins: Soil Fertility and Permanent Agriculture, p. 541, *et seq.* Van Slyke: Fertilizers and Crops, p. 301, *et seq.*

During the first twenty-two weeks of the experiment proper the ration consisted of clover hay and ground corn, and during the last fifteen weeks, of clover hay, ground corn, and linseed oil meal. Half an ounce of salt, given daily, was taken very consistently by all of the steers. Water also was given twice daily, and an exact record was kept of the amounts drunk.

To determine the effect of variations in the proportions of roughage to concentrates in the ration, and the effect of the introduction of linseed oil meal into the ration, the experiment was divided into five experimental periods. During the first experimental period the ration consisted of clover hay and ground corn in equal amounts by weight; during the second, of one part of clover hay and three parts of ground corn; during the third, of one part of clover hay and five parts of ground corn; and during the fourth and fifth, of one part of clover hay, four parts of ground corn, and one part of linseed oil meal. Thus the proportion of concentrates was gradually increased up to the third experimental period, and then maintained constant to the end of the experiment. These changes are comparable to the changes often made in the proportions of roughage and concentrates in ordinary feeding practice. The first experimental period was five weeks in length; the second, third, and fourth, each six weeks in length; and the fifth, four weeks in length. The changes in the ration made from one test period to another were effected very gradually in transitional periods one of which immediately followed each experimental period. The first and third transitional periods were two weeks in length; and the second and fourth, three weeks in length.

TABLE 1.—DIVISION OF EXPERIMENT INTO PERIODS, AND RATIOS OF HAY, CORN AND LINSEED MEAL IN RATIONS

Experimental period	Experimental weeks	Number of weeks in period	Ratio of hay to corn to linseed meal
1	1–5	5	1:1:0
2	8–13	6	1:3:0
3	17–22	6	1:5:0
4	25–30	6	1:4:1
5	34–37	4	1:4:1

To determine the effect of variations in the amount of feed consumed, the eight steers were divided into four lots of two animals each, and each lot was given thruout the experiment an amount of feed different from that received by the other lots. The lots were as similar as possible in regard to age, condition, and breeding. One lot was given just enough feed to maintain the weights of the steers about constant; another, as much as the steers would eat readily; another, an amount of feed equal to the maintenance ration plus one-third of the difference between the maintenance and the full-feed rations; and another, an amount equal to the maintenance ration plus two-thirds

of the difference between the maintenance and full-feed rations. Beginning with the 31st week, one steer each from the maintenance, the one-third, and the two-thirds feed lots was gradually put on a full-feed ration and continued thus until the end of the experiment.

The average daily gains of the different lots during the thirty-seven weeks of the experiment were as follows: maintenance lot, 0.76 pound; one-third-feed lot, 1.28 pounds; two-thirds-feed lot, 1.76 pounds; and full-feed lot, 2.05 pounds.

Equipment and Methods.—For a detailed description of the equipment and methods used in this investigation, see Bulletin 172 of this station. In this connection, it will be sufficient to state briefly the essentials of the procedure. The feeds were thoroly mixed, analyzed, and weighed out to each steer. The refused feeds, or orts, were also weighed, mixed, and analyzed. From the data so obtained, the quantities of organic matter, nitrogen, and phosphorus consumed by each steer were calculated. The feces were weighed, mixed, and analyzed, and the quantities of organic matter, nitrogen, and phosphorus excreted via the intestines were calculated. The urine was weighed, mixed, and analyzed, and the quantities of nitrogen and phosphorus excreted thru the kidneys were calculated. The details of the methods used in the collection and sampling of the urine are given below since they were not reported in Bulletin 172.

Collection and Sampling of Urine.—The weighing of the urine was done at the end of the experimental day. After the total weight of this twenty-four hour sample was obtained, the urine was stirred thoroly and one-fourth of the total amount was weighed off for the daily sample. The urine sample was transferred to a dry, thymolized bottle, provided with a cork stopper. The acidity or alkalinity of the urine to litmus was ascertained at the time of the sampling each day. The samples of urine and feces were taken to cold storage rooms and kept until the end of the experimental week.

The samples of the urine were composited weekly. In doing this, the seven daily fractions for each steer were transferred to a large pail and stirred thoroly until well mixed. Then two liters of the composite sample was strained thru a 40-mesh sieve into a thymolized bottle. In this way hair or foreign matter that might be present was removed, but the normal sediment passed thru. The alkalinity or acidity of the composite samples, the color of the urines, the comparative amount of sediment, and the specific gravity, with the temperature, were all recorded. The samples were then ready for chemical examination.

Methods of Analysis.—The methods of analysis used in this experiment were essentially the same as the official methods given in the revised edition for 1908 of Bulletin 107 of the Bureau of Chemistry, United States Department of Agriculture. The total carbohydrates were determined by difference. No determinations were made of the crude fiber.

AMOUNTS AND COMPOSITION OF FEEDS CONSUMED

The total amounts of feeds consumed by each animal per period are given in Table 2; the average amounts of feeds consumed daily per steer per period are given in Table 3; and Table 4 shows the average chemical composition of the feeds. For a more complete discussion of the feed consumption and composition, the reader is referred to Bulletin 197 of this station.

TABLE 2.—TOTAL FEED CONSUMED PER PERIOD
(Results expressed in pounds)

Period	Weeks	Ratio of hay to corn to linseed meal	Clover hay	Ground corn	Linseed meal	Clover hay	Ground corn	Linseed meal
			Maintenance Lot					
			Steer 650			Steer 656		
1	1–5	1:1:0	192.6	192.6	....	192.6	192.6	....
2	8–13	1:3:0	95.8	287.3	....	95.6	286.8	....
3	17–22	1:5:0	58.8	294.0	....	58.8	294.0	....
4	25–30	1:4:1	58.2	233.0	58.2	58.2	233.0	58.2
5[3]	34–37	1:4:1	81.7	326.9	81.7	37.0	147.8	37.0
Total[4]	1–37	....	627.4	1791.6	184.7	577.4	1589.5	133.3
			One-Third-Feed Lot					
			Steer 666			Steer 669		
1	1–5	1:1:0	270.0	270.0	....	277.9	277.9	....
2	8–13	1:3:0	153.4	460.3	....	160.0	479.8	....
3	17–22	1:5:0	88.5	442.4	....	96.0	480.2	....
4	25–30	1:4:1	84.0	336.0	84.0	90.7	362.9	90.7
5[3]	34–37	1:4:1	88.6	354.4	88.6	60.5	241.9	60.5
Total[4]	1–37	....	890.7	2537.3	236.3	901.8	2549.9	214.3
			Two-Thirds-Feed Lot					
			Steer 652[1]			Steer 665		
1	1–5	1:1:0	348.9	348.9	....	362.8	362.8	....
2	8–13	1:3:0	210.1	630.4	....	224.7	674.3	....
3	17–22	1:5:0	119.3	596.4	....	134.4	672.0	....
4	25–30	1:4:1	109.8	439.0	109.8	123.2	492.8	123.2
5[3]	34–37	1:4:1	21.5	86.1	21.5	84.0	336.0	84.0
Total[4]	1–37	.....	1079.6	2981.3	211.1	1221.7	3503.1	294.4
			Full-Feed Lot					
			Steer 663[2]			Steer 661		
1	1–5	1:1:0	408.4	408.4	.....	444.1	444.1	.....
2	8–13	1:3:0	241.3	723.9	.....	283.6	851.0	.....
3	17–22	1:5:0	128.5	642.6	.....	144.8	724.2	.....
4	25–30	1:4:1	118.2	472.8	118.2	155.7	622.7	155.7
5	34–37	1:4:1	.....	.....	.....	105.2	420.8	105.2
Total[4]	1–37	.....	1144.1	3002.2	145.2	1496.6	4252.3	372.3

[1]Removed at end of 34th week. [2]Removed at end of 30th week.
[3]Steers 650, 666, and 652 were on full feed in this period.
[4]Includes feeds for transitional periods.

TABLE 3.—AVERAGE FEED CONSUMED DAILY
(Results expressed in pounds)

Period	Weeks	Ratio of hay to corn to linseed meal	Clover hay	Ground corn	Linseed meal	Clover hay	Ground corn	Linseed meal
			Maintenance Lot					
			Steer 650			Steer 656		
1	1–5	1:1:0	5.50	5.50	....	5.50	5.50	....
2	8–13	1:3:0	2.28	6.84	....	2.28	6.83	....
3	17–22	1:5:0	1.40	7.00	....	1.40	7.00	....
4	25–30	1:4:1	1.39	5.55	1.39	1.39	5.55	1.39
5[3]	34–37	1:4:1	2.92	11.67	2.92	1.32	5.28	1.32
			One-Third-Feed Lot					
			Steer 666			Steer 669		
1	1–5	1:1:0	7.71	7.71	....	7.94	7.94	....
2	8–13	1:3:0	3.65	10.96	....	3.81	11.42	....
3	17–22	1:5:0	2.11	10.53	....	2.29	11.43	....
4	25–30	1:4:1	2.00	8.00	2.00	2.16	8.64	2.16
5[3]	34–37	1:4:1	3.16	12.66	3.16	2.16	8.64	2.16
			Two-Thirds-Feed Lot					
			Steer 652[1]			Steer 665		
1	1–5	1:1:0	9.97	9.97	....	10.37	10.37	....
2	18–13	1:3:0	5.00	15.01	....	5.35	16.06	....
3	17–22	1:5:0	2.84	14.20	....	3.20	16.00	....
4	25–30	1:4:1	2.61	10.45	2.61	2.93	11.73	2.93
5[3]	34–37	1:4:1	3.07	12.29	3.07	3.00	12.00	3 00
			Full-Feed Lot					
			Steer 663[2]			Steer 661		
1	1–5	1:1:0	11.67	11.67	....	12.69	12.69	....
2	8–13	1:3:0	5.75	17.24	....	6.75	20.26	....
3	17–22	1:5:0	3.06	15.30	....	3.45	17.24	....
4	25–30	1:4:1	2.81	11.26	2.81	3.71	14.83	3.71
5	34–37	1:4:1	....	....	....	3.76	15.03	3.76

[1]Removed at end of 34th week. [2]Removed at end of 30th week.
[3]Steers 650, 666, and 652 were on full feed in this period.

TABLE 4.—AVERAGE COMPOSITION OF FEEDS
(Results expressed in percent of fresh substance)

Feed	Dry substance	Organic matter	Crude protein (N x 6.25)	Total carbohydrates	Fat (ether extract)	Ash	Total nitrogen	Phosphorus
Ground corn..	87.09	85.82	7.69	74.21	3.93	1.27	1.230	0.263
Linseed meal..	90.74	85.32	34.80	43.72	6.79	5.42	5.564	0.869
Clover hay....	88.46	83.07	10.97	69.75	2.36	5.39	1.756	0.153

AMOUNTS AND COMPOSITION OF FECES

As would be expected, the amounts of feces excreted depended roughly upon the amount of the ration consumed and upon the proportion of roughage in the ration (see Tables 5 and 6). However, there was considerable variation in the amounts excreted by the steers of the same lot in the same period.

TABLE 5.—TOTAL FECES EXCRETED PER PERIOD
(Results expressed in pounds)

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot		One-Third-Feed Lot	
			Steer 650	Steer 656	Steer 666	Steer 669
1	1–5	1:1:0	721.45	623.25	966.05	1284.15
2	8–13	1:3:0	457.02	468.78	848.28	927.66
3	17–22	1:5:0	344.52	372.36	559.32	644.04
4	25–30	1:4:1	284.40	336.96	515.76	581.40
5[5]	34–37	1:4:1	555.36	227.14	757.37	373.49
Total[4]	1–37	....	3066.19	2713.39	4868.95	5155.09
			Two-Thirds-Feed Lot		Full-Feed Lot	
			Steer 652[1]	Steer 665	Steer 663[2]	Steer 661
1	1–5	1:1:0	1599.95	1583.45	1824.25[3]	2156.25
2	8–13	1:3:0	1306.38	1448.76	1469.16	2240.64
3	17–22	1:5:0	823.02	1063.92	918.66	1323.24
4	25–30	1:4:1	802.32	872.88	698.82	1177.74
5[5]	34–37	1:4:1	155.17	603.78	.....	802.05
Total[4]	1–37	.....	6473.49	7545.01	6469.69	10538.34

[1]Removed at end of 34th week. [2]Removed at end of 30th week.
[3]Weeks 3, 4, and 5 only. [4]Includes transitional periods.
[5]Steers 650, 666, and 652 were on full feed in this period.

TABLE 6.—AVERAGE FECES EXCRETED PER WEEK
(Results expressed in pounds)

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot		One-Third-Feed Lot	
			Steer 650	Steer 656	Steer 666	Steer 669
1	1–5	1:1:0	144.29	124.65	193.21	256.83
2	8–13	1:3:0	76.17	78.13	141.38	154.61
3	17–22	1:5:0	57.42	62.06	93.22	107.34
4	25–30	1:4:1	47.40	60.66	85.96	96.90
5[5]	34–37	1:4:1	138.84	56.78	189.34	93.37
Average[4]	1–37	....	82.87	73.33	131.59	139.33
			Two-Thirds-Feed Lot		Full-Feed Lot	
			Steer 652[1]	Steer 665	Steer 663[2]	Steer 661
1	1–5	1:1:0	319.99	316.69	364.85[3]	431.25
2	8–13	1:3:0	217.73	241.46	244.86	373.44
3	17–22	1:5:0	137.17	177.32	153.11	220.54
4	25–30	1:4:1	133.72	145.48	116.47	196.29
5[5]	34–37	1:4:1	155.17	150.94	.....	200.51
Average[4]	1–37	....	190.40	203.92	231.0	284.82

[1]Removed at end of 34th week. [2]Removed at end of 30th week.
[3]Weeks 3, 4, and 5 only. [4]Includes transitional periods.
[5]Steers 650, 666, and 652 were on full feed in this period.

With respect to the percentages of water and organic matter in the feces, the individual steers of the different lots were quite similar in the same period (see Table 7). In the cases of nitrogen and phosphorus, the variations of the different steers in the same period were greater.

TABLE 7.—CHEMICAL COMPOSITION OF FECES
(Results expressed in percent of fresh substance)

Period	Weeks	Ratio of hay to corn to linseed meal	Water	Organic matter	Nitrogen	Phosphorus	Water	Organic matter	Nitrogen	Phosphorus
			Maintenance Lot							
			Steer 650				Steer 656			
1	1–5	1:1:0	85.32	13.42	0.478	0.110	83.82	14.87	0.488	0.101
2	8–13	1:3:0	83.14	15.40	0.586	0.189	84.77	14.08	0.537	0.101
3	17–22	1:5:0	80.53	17.85	0.643	0.232	82.52	16.31	0.596	0.088
4	25–30	1:4:1	78.66	19.20	0.755	0.339	82.11	16.63	0.620	0.098
5[3]	34–37	1:4:1	80.78	17.65	0.605	0.238	82.61	15.81	0.633	0.100
			One-Third Feed Lot							
			Steer 666				Steer 669			
1	1–5	1:1:0	84.66	14.10	0.458	0.101	86.12	12.76	0.384	0.088
2	8–13	1:3:0	82.75	15.82	0.476	0.157	82.68	16.01	0.434	0.142
3	17–22	1:5:0	79.17	19.28	0.585	0.213	81.51	16.94	0.537	0.209
4	25–30	1:4:1	80.77	17.47	0.676	0.265	80.26	17.94	0.630	0.294
5[3]	34–37	1:4:1	84.13	14.44	0.533	0.217	81.47	16.81	0.585	0.281
			Two-Thirds-Feed Lot							
			Steer 652[1]				Steer 665			
1	1–5	1:1:0	86.32	12.58	0.405	0.099	85.39	13.52	0.423	0.098
2	8–13	1:3:0	82.85	15.88	0.450	0.136	81.59	17.13	0.445	0.146
3	17–22	1:5:0	81.90	16.85	0.573	0.155	80.69	17.93	0.491	0.180
4	25–30	1:4:1	83.76	14.92	0.571	0.177	79.47	18.92	0.606	0.254
5[3]	34–37	1:4:1	83.85	15.21	0.540	0.215	80.69	17.72	0.582	0.240
			Full-Feed Lot							
			Steer 663[2]				Steer 661			
1	1–5	1:1:0	85.61	13.33	0.412	0.096	86.05	12.87	0.397	0.093
2	8–13	1:3:0	82.37	16.27	0.486	0.145	82.29	16.56	0.398	0.119
3	17–22	1:5:0	80.78	17.91	0.530	0.148	79.83	18.85	0.448	0.148
4	25–30	1:4:1	81.39	16.77	0.611	0.287	81.12	17.45	0.571	0.207
5	34–37	1:4:1	.....	.....	.....	.....	83.18	15.39	0.537	0.220

[1]Removed at end of 34th week. [2]Removed at end of 30th week.
[3]Steers 650, 666, and 652 were on full feed in this period.

TABLE 8.—AVERAGE CHEMICAL COMPOSITION OF FECES
(Results expressed in percent of fresh substance)

Period	Weeks	Ratio of hay to corn to linseed meal	Water	Organic matter	Nitrogen	Phosphorus
1	1–5	1:1:0	85.41	13.43	0.431	0.098
2	8–13	1:3:0	82.80	15.89	0.476	0.142
3	17–22	1:5:0	80.87	17.74	0.550	0.172
4	25–30	1:4:1	80.94	17.41	0.630	0.240
5	34–37	1:4:1	82.39	16.15	0.574	0.216

AMOUNTS AND COMPOSITION OF URINE

The weights of the urine excreted and the percentages of total nitrogen and phosphorus in the urine are given in Tables 9 to 12, inclusive. In the case of the phosphorus determination, the results obtained were none too satisfactory; which fact, along with the pressure of other duties, caused this work to be abandoned after the thirteenth week. The results, so far as determined, are given in Table 12. While not accurate, these results serve as an indication of the amounts of phosphorus present in the urine. The excretion of phosphorus in the urine was very small except in case of Steer 656, whose urine contained much more phosphorus than the urine of the other steers. Further mention is made of this fact later in the discussion.

TABLE 9.—TOTAL URINE EXCRETED PER PERIOD
(Results expressed in pounds)

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot		One-Third-Feed Lot	
			Steer 650	Steer 656	Steer 666	Steer 669
1	1–5	1:1:0	209.60	419.35	247.05	310.05
2	8–13	1:3:0	295.86	612.12	361.32	658.74
3	17–22	1:5:0	212.46	260.70	313.68	508.20
4	25–30	1:4:1	262.80	292.50	283.14	311.58
5[4]	34–37	1:4:1	207.27	172.66	258.25	201.64
Total[3]	1–37	....	1575.15	2366.48	1977.19	2782.09
			Two-Thirds-Feed Lot		Full-Feed Lot	
			Steer 652[1]	Steer 665	Steer 663[2]	Steer 661
1	1–5	1:1:0	375.80	327.45	400.70	438.70
2	8–13	1:3:0	567.24	323.82	501.84	604.86
3	17–22	1:5:0	730.68	315.60	255.72	412.62
4	25–30	1:4:1	588.66	481.44	522.30	680.10
5[4]	34–37	1:4:1	97.31	330.81	.....	419.13
Total[3]	1–37	....	3337.42	2428.27	2237.62	3422.98

[1]Removed at end of 34th week. [2]Removed at end of 30th week.
[3]Includes transitional periods.
[4]Steers 650, 666, and 652 were on full feed in this period.

TABLE 10.—AVERAGE URINE EXCRETED PER WEEK
(Results expressed in pounds)

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot		One-Third-Feed Lot	
			Steer 650	Steer 656	Steer 666	Steer 669
1	1–5	1:1:0	41.92	83.87	49.41	62.01
2	8–13	1:3:0	49.31	102.02	60.22	109.79
3	17–22	1:5:0	35.41	43.45	52.28	84.70
4	25–30	1:4:1	43.80	48.75	47.19	51.93
5[4]	34–37	1:4:1	51.82	43.16	64.56	50.41
Average[3]	1–37	....	42.57	63.96	53.44	75.19
			Two-Thirds-Feed Lot		Full-Feed Lot	
			Steer 652[1]	Steer 665	Steer 663[2]	Steer 661
1	1–5	1:1:0	75.16	65.49	80.14	87.74
2	8–13	1:3:0	94.54	53.97	83.64	100.81
3	17–22	1:5:0	121.78	52.60	42.62	68.77
4	25–30	1:4:1	98.11	80.24	87.05	113.35
5[4]	34–37	1:4:1	97.31	82.70	.....	104.78
Average[3]	1–37	....	98.16	65.63	74.59	92.51

[1]Removed at end of 34th week. [2]Removed at end of 30th week.
[3]Includes transitional periods.
[4]Steers 650, 666, and 652 were on full feed in this period.

TABLE 11.—TOTAL NITROGEN IN URINE PER PERIOD
(Expressed in percent of fresh urine)

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot		One-Third-Feed Lot	
			Steer 650	Steer 656	Steer 666	Steer 669
1	1–5	1:1:0	0.788	0.476	0.886	0.806
2	8–13	1:3:0	0.774	0.351	0.963	0.524
3	17–22	1:5:0	0.717	0.608	1.015	0.502
4	25–30	1:4:1	1.612	1.557	2.019	2.190
5[3]	34–37	1:4:1	2.389	1.815	2.473	2.412
			Two-Thirds-Feed Lot		Full-Feed Lot	
			Steer 652[1]	Steer 665	Steer 663[2]	Steer 661
1	1–5	1:1:0	0.730	0.847	0.745	0.735
2	8–13	1:3:0	0.707	1.266	0.937	0.820
3	17–22	1:5:0	0.416	1.282	1.379	0.965
4	25–30	1:4:1	1.283	1.774	1.855	1.507
5[3]	34–37	1:4:1	1.729	1.968	.....	1.893

[1]Removed at end of 34th week. [2]Removed at end of 30th week.
[3]Steers 650, 666, and 652 were on full feed in this period.

TABLE 12.—TOTAL PHOSPHORUS IN URINE PER PERIOD
(Results expressed in percent of fresh urine)

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot		One-Third-Feed Lot		Two-Thirds-Feed Lot		Full-Feed Lot	
			Steer 650	Steer 656	Steer 666	Steer 669	Steer 652	Steer 665	Steer 663	Steer 661
1	1–5	1:1:0	0.0030	0.0302	0.0034	0.0028	0.0026	0.0029	0.0025	0.0031
2	8–13	1:3:0	0.0034	0.0472	0.0036	0.0023	0.0026	0.0038	0.0030	0.0035

EXCRETION OF ORGANIC MATTER

The proportion of the organic matter of the ration which may be recovered in the manure is of especial importance to the live-stock farmer who is attempting to establish a permanent system of soil fertility. Decomposing or decomposed organic matter in the soil not only acts as a source of plant food, but it also helps to make available some of the insoluble mineral plant food, (e. g., raw rock phosphate). Also, the presence of organic matter favorably influences the physical condition of the soil.

An inspection of the data given in Tables 13 and 14 shows that, in general, the steers on the larger rations excreted a larger proportion of organic matter than the steers on the smaller rations. This was undoubtedly due to the fact that the digestibility of the dry substance and carbohydrates in Period 1, when the ration was composed of corn and clover hay in equal parts, varied inversely as the amounts of feeds consumed. Also in Period 2 there was an indication that the digestibility of the dry substance and carbohydrates varied inversely with the amounts of feeds consumed.[1] However, the differences in the percentages of organic matter excreted by the steers of the different lots during the same period were small and it seems justifiable to take an average of them. Such averages are shown in Table 27.

The percentage of organic matter excreted varied directly with the proportion of roughage in the ration, owing to the fact that the digestibility of the nutrients of the ration increased as the ratio of roughage to concentrates was varied from 1 to 1 to 1 to 5. From these results the following summary, relating to the percentage of organic matter recovered in the manure, can be made: In Period 1, an average of 33 percent of the organic matter consumed was recovered in the feces; in Period 2, 28 percent; in Period 3, 24 percent; in Period 4, 22 percent; in Period 5, 23 percent; and for the entire thirty-seven weeks of the experiment, 26 percent.

[1]Ill. Agr. Exp. Sta. Bul. 172.

From the data given in Table 15, it is apparent that in Periods 4 and 5 the amount of feed consumed had little influence upon the percentage of organic matter excreted. The data show further that when clover hay, ground corn, and linseed meal were fed in the proportions of 1 to 4 to 1, there was excreted in the manure from 22 to 31 percent (or an average of 27 percent) as much organic matter as was consumed in the *farm-grown* feeds.

In the case of the organic matter, the plant elaborates practically its entire content from the carbon dioxid of the air and of the water and other inorganic constituents of the soil, probably not drawing upon the organic matter of the soil to any appreciable extent. However, coincident with the elaboration of organic matter by the plant from the air and water, the organic matter of the soil is being broken down by natural agencies, such as the various chemical and biological actions which are taking place in the soil. That is, the organic matter of the soil is continuously being depleted, and this depletion apparently takes place whether the soil is fallow or producing a crop.

When farm products are fed to live stock on the farm rather than sold away from the farm, about one-fourth of the organic matter built up by the plant from the carbon dioxid of the air and the water and other inorganic constituents of the soil can be returned to the soil in some organic form, and the organic matter applied in the form of manure may therefore be looked upon as clear gain over a system of farming in which all the products of the soil are sold directly from the farm. If one assumes that a considerable part of the stover, straw, etc., is also returned to the soil, as is usually the case in live-stock farming, the proportion of the organic matter of the crop which can be returned to the soil may be increased to as much as one-half or two-thirds. The results of this experiment, as well as actual good farming practice, indicate that the destruction of organic matter is not a serious proposition in live-stock farming.

It is also of interest to compare the amount of organic matter returned to the farm when the corn and clover are fed to two-year-old beef cattle, with the amount returned by a system of farming where the corn is sold and the clover is turned under as a green manure. Referring again to Table 14, it is seen in the case of the maintenance lot, that in all periods except Periods 1 and 2 more organic matter could have been returned to the soil by feeding the corn and clover than would have been returned to the soil if the corn had been sold and the clover turned under as green manure. An average of the results for the eight steers shows that in Period 1, 68.16 percent as much organic matter was recovered in the manure as was consumed in the clover hay; in Period 2, 113.96 percent; in Period 3, 146.80 percent; in Period 4, 136.38 percent; and in Period 5, 137.11 percent.

In the entire experiment there was 108.18 percent as much organic matter in the manure as would have been returned to the farm by plowing under the clover and selling off the corn.

In this connection it may be noted that in good rotations in the corn belt where two crops of corn are secured in a four- or five-year rotation (e. g., corn, corn, oats, and clover; or corn, corn, oats, clover, and wheat), corn and clover hay are produced in approximately the ratio of 1.5 to 2 parts of corn by weight, to 1 part of clover hay—a ratio not greatly different from the proportions in which these feeds were used in Periods 1 and 2. In a three-year rotation (e. g., corn, oats, and clover), corn and clover are produced in about equal amounts, or in the same proportions as these feeds were used in Period 1. Thus it is seen that in either the four- or five-year rotation noted above, as much or more organic matter could be returned to the soil by feeding the corn and clover as would be returned if the corn were sold and the clover turned under. In the three-year rotation noted above, about two-thirds as much organic matter could be returned by feeding the corn and clover as by selling the corn and plowing under the clover.

Of course the results of Periods 3, 4, and 5 are of little practical value in this connection, unless the feeder purchases corn in addition to the amount produced on the farm or feeds a part of his clover hay to other farm animals. Purchased feeds may add to the organic matter, but only at the expense of the fertility of some other farm. Consequently organic matter may be added in this manner to only a limited extent.

TABLE 13.—CONSUMPTION AND EXCRETION OF ORGANIC MATTER
(Results expressed in pounds per period)

Period	Weeks	Ratio of hay to corn to linseed meal	Total organic matter consumed	Organic matter consumed from clover hay	Total organic matter excreted in feces	Total organic matter consumed	Organic matter consumed from clover hay	Total organic matter excreted in feces
			Maintenance Lot					
			Steer 650			Steer 656		
1	1–5	1:1:0	323.03	157.43	96.64	323.01	157.43	92.74
2	8–13	1:3:0	324.18	79.10	70.26	323.71	78.94	64.96
3	17–22	1:5:0	303.32	50.06	61.43	303.32	50.06	60.57
4	25–30	1:4:1	298.23	47.76	54.60	297.13	47.76	60.36
5[1]	34–37	1:4:1	411.39	68.68	97.77	184.57	31.10	35.95
Total[3]	1–37	....	2205.67	521.18	495.98	1948.44	479.65	421.60
			One-Third-Feed Lot					
			Steer 666			Steer 669		
1	1–5	1:1:0	452.75	220.70	135.41	465.84	227.16	164.44
2	8–13	1:3:0	519.46	126.66	134.19	541.62	132.11	148.33
3	17–22	1:5:0	456.37	75.35	107.70	495.24	81.73	109.00
4	25–30	1:4:1	430.14	68.94	89.86	464.54	74.44	106.05
5[1]	34–37	1:4:1	447.24	74.48	109.28	305.33	50.86	64.99
Total[3]	1–37	....[4]	3162.07	739.90	769.24	3110.33	749.13	806.15
			Two-Thirds-Feed Lot					
			Steer 652[1]			Steer 665		
1	1–5	1:1:0	585.09	285.19	200.69	608.57	296.55	213.65
2	8–13	1:3:0	711.03	173.48	207.27	760.92	185.53	230.77
3	17–22	1:5:0	610.19	101.57	138.60	692.42	114.43	189.91
4	25–30	1:4:1	563.02	90.11	119.01	630.89	101.11	165.11
5[1]	34–37	1:4:1	109.82	18.07	23.59	424.08	70.61	111.11
Total[3]	1–37	....	3623.24	896.82	948.92	4258.87	1014.87	1243.57
			Full-Feed Lot					
			Steer 663[2]			Steer 661		
1	1–5	1:1:0	688.39	333.83	241.66	744.71	363.01	277.51
2	8–13	1:3:0	818.39	199.24	238.27	962.34	234.17	372.06
3	17–22	1:5:0	664.65	109.40	164.14	748.97	123.28	248.92
4	25–30	1:4:1	606.73	97.01	117.49	797.15	127.78	205.77
5	34–37	1:4:1	.....	.....	.....	546.16	88.43	123.26
Total[3]	1–37	....	3651.55	950.40	1014.45	5212.46	1243.23	1686.91

[1]Removed at end of 34th week. [2]Removed at end of 30th week.
[3]Includes transitional periods.
[4]Steers 650, 666, and 652 were on full feed in this period.

TABLE 14.—EXCRETION OF ORGANIC MATTER

(Results expressed in percent of total organic matter consumed and in percent of organic matter of hay)

Period	Weeks	Ratio of hay to corn to linseed meal	Percent of total organic matter excreted in feces	Percent of organic matter of clover hay excreted in feces	Percent of total organic matter excreted in feces	Percent of organic matter of clover hay excreted in feces
			Maintenance Lot			
			Steer 650		Steer 656	
1	1–5	1:1:0	29.92	61.39	28.71	58.91
2	8–13	1:3:0	21.67	88.82	20.38	82.29
3	17–22	1:5:0	20.25	122.71	19.97	120.99
4	25–30	1:4:1	18.31	114.32	20.31	126.38
5[1]	34–37	1:4:1	23.77	142.36	19.48	115.59
Total[3]	1–37	....	22.49	95.16	21.64	87.90
			One-Third-Feed Lot			
			Steer 666		Steer 669	
1	1–5	1:1:0	29.91	61.35	35.30	72.39
2	8–13	1:3:0	25.83	105.95	27.39	112.28
3	17–22	1:5:0	23.60	142.93	22.01	133.37
4	25–30	1:4:1	20.89	130.35	22.83	142.46
5[1]	34–37	1:4:1	24.43	146.72	21.29	127.78
Total[3]	1–37	....	24.33	103.97	25.92	107.61
			Two-Thirds-Feed Lot			
			Steer 652[1]		Steer 665	
1	1–5	1:1:0	34.30	70.37	35.11	72.05
2	8–13	1:3:0	29.75	119.48	30.33	124.38
3	17–22	1:5:0	22.71	136.46	27.43	165.96
4	25–30	1:4:1	21 14	132.07	26.17	163.30
5[1]	34–37	1:4:1	21.48	130.55	26.20	157.36
Total[3]	1–37	....	26.19	105.81	29.20	122.53
			Full-Feed Lot			
			Steer 663[2]		Steer 661	
1	1–5	1:1:0	35.11	72.39	37.27	76.45
2	8–13	1:3:0	29.11	119.59	38.66	158.88
3	17–22	1:5:0	24.70	150.04	33.24	201.91
4	25–30	1:4:1	19.36	121.11	25.81	161.03
5	34–37	1:4:1	.....	.....	22.57	139.39
Total[3]	1–37	....	27.78	106.74	32.36	135.69

[1]Removed at end of 34th week. [2]Removed at end of 30th week.

[3]Includes transitional periods.

[4]Steers 650, 666, and 652 were on full feed in this period.

TABLE 15.—ORGANIC MATTER CONSUMED FROM FARM-GROWN FEEDS AND ORGANIC MATTER EXCRETED IN THE FECES

(Results expressed in pounds and in percent per period)

Period	Organic matter consumed from farm-grown feeds	Total organic matter excreted in feces	Percent excreted in feces[1]	Organic matter consumed from farm-grown feeds	Total organic matter excreted in feces	Percent excreted in feces[1]
Maintenance Lot						
	Steer 650			Steer 656		
	lbs.	*lbs.*	*percent*	*lbs.*	*lbs.*	*percent*
4	248.57	54.60	21.97	247.47	60.36	24.39
5[2]	341.68	97.77	28.61	153.00	35.95	23.50
One-Third-Feed Lot						
	Steer 666			Steer 669		
4	358.47	89.86	25.07	387.15	106.05	27.39
5[2]	371.65	109.28	29.40	253.71	64.99	25.62
Two-Thirds-Feed Lot						
	Steer 652[3]			Steer 665		
4	469.34	119.01	25.36	525.78	165.11	31.40
5[2]	91.48	23.59	25.79	352.41	111.11	31.53
Full-Feed Lot						
	Steer 663[4]			Steer 661		
4	505.88	117.49	24.22	664.31	205.77	30.97
5	.....	.....	.....	456.40	123.26	27.01

[1]This column expresses the total organic matter excreted in percentage of the organic matter consumed from the farm-grown feeds of the ration.

[2]Steers 650, 666, and 652 were on full feed in this period.

[3]Removed at end of 34th week. [4]Removed at end of 30th week.

EXCRETION OF NITROGEN

Inasmuch as nitrogen is one of the essential fertilizing elements in which the soil is often deficient, and as the ordinary farm ration usually contains a considerable amount of this element, largely in the form of proteins and their derivatives, it is not only of scientific interest but also of practical importance to study the amounts of nitrogen excreted by farm animals and the manner in which it is excreted.

All animals require the element nitrogen. However, an animal cannot utilize free nitrogen as it exists in the air, nor nitrogen in inorganic forms. As a matter of fact, the animal organism utilizes nitrogen only when it is in organic combination in the form of complex substances known as proteins, and to some extent in the form of the derivatives of the proteins. Thus in practice the proteins must be supplied in the food. However, before the food proteins can be utilized by the animal as a source of nitrogen, they must undergo digestion, a process by which the digestive agents change into forms which are soluble, diffusible, and available to the tissues, such portions

of the feed as are capable of such changes in the digestive tract. Thus only a part of the nitrogen of the food is digested and absorbed. The other part, including various excretory substances from the body, usually amounts to from 25 to 75 percent of the total nitrogen of the food, and is excreted in the feces. The nitrogen of the feces may be used as plant food.

The animal organism requires a certain amount of nitrogen in the form of proteins (or their derivatives) for the repair and growth of the protein tissues of the body. The protein tissues are continually undergoing a breaking-down process, with the elimination of the nitrogen of the protein molecule thru the urine. This broken-down tissue must be replaced by the digested proteins from the food. Also, in the growing animal, there is an actual increase in the amount of protein tissue.

In the young animal the demands of the body for nitrogen for growth are considerable, while in the older animal they are quite small, being reduced to practically nothing in the mature animal. In the pregnant animal, a small amount of nitrogen is essential for the development of the fetus, while later, a considerable amount is essential for milk production. After all these demands of the body have been satisfied, any surplus of protein digestion products which remains may be oxidized for the energy which it contains, or it probably may be changed to fat and stored as such in the body. In either case, the nitrogen of the protein digestion products is split off and is excreted in the urine. Thus, the urine contains nitrogen from two sources: viz., (1) from the tissue protein which is broken down in the functioning of the body; and (2) from any surplus of digested protein which may remain after the demands of the body for nitrogen have been satisfied. The amount of nitrogen from the first source is practically constant, while the amount from the second source may be quite variable, depending especially upon the amount of nitrogen consumed by the animal.

Thus it is evident that the amount of nitrogen excreted, and the manner by which it is excreted by the animal may be quite variable, depending upon a number of important factors, among which may be enumerated the following: (1) The amount of protein in the ration; of course the more protein there is in the ration, the more nitrogen there will be excreted, other things being equal. (2) The digestibility of the protein; there will be more nitrogen excreted from a ration containing less digestible feeds, other things being equal. (3) The age of the animal; an older animal will require less protein for growth and, consequently, there will be a larger surplus, the nitrogen of which will be excreted. (4) The condition of the animal as regards pregnancy; a pregnant animal will utilize somewhat more of the protein of the food, leaving less nitrogen to be excreted. (5) The

condition of the animal as regards milk production; a milk-producing animal will utilize more of the protein of the food, leaving less nitrogen to be excreted. Consequently, in applying the results of this or any similar experiment to other conditions, these factors should all be carefully considered.

Referring to the data given in Table 17, it may be seen that the amounts of feeds consumed apparently had but little effect upon the

TABLE 16.—CONSUMPTION AND EXCRETION OF NITROGEN
(Results expressed in pounds per period)

Period	Weeks	Ratio of hay to corn to linseed meal	Total nitrogen consumed	Nitrogen consumed in hay	Nitrogen excreted			Total nitrogen consumed	Nitrogen consumed in hay	Nitrogen excreted		
					In feces	In urine	Total			In feces	In urine	Total
			Maintenance Lot									
			Steer 650					Steer 656				
1	1–5	1:1:0	6.10	3.81	3.45	1.68	5.13	6.10	3.81	3.03	1.95	4.98
2	8–13	1:3:0	5.20	1.73	2.66	1.90	4.57	5.20	1.73	2.51	2.00	4.52
3	17–22	1:5:0	4.60	1.02	2.21	1.76	3.98	4.60	1.02	2.21	1.70	3.92
4	25–30	1:4:1	7.25	0.93	2.15	4.25	6.40	7.25	0.93	2.25	4.52	6.77
5[4]	34–37	1:4:1	10.24	1.40	3.35	4.96	8.31	4.63	0.63	1.44	3.11	4.56
Total[3]	1–37	....	44.10	11.04	18.05	19.51	37.56	37.72	10.16	15.35	18.13	33.48
			One-Third-Feed Lot									
			Steer 666					Steer 669				
1	1–5	1:1:0	8.55	5.35	4.42	2.16	6.58	8.80	5.50	4.91	2.46	7.37
2	8–13	1:3:0	8.33	2.78	4.03	3.28	7.31	8.69	2.90	4.03	3.32	7.34
3	17–22	1:5:0	6.92	1.53	3.27	2.87	6.14	7.51	1.66	3.39	3.31	6.70
4	25–30	1:4:1	10.41	1.34	3.48	5.29	8.77	11.30	1.44	3.66	6.80	10.46
5[4]	34–37	1:4:1	11.10	1.52	4.03	6.38	10.41	7.58	1.03	2.26	4.86	7.12
Total[3]	1–37	....	60.99	15.68	25.65	27.24	52.89	60.03	15.87	24.63	28.69	53.33
			Two-Thirds-Feed Lot									
			Steer 652[1]					Steer 665				
1	1–5	1:1:0	11.05	6.91	6.45	2.66	9.10	11.49	7.18	6.68	2.76	9.44
2	8–13	1:3:0	11.42	3.80	5.87	3.85	9.72	12.20	4.07	6.00	4.06	10.06
3	17–22	1:5:0	9.32	2.06	4.72	3.41	8.13	10.49	2.33	5.21	3.99	9.20
4	25–30	1:4:1	13.67	1.75	4.54	7.55	12.09	15.34	1.96	5.29	8.52	13.82
5[4]	34–37	1:4:1	2.73	0.37	0.84	1.68	2.52	10.53	1.44	3.65	6.50	10.15
Total[3]	1–37	....	68.40	19.00	30.93	28.44	59 37	82.10	21.50	56.71	35.57	72.28
			Full-Feed Lot									
			Steer 663[2]					Steer 661				
1	1–5	1:1:0	12.96	8.09	7.46	2.91	10.37	14.15	8.79	8.62	3.22	11.84
2	8–13	1:3:0	13.16	4.37	7.09	4.61	11.69	15.43	5.13	8.89	4.78	13.67
3	17–22	1:5:0	10.07	2.22	4.84	3.42	8.26	11.29	2.51	5.89	3.89	9.78
4	25–30	1:4:1	14.61	1.88	4.28	9.70	13.98	19.39	2.48	6.72	10.18	16.89
5	34–37	1:4:1	.....	....	....	....	....	13.31	1.80	4.31	7.93	12.24
Total[3]	1–37	....	65.73	20.14	30.97	26.44	57.41	101.07	26.34	47.01	41.49	88.50

[1]Removed at end of 34th week. [2]Removed at end of 30th week.
[3]Includes transitional periods.
[4]Steers 650, 666, and 652 were on full feed in this period.

percentage of nitrogen excreted. In fact, the nitrogen excretions of all eight steers, with only a few exceptions, showed little variation during a given period. Also, there were only slight variations when the entire thirty-seven weeks of the experiment are considered. Consequently, it seems justifiable to take an average of the results of the eight steers as representing the percentage of nitrogen excreted during each period. From these results (Table 27) it is apparent that

TABLE 17.—EXCRETION OF NITROGEN

(Results expressed in percent of total nitrogen consumed, and in percent of nitrogen of hay)

Period	Weeks	Ratio of hay to corn to linseed meal	In percent of total nitrogen	In percent of nitrogen of clover hay	In percent of total nitrogen	In percent of nitrogen of clover hay
			Maintenance Lot			
			Steer 650		Steer 656	
1	1–5	1:1:0	84.10	134.65	81.56	130.71
2	8–13	1:3:0	87.77	264.16	87.07	261.27
3	17–22	1:5:0	86.68	390.20	85.25	384.31
4	25–30	1:4:1	88.22	688.17	93.35	727.96
5[4]	34–37	1:4:1	81.21	593.57	98.32	723.81
Total[3]	1–37	....	85.18	340.22	88.77	329.53
			One-Third-Feed Lot			
			Steer 666		Steer 669	
1	1–5	1:1:0	76.95	122.99	83.74	134.00
2	8–13	1:3:0	87.69	262.95	84.60	253.10
3	17–22	1:5:0	88.73	401.31	89.45	403.61
4	25–30	1:4:1	84.28	654.48	92.58	726.39
5[4]	34–37	1:4:1	93.81	684.87	93.93	691.26
Total[3]	1–37	....	86.72	337.31	88.84	336.04
			Two-Thirds-Feed Lot			
			Steer 652[1]		Steer 665	
1	1–5	1:1:0	82.39	131.69	82.11	131.48
2	8–13	1:3:0	85.13	255.79	82.50	247.17
3	17–22	1:5:0	87.19	394.66	87.71	394.85
4	25–30	1:4:1	88.45	690.86	90.06	705.10
5[4]	34–37	1:4:1	92.31	681.08	96.41	704.86
Total[3]	1–37	....	86.80	312.47	88.03	336.19
			Full-Feed Lot			
			Steer 663[2]		Steer 661	
1	1–5	1:1:0	80.02	128.18	83.67	134.70
2	8–13	1:3:0	88.83	267.51	88.61	266.47
3	17–22	1:5:0	82.06	372.07	86.66	389.64
4	25–30	1:4:1	95.68	743.62	87.14	681.05
5	34–37	1:4:1	.....	.....	91.94	680.00
Total[3]	1–37	....	87.34	285.05	87.56	332.19

[1]Removed at end of 34th week. [2]Removed at end of 30th week.

[3]Includes transitional periods.

[4]Steers 650, 666, and 652 were on full feed in this period.

the total excretory nitrogen (urine and feces) made up 82 percent of the total nitrogen consumed in Period 1; 87 percent, in Period 2; 87 percent, in Period 3; 90 percent, in Period 4; 93 percent, in Period 5; and 87 percent for the entire experiment of thirty-seven weeks.

In an experiment with six mature milch cows at this station,[1] 80.32 percent of the nitrogen consumed was excreted in the feces and urine, and 20.12 percent was excreted in the milk. In an experiment with two milch cows at the Pennsylvania Station,[2] 84.64 percent of the nitrogen appeared in the feces and urine and 16.76 percent in the milk. Warington[3] calculates from experiments by Lawes and Gilbert at the Rothamsted Station that in the case of a mature fat steer 96 percent of the nitrogen of the ration was excreted. A milch cow excreted 75 percent of the nitrogen in the manure, while a calf excreted only 31 percent. Thus the results of our own experiment do not differ materially from the results of other investigations with cattle, except in the case of the milch cow of Lawes and Gilbert. It is of interest to note that the addition of nitrogen in the form of linseed meal to the ration in Periods 4 and 5 caused not only an increase in the absolute amounts of nitrogen excreted but also an increase in the percentage of nitrogen excreted.

Inasmuch as the nitrogen is excreted in both the feces and the urine, it is of interest and practical value to note what proportion of the total amount excreted is in each. Apparently the amount of feed consumed had little or no influence upon the way the nitrogen was excreted, i. e., whether it was in the feces or in the urine (Table 18). The averages of these results (Table 19) show the distribution of the nitrogen excreted to have been in Period 1, 68.5 percent in the feces and 31.5 percent in the urine; in Period 2, 59 percent in the feces and 41 percent in the urine; in Period 3, 56 percent in the feces and 44 percent in the urine; in Period 4, 36 percent in the feces and 64 percent in the urine; in Period 5, 35 percent in the feces and 65 percent in the urine; and in the entire experiment of thirty-seven weeks, 50 percent in the feces and 50 percent in the urine.

In the Illinois experiment with milch cows already noted, 44 percent of the nitrogen excreted in the manures was in the feces and 56 percent in the urine. In the Pennsylvania experiment with milch cows, 37 percent of the nitrogen was in the feces and 63 percent in the urine. According to Van Slyke,[4] 49 percent of the nitrogen is excreted in the feces and 51 percent in the urine, in the case of cattle.

From these figures it is evident that a large percentage of the nitrogen excreted is in the urine. Thus it is important to conserve the

[1]Hopkins: Soil Fertility and Permanent Agriculture, p. 201.

[2]Penn. Agr. Exp. Sta. Ann. Rpt. 1899-1900, p. 321.

[3]Chemistry of the Farm, p. 214.

[4]Fertilizers and Crops, p. 295.

urine of our farm animals by using plenty of bedding, water-tight stalls and barnyards, and by other suitable means. If the urine in this experiment had been wasted, from one-third to two-thirds of the nitrogen of the manure would have been lost. Incidentally, according to Van Slyke, 85 percent of the potassium (potash) excreted is in the urine and 15 percent in the feces, in the case of cattle. Inasmuch as the fertilizing ingredients of the liquid excrement are on the whole more available for plant growth than those of the solid excrement, and inasmuch as nitrogen and potassium are expensive fertilizing elements and occur in manure in large amounts, it is evident that at least half the fertilizing value of cattle manure is in the urine.

TABLE 18.—EXCRETION OF NITROGEN
(Results expressed in percent of total nitrogen excreted)

Period	Weeks	Ratio of hay to corn to linseed meal	In feces	In urine	In feces	In urine	In feces	In urine
			Maintenance Lot					
			Steer 650		Steer 656		Average	
1	1–5	1:1:0	67.25	32.75	60.84	39.16	64.05	35.95
2	8–13	1:3:0	58.21	41.79	55.53	44.47	56.87	43.13
3	17–22	1:5:0	55.53	44.47	56.38	43.62	55.95	44.05
4	25–30	1:4:1	33.59	66.41	33.23	66.77	33.41	66.59
5	34–37	1:4:1	40.31	59.69	31.58	68.42	35.94	64.06
Average[3]	1–37	....	48.06	51.94	45.85	54.15	46.95	53.05
			One-Third-Feed Lot					
			Steer 666		Steer 669		Average	
1	1–5	1:1:0	67.17	32.82	66.62	33.38	66.89	33.11
2	8–13	1:3:0	55.13	44.87	54.90	45.10	55.01	44.99
3	17–22	1:5:0	53.26	46.74	50.60	49.40	51.93	48.07
4	25–30	1:4:1	39.68	60.32	34.99	65.01	37.33	62.67
5	34–37	1:4:1	38.71	61.29	31.74	68.26	35.22	64.78
Average[3]	1–37	....	48.50	51.50	46.18	53.82	47.34	52.66
			Two-Thirds-Feed Lot					
			Steer 652[1]		Steer 665		Average	
1	1–5	1:1:0	70.88	29.12	70.76	29.24	70.82	29.18
2	8–13	1:3:0	60.39	39.61	59.64	40.36	60.01	39.99
3	17–22	1:5:0	58.06	41.94	56.63	43.37	57.34	42.66
4	25–30	1:4:1	37.55	62.45	38.28	61.72	37.91	62.09
5	34–37	1:4:1	33.33	66.67	35.96	64.04	34.64	65.36
Average[3]	1–37	....	52.10	47.90	50.79	49.21	51.44	48.56
			Full-Feed Lot					
			Steer 663[2]		Steer 661		Average	
1	1–5	1:1:0	71.94	28.06	72.80	27.20	72.37	27.63
2	8–13	1:3:0	60.65	39.35	65.03	34.97	62.84	37.16
3	17–22	1:5:0	58.60	41.40	60.22	39.78	59.41	40.59
4	25–30	1:4:1	30.62	69.38	39.79	60.21	35.20	64.80
5	34–37	1:4:1	.....	.....	35.21	64.79	35.21	64.79
Average[3]	1–37	....	53.95	46.05	53.12	46.88	53.53	46.47

[1]Removed at end of 34th week. [2]Removed at end of 30th week.
[3]Includes transitional periods.

TABLE 19.—AVERAGE EXCRETION OF NITROGEN BY ALL STEERS
(Results expressed in percent of total nitrogen excreted)

Period	Weeks	Ratio of hay to corn to linseed meal	In feces	In urine
1	1–5	1:1:0	68.53	31.47
2	8–13	1:3:0	58.68	41.32
3	17–22	1:5:0	56.16	43.84
4	25–30	1:4:1	35.96	64.04
5	34–37	1:4:1	35.25	64.75
Average.....	1–37	....	49.82	50.18

The data given in Table 20 show that in Periods 4 and 5 the amount of the ration consumed had no apparent influence upon the percentage of nitrogen excreted. Also the data show that 123 to 177, or an average of 160, percent as much nitrogen was excreted in the manure as was consumed in the farm-grown feeds. In other words, when the ration consisted of clover hay, ground corn, and linseed meal in the proportions of 1 to 4 to 1, 1.6 pounds of nitrogen were excreted in the manure for every pound of nitrogen removed from the soil (or air) by the hay and corn of the ration. Altho some of

TABLE 20.—NITROGEN CONSUMED FROM FARM-GROWN FEEDS AND TOTAL NITROGEN EXCRETED
(Results expressed in pounds and in percent per period)

Period	Nitrogen consumed from farm-grown feeds	Total nitrogen excreted	Percent excreted[1]	Nitrogen consumed from farm-grown feeds	Total nitrogen excreted	Percent excreted[1]
Maintenance Lot						
	Steer 650			Steer 656		
	lbs.	*lbs.*	*percent*	*lbs.*	*lbs.*	*percent*
4	4.01	6.40	159.60	4.01	6.77	168.83
5[2]	5.69	8.31	146.05	2.57	4.56	177.43
One-Third-Feed Lot						
	Steer 666			Steer 669		
4	5.74	4.67	122.91	6.25	10.46	167.36
5[2]	6.17	4.93	125.15	4.19	7.12	169.93
Two-Thirds-Feed Lot						
	Steer 652[3]			Steer 665		
4	7.56	12.09	159.92	8.49	13.82	162.78
5[2]	1.53	2.52	164.70	5.86	10.15	173.21
Full-Feed Lot						
	Steer 663[4]			Steer 661		
4	8.03	13.98	174.10	10.73	16.89	157.41
5	....	.....	.....	7.46	12.24	164.08

[1]This column expresses the total nitrogen excreted in percentage of the nitrogen consumed from the farm-grown feeds of the ration.
[2]Steers 650, 666, and 652 were on full feed in this period.
[3]Removed at end of 34th week.
[4]Removed at end of 30th week.

the nitrogen of the manure undoubtedly would be lost even under optimum conditions (probably 10 to 15 percent), still, if reasonable care were exercised in the conservation of the manure, the quantity of nitrogen returned to the soil in the manure would be equal to and probably exceed the nitrogen removed by the clover hay and the corn, especially is this seen to be true when one considers the amount of nitrogen added to the soil by the roots and stubble of the clover plants. In this connection it should be noted that in case nitrogenous by-products were for any reason unavailable, it obviously would be impossible to maintain the fertility by this method alone.

It is also of interest to compare the amount of nitrogen which was returned in the form of manure, with the amount which would have been returned by a system of farming in which the corn is sold and the clover is plowed under. Referring again to Table 17, it is seen that in all the periods of this experiment more nitrogen was returned in the manure than was contained in the clover hay fed. An average of the results for the eight steers shows that in Period 1, 131.05 percent as much nitrogen was returned in the manure as would have been returned by plowing under the clover; in Period 2, 259.80 percent; in Period 3, 391.33 percent; in Period 4, 702.20 percent; in Period 5, 679.92 percent; and for the entire experiment, 326.12 percent. The large increase in Periods 4 and 5 is due to the addition of the nitrogenous concentrate (linseed meal) to the ration.

It has already been noted on page 140 that in rotations where two crops of corn are secured in four or five years, corn and clover hay are produced in a proportion not greatly different from that in which these feeds were used in Periods 1 and 2. In a three-year rotation the proportions of corn and clover are approximately the same as fed in Period 1. Thus it is apparent that when corn and clover hay are fed in approximately the same proportions in which they should be produced in a good corn-belt rotation, considerably more nitrogen can be returned to the soil than under the other system of farming assumed immediately above. As previously explained (page 140) the results in Periods 3, 4, and 5 are of practical value only in case the feeder feeds a part of his clover to other stock or purchases corn additional to that produced on the farm.

EXCRETION OF PHOSPHORUS

Inasmuch as phosphorus is the key to permanent systems of agriculture, in a large part of the corn belt at least, the excretion of phosphorus should be of considerable interest to the practical farmer as well as to the scientific investigator.

As already stated, practically all of the phosphorus excreted by the animals used in this study was in the feces, only small amounts being found in the urine, except in the case of Steer 656, whose urine

contained twenty times as much phosphorus as the urine of some of the other steers. In the Illinois and Pennsylvania experiments with milch cows previously quoted, only very small amounts of phosphorus were excreted in the urine. According to Van Slyke,[1] the cow and horse excrete practically all the phosphorus in the feces. In the case of the hog, 12 percent of the excreted phosphorus is in the urine, while in the case of the sheep 5 percent is in the urine. Why Steer 656 was an exception to the general rule, we are unable to explain.

It is seen from the data given in Table 22 that the amount of feed consumed apparently had no effect upon the percentage of the phosphorus of the total ration that was excreted. However, it will be noted that there is considerably more variation between the steers in the same period than in the case of the nitrogen excreted. The percentage of phosphorus excreted by Steer 656 is considerably lower than that excreted by the other steers, owing to the fact already noted, that this steer excreted considerable phosphorus in his urine. If the phosphorus excreted in the feces in Periods 1 and 2 is added to the amounts of phosphorus excreted in the urine in these periods (see Tables 9 and 12), and then the percentage of total phosphorus excreted calculated, it is found that in Period 1, 87.79 percent, and in Period 2, 84.94 percent of the total phosphorus consumed was excreted. These results are not essentially different from the results from the other steers during these periods. It is possible that the variations among the other steers would be lessened if accurate determinations of the amounts of phosphorus in the urine were available and included in the amounts of phosphorus excreted.

Table 27 shows the average percentage of phosphorus excreted by all the steers excepting Steer 656, which has been omitted for obvious reasons. From these data it is seen that of the total amount of phosphorus excreted, practically all was in the feces, and that the quantity of feed consumed had no influence upon the percentage of phosphorus excreted. In Period 1, 93 percent of the total phosphorus consumed was excreted; in Period 2, 96 percent; in Period 3, 85 percent; in Period 4, 81 percent; in Period 5, 81 percent; and in the entire experiment, 87 percent.

In the experiment at this station with four milch cows, already mentioned, about 73 percent of the phosphorus of the ration was excreted in the manures and about 22 percent in the milk. In the Pennsylvania experiment with two milch cows, about 71 percent of the phosphorus of the ration was excreted in the manures and about 21 percent in the milk. One would naturally expect that milch cows would excrete in the manures a smaller proportion of the phosphorus of their rations than two-year-old steers.

Table 23 shows the amounts of phosphorus consumed from the farm-grown feeds (i.e., the corn and clover hay); the amounts of

[1]Fertilizers and Crops, p. 295.

phosphorus excreted from the total ration (i.e., the clover hay, corn, and linseed meal); and the phosphorus excreted from the total ration expressed in the percentage of the phosphorus consumed from the farm-grown feeds of the ration.

The results pertaining to Steer 656 need not be considered, owing to the fact, already explained, that he excreted a large but undetermined part of the phosphorus in the urine, while the other steers excreted the phosphorus largely thru the feces. As in the case of the organic matter and the nitrogen, so with the phosphorus, the

TABLE 21.—CONSUMPTION AND EXCRETION OF PHOSPHORUS
(Results expressed in pounds per period)

Period	Weeks	Ratio of hay to corn to linseed meal	Total phosphorus consumed	Phosphorus consumed in hay	Phosphorus excreted in feces	Total phosphorus consumed	Phosphorus consumed in hay	Phosphorus excreted in feces
			Maintenance Lot					
			Steer 650			Steer 656		
1	1–5	1:1:0	0.868	0.358	0.794	0.868	0.358	0.632
2	8–13	1:3:0	0.871	0.156	0.860	0.870	0.156	0.477
3	17–22	1:5:0	0.890	0.081	0.799	0.890	0.081	0.325
4	25–30	1:4:1	1.188	0.077	0.966	1.188	0.077	0.357
5[4]	34–37	1:4:1	1.678	0.127	1.319	0.759	0.057	0.229
Tota[3]	1–37	....	7.309	0.960	6.245	6.265	0.883	2.686
			One-Third-Feed Lot					
			Steer 666			Steer 669		
1	1–5	1:1:0	1.216	0.502	0.988	1.251	0.517	1.119
2	8–13	1:3:0	1.396	0.250	1.331	1.456	0.261	1.321
3	17–22	1:5:0	1.341	0.122	1.191	1.456	0.132	1.340
4	25–30	1:4:1	1.725	0.111	1.367	1.852	0.120	1.707
5[4]	34–37	1:4:1	1.820	0.137	1.638	1.243	0.094	1.088
Total[3]	1–37	....	10.149	1.363	8.921	10.009	1.380	9.065
			Two-Thirds-Feed Lot					
			Steer 652[1]			Steer 665		
1	1–5	1:1:0	1.583	0.649	1.581	1.635	0.675	1.528
2	8–13	1:3:0	1.913	0.342	1.774	2.046	0.366	1.965
3	17–22	1:5:0	1.808	0.165	1.277	2.036	0.185	1.916
4	25–30	1:4:1	2.240	0.145	1.409	2.514	0.163	2.216
5[4]	34–37	1:4:1	0.417	0 033	0.255	1.726	0.130	1.504
Total[3]	1–37	....	11.385	1.652	8.843	13.718	1.869	12.507
			Full-Feed Lot					
			Steer 663[2]			Steer 661		
1	1–5	1:1:0	1.856	0.760	1.732	1.994	0.826	2.005
2	8–13	1:3:0	2.209	0.393	2.072	2.584	0.462	2.668
3	17–22	1:5:0	1.954	0.177	1.366	2.190	0.200	1.951
4	25–30	1:4:1	2.392	0.156	2.011	3.178	0.206	2.427
5	34–37	1:4:1	.....	.....	.....	2.182	0.163	1.758
Total[3]	1–37	....	11.024	1.750	9.457	16.794	2.290	14.616

[1]Removed at end of 34th week. [2]Removed at end of 30th week.
[3]Includes transitional periods.
[4]Steers 650, 666, and 652 were on full feed in this period.

percentages excreted in Periods 4 and 5 apparently were not influenced by the amounts of feed consumed. It is also seen that during these periods, when the ration consisted of clover hay, ground corn, and linseed meal in the proportions of 1 to 4 to 1, there was excreted in the manure 110 to 160 percent as much phosphorus as was consumed in the farm-grown feeds. In other words, an average of 1.4 pounds of phosphorus was excreted in the manure (principally in the feces)

TABLE 22.—EXCRETION OF PHOSPHORUS

(Results expressed in percent of total phosphorus consumed, and in percent of phosphorus of hay)

Period	Weeks	Ratio of hay to corn to linseed meal	In percent of total phosphorus	In percent of phosphorus of clover hay	In percent of total phosphorus	In percent of phosphorus of clover hay
			Maintenance Lot			
			Steer 650		Steer 656	
1	1–5	1:1:0	91.48	221.79	72.81	176.54
2	8–13	1:3:0	98.76	551.28	54.82	305.77
3	17–22	1:5:0	89.79	986.42	36.54	401.23
4	25–30	1:4:1	81.29	1254.55	30.02	463.64
5[4]	34–37	1:4:1	78.60	1038.58	30.13	401.75
Total[3]	1–37	....	85.45	650.52	42.87	304.19
			One-Third-Feed Lot			
			Steer 666		Steer 669	
1	1–5	1:1:0	81.25	196.81	89.42	216.44
2	8–13	1:3:0	95.34	532.40	90.79	506.13
3	17–22	1:5:0	88.87	976.23	92.09	1015.15
4	25–30	1:4:1	79.28	1231.53	92.21	1422.50
5[4]	34–37	1:4:1	89.98	1195.62	87.50	1157.45
Total[3]	1–37	....	87.89	654.51	90.57	656.88
			Two-Thirds-Feed Lot			
			Steer 652[1]		Steer 665	
1	1–5	1:1:0	99.89	243.61	93.44	226.37
2	8–13	1:3:0	92.72	518.71	96.00	536.89
3	17–22	1:5:0	70.61	773.94	94.10	1035.68
4	25–30	1:4:1	62.89	971.72	88.12	1359.51
5	34–37	1:4:1	61.15	772.73	87.12	1156.92
Total[3]	1–37	....	77.67	535.29	91.17	669.18
			Full-Feed Lot			
			Steer 663[2]		Steer 661	
1	1–5	1:1:0	93.34	227.89	100.55	242.73
2	8–13	1:3:0	93.80	527.23	103.24	577.49
3	17–22	1:5:0	69.91	771.75	89.07	975.50
4	25–30	1:4:1	84.09	1289.10	76.36	1178.16
5	34–37	1:4:1	.....	.....	80.57	1078.53
Total[3]	1–37	....	85.79	540.40	87.03	638.25

[1]Removed at end of 34th week. [2]Removed at end of 30th week.

[3]Includes transitional periods.

[4]Steers 650, 666, and 652 were on full feed in this period.

for every pound of phosphorus removed from the soil by the hay and corn that were fed. It is true with phosphorus, as with nitrogen, that some of it may be lost before the manure is put on the soil; but if the manure is properly cared for, most of the element can be returned. Under conditions such as prevailed during Periods 4 and 5 of this experiment, the phosphorus content of the soil would not only be maintained but it probably would be increased.

It is also of interest to compare the amount of phosphorus returned to the farm when the corn and clover are fed to two-year-old beef cattle, with the amount returned when the corn is sold and the clover is plowed under for manure. From Table 22 it is seen that considerably more phosphorus was excreted in the manure than would have been returned to the farm had the clover been plowed under. An average of the results for the eight steers shows that in Period 1, 225.09 percent as much phosphorus was returned in the manure as was in the clover hay consumed; in Period 2, 550.02 percent; in Period 3, 933.52 percent; in Period 4, 1,243.87 percent; in Period 5, 1,066.64 percent; and in the entire experiment, 620.72 percent. It seems safe to conclude, therefore, that much more phosphorus can

TABLE 23.—PHOSPHORUS CONSUMED FROM FARM-GROWN FEEDS AND TOTAL PHOSPHORUS EXCRETED

(Results expressed in pounds and in percent per period)

Period	Phosphorus consumed in farm feeds	Total phosphorus excreted	Percent excreted[1]	Phosphorus consumed in farm feeds	Total phosphorus excreted	Percent excreted[1]
Maintenance Lot						
	Steer 650			Steer 656		
	lbs.	*lbs.*	*percent*	*lbs.*	*lbs.*	*percent*
4	0.682	0.966	141.64	0.682	0.357	.....
5[2]	0.968	1.319	136 26	0.437	0.229	.....
One-Third-Feed Lot						
	Steer 666			Steer 669		
4	0.995	1.367	137.39	1.064	1.707	160.43
5[2]	1.050	1.638	156.00	0.717	1.088	151.74
Two-Thirds-Feed Lot						
	Steer 652[3]			Steer 665		
4	1.286	1.409	109.56	1.443	2.216	153.57
5[2]	0.230	0.255	110.87	0.996	1.504	151.00
Full-Feed Lot						
	Steer 663[4]			Steer 661		
4	1.365	2.011	147.33	1.825	2.427	132.99
5	.....	.....	.....	1.268	1.758	138.64

[1]This column expresses the total phosphorus excreted in percentage of the phosphorus consumed from the farm-grown feeds of the ration.

[2]Steers 650, 666, and 652 were on full feed in this period.

[3]Removed at end of 34th week.

[4]Removed at end of 30th week.

be returned to the farm by feeding the crops to two-year-old beef cattle than can be returned in a system of farming in which the corn is sold and the clover plowed under.

Even in Periods 1 and 2, when corn and clover hay were fed in approximately the same proportions as they are grown in a good rotation, it would have been possible to return to the soil relatively much more phosphorus than could have been returned by the other system of farming assumed above.

FINANCIAL STATEMENT

It is of interest to calculate the value of the fertilizing elements of the manure on the basis of their cost in commercial fertilizers. Accordingly, we have assumed the following prices: for nitrogen 15 cents; for phosphorus 10 cents; and for potassium 6 cents per pound; which values are approximately the average market prices of these fertilizing elements under ordinary conditions. Unfortunately, the consumption and excretion of potassium was not determined. However, assuming the average potassium content of clover hay, corn, and linseed meal, and assuming further that 90 percent of the potassium consumed was excreted, it is possible to calculate the approximate amounts of potassium in the manure.

TABLE 24.—COMMERCIAL VALUE OF THE NITROGEN, PHOSPHORUS, AND POTASSIUM EXCRETED PER PERIOD[1]

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot		One-Third-Feed Lot	
			Steer 650	Steer 656	Steer 666	Steer 669
1	1–5	1:1:0	$1.06	$1.02	$1.38	$1.52
2	8–13	1:3:0	0.92	0.87	1.45	1.46
3	17–22	1:5:0	0.78	0.72	1.20	1.31
4	25–30	1:4:1	1.19	1.19	1.64	1.94
5[2]	34–37	1:4:1	1.56	0.78	1.92	1.31
Total	1–37	....	$7.24	$6.17	$10.21	$10.29
			Two-Thirds-Feed Lot		Full-Feed Lot	
			Steer 652[3]	Steer 665	Steer 663[4]	Steer 661
1	1–5	1:1:0	$1.90	$1.96	$2.17	$2.37
2	8–13	1:3:0	1.94	2.03	2.30	2.72
3	17–22	1:5:0	1.56	1.81	1.61	1.93
4	25–30	1:4:1	2.19	2.56	2.57	3.11
5[2]	34–37	1:4:1	0.46	1.85	....	2.25
Total	1–37	....	$11.41	$14.98	$11.20	$15.97

[1]This table is based upon the assumption that nitrogen costs 15 cents, phosphorus 10 cents, and potassium 6 cents per pound if purchased in commercial fertilizers.

[2]Steers 650, 666, and 652 were on full feed in this period.

[3]Removed at end of 34th week. [4]Removed at end of 30th week.

The total commercial value of the fertilizing elements as shown in Table 24, has been calculated by using the amounts of nitrogen actually excreted (see Table 16), the amounts of phosphorus actually excreted (see Table 21), and the calculated amounts of potassium excreted, together with the respective prices of the elements stated above.

An inspection of these data shows that the fertilizing elements in the manure of Steers 650 and 656 of the maintenance lot, for the entire thirty-seven weeks, would have cost $7.24 and $6.17, respectively, if they had been purchased in the form of commercial fertilizers; of Steers 666 and 669 of the one-third-feed lot, $10.21 and $10.29, respectively; of Steers 652 and 665 of the two-thirds-feed lot, $11.41 and $14.98, respectively; and of Steers 663 and 661 of the full-feed lot, $11.20 and $15.97, respectively. The individual farmer must not assume that these fertilizing elements will necessarily have these values, as these will depend largely upon the requirements of his soil and his system of crop production. However, these figures do show conclusively that the fertilizing value of the manure from fattening steers is no small item and should be considered in the balance sheet showing the profit or loss of feeding operations.

Table 25 shows the same values as those in Table 24, calculated per week. From this table it is seen that the value of the manure varied directly with the amount of the ration consumed; that the

TABLE 25.—COMMERCIAL VALUE OF THE NITROGEN, PHOSPHORUS, AND POTASSIUM EXCRETED PER WEEK[1]

Period	Weeks	Ratio of hay to corn to linseed meal	Maintenance Lot			One-Third-Feed Lot		
			Steer 650	Steer 656	Average	Steer 666	Steer 669	Average
1	1–5	1:1:0	$0.21	$0.20	$0.20	$0.28	$0.30	$0.29
2	8–13	1:3:0	0.15	0.15	0.15	0.24	0.24	0.24
3	17–22	1:5:0	0.13	0.12	0.12	0.20	0.22	0.21
4	25–30	1:4:1	0.20	0.20	0.20	0.27	0.32	0.30
5[2]	34–37	1:4:1	0.39	0.19	0.29	0.48	0.33	0.40
Average	1–37	....	$0.20	$0.17	$0.18	$0.28	$0.28	$0.28
			Two-Thirds-Feed Lot			Full-Feed Lot		
			Steer 652	Steer 665	Average	Steer 663	Steer 661	Average
1	1–5	1:1:0	$0.38	$0.39	$0.38	$0.43	$0.47	$0.45
2	8–13	1:3:0	0.32	0.34	0.33	0.38	0.45	0.41
3	17–22	1:5:0	0.26	0.30	0.28	0.27	0.32	0.29
4	25–30	1:4:1	0.36	0.43	0.40	0.43	0.52	0.47
5[2]	34–37	1:4:1	0.46	0.46	0.46	....	0.56	0.56
Average	1–37	....	$0.34	$0.40	$0.37	$0.37	$0.43	$0.40

[1]This table is based upon the assumption that nitrogen costs 15 cents, phosphorus, 10 cents, and potassium, 6 cents per pound if purchased in commercial fertilizers.

[2]Steers 650, 666, and 652 were on full feed in this period.

presence of a considerable amount of clover hay in the ration increased the value of the manure, while the presence of a large proportion of corn decreased the value of the manure; and that the addition of linseed meal to the ration increased the value of the manure. In Period 1, when the ration consisted of clover hay and ground corn in equal parts, the fertilizing elements in the manure of the maintenance steers would have cost 20 cents; of the one-third-feed steers, 29 cents;

TABLE 26.—COST OF FEEDS CONSUMED COMPARED WITH COMMERCIAL VALUE OF MANURE EXCRETED[1]

Period	Weeks	Ratio of hay to corn to linseed meal	Value of feed	Value of manure	Value of manure in per-cent of value of feed	Value of feed	Value of manure	Value of manure in per-cent of value of feed
			Maintenance Lot					
			Steer 650			Steer 656		
1	1–5	1:1:0	$2.89	$1.06	36.68	$2.89	$1.02	35.29
2	8–13	1:3:0	3.35	0.92	27.46	3.35	0.87	25.97
3	17–22	1:5:0	3.23	0.78	24.15	3.23	0.72	22.29
4	25–30	1:4:1	3.78	1.19	31.48	3.79	1.19	31.40
5	34–37	1:4:1	5.31	1.56	29.38	2.40	0.78	32.50
Total	1–37	....	$24.75	$7.24	29.25	$21.45	$6.17	28.76
			One-Third-Feed Lot					
			Steer 666			Steer 669		
1	1–5	1:1:0	$4.05	$1.38	34.07	$4.17	$1.52	36.45
2	8–13	1:3:0	5.37	1.45	27.00	5.60	1.46	26.07
3	17–22	1:5:0	4.87	1.20	24.64	5.28	1.31	24.81
4	25–30	1:4:1	5.46	1.64	30.04	5.90	1.94	32.88
5	34–37	1:4:1	5.76	1.92	33.33	3.93	1.31	33.33
Total	1–37	....	$34.55	$10.21	29.55	$34.29	$10.29	30.01
			Two-Thirds-Feed Lot					
			Steer 652			Steer 665		
1	1–5	1:1:0	$5.23	$1.90	36.33	$5.44	$1.96	36.03
2	8–13	1:3:0	7.35	1.94	26.39	7.87	2.03	25.79
3	17–22	1:5:0	6.56	1.56	23.78	7.39	1.81	24.49
4	25–30	1:4:1	7.14	2.19	30.67	8.01	2.56	31.96
5	34–37	1:4:1	1.40	0.46	32.86	5.46	1.85	33.88
Total	1–37	....	$39.43	$11.41	28.94	$47.03	$14.98	31.85
			Full-Feed Lot					
			Steer 663			Steer 661		
1	1–5	1:1:0	$6.13	$2.17	35.40	$6.66	$2.37	35.58
2	8–13	1:3:0	8.45	2.30	27.22	9.93	2.72	27.39
3	17–22	1:5:0	7.07	1.61	22.77	7.97	1.93	24.22
4	25–30	1:4:1	7.68	2.57	33.46	10.12	3.11	30.73
5	34–37	1:4:1	....	....	....	6.84	2.25	32.89
Total	1–37	....	$38.65	$11.20	28.98	$57.45	$15.97	27.79

[1]Corn valued at 56 cents per bushel, hay at $10 per ton, linseed meal at $40 per ton, nitrogen at 15 cents per pound, phosphorus at 10 cents per pound, and potassium at 6 cents per pound.

of the two-thirds-feed steers, 38 cents; and of the full-feed steers, 45 cents per head per week. In Period 2, when the ration consisted of one part of clover hay and three parts of ground corn, the fertilizing elements in the manure of the maintenance steers would have cost 15 cents; of the one-third-feed steers, 24 cents; of the two-thirds-feed steers, 33 cents; and of the full-feed steers, 41 cents per head per week. In Period 3, when the ration consisted of one part of clover hay and five parts of ground corn, the fertilizing elements in the manure of the maintenance steers would have cost 12 cents; of the one-third-feed steers, 21 cents; of the two-thirds-feed steers, 28 cents; and of the full-feed steers, 29 cents, per head per week. In Period 4, when the ration consisted of one part of clover hay, four parts of corn, and one part of linseed meal, the fertilizing elements in the manure of the maintenance steers would have cost 20 cents; of the one-third-feed steers, 30 cents; of the two-thirds-feed steers, 40 cents; and of the full-feed steers, 47 cents per head per week. In Period 5, on the same ration as in Period 4, the fertilizing elements in the manure from Steer 650 (on full feed) would have cost 39 cents; of Steer 656 (on maintenance), 19 cents; of Steer 666 (on full feed), 48 cents; of Steer 669 (on one-third feed), 33 cents; of Steer 652 (on full feed), 46 cents; of Steer 665 (on two-thirds feed), 46 cents; and of Steer 661 (on full feed), 56 cents per week. In this connection, it should be noted that these figures do not include the values of the organic matter of the manures.

These figures will give the stock-feeder some idea, at least, as to the value of the manure produced by two-year-old steers under similar conditions.

It is also of interest to compare the commercial value of the manure produced by the two-year-old steers with the cost of the feed consumed. Table 26 has been calculated upon this basis, corn being valued at 56 cents a bushel, clover hay at $10 per ton, linseed meal at $40 per ton, nitrogen at 15 cents per pound, phosphorus at 10 cents per pound, and potassium at 6 cents per pound. While these valuations do not represent the market prices of either the feeds used or of the fertilizing elements at the time of the publication of this bulletin, yet they are comparable with each other and represent average prices under ordinary conditions.

It is clear from the data in Table 26 that no inconsiderable part of the cost of the feed is returned in the manure. In Period 1, the commercial value of the manure represented 35.77 percent of the cost of the feed consumed; in Period 2, 26.66 percent; in Period 3, 23.89 percent; in Period 4, 31.58 percent; in Period 5, 28.52 percent; and during the entire experiment, 29.39 percent. Of course, this does not take into consideration any losses in handling the manure from the time it is excreted until it is applied to the soil. While these losses

may be considerable, yet such is not necessarily the case. On the other hand, these figures do not assign any value to the organic matter of the manure. It is possible, or even probable, that the value of the organic matter would more than offset the losses of nitrogen, phosphorus, and potassium in handling the manure. In any case, the fact remains that the manure does have a considerable value which is not often taken into consideration in figuring the financial balance in cattle-feeding operations.

SUMMARY

1. Eight two-year-old, choice feeder steers were divided into four lots of two steers each. One lot was given a ration slightly above maintenance; another, as much feed as the steers would eat readily; another, an amount of feed equal to the maintenance ration plus one-third of the difference between the maintenance and the full-feed ration; and another, an amount equal to the maintenance ration plus two-thirds of the difference between the maintenance and the full-feed ration.

2. The experiment lasted for thirty-seven weeks and was divided into five test periods. The first period was five weeks in length, the second, third, and fourth were each six weeks in length, and the fifth was four weeks in length.

3. The feeds used were clover hay, ground corn, and linseed oil meal. The ration of the first test period consisted of clover hay and ground corn in the ratio of 1 to 1; that of the second, of clover hay and ground corn in the ratio of 1 to 3; that of the third, of clover hay and ground corn in the ratio of 1 to 5; and that of the fourth and fifth, of clover hay, ground corn, and linseed oil meal in the ratio of 1 to 4 to 1.

4. The consumption of organic matter, nitrogen, and phosphorus, the excretion of organic matter in the feces, the excretion of nitrogen

TABLE 27.—SUMMARY OF THE AVERAGE EXCRETION OF ORGANIC MATTER, NITROGEN, AND PHOSPHORUS

(Results expressed in percent of the amount consumed)

Period	Weeks	Ratio of hay to corn to linseed meal	Organic matter in feces	Nitrogen in feces and urine	Phosphorus in feces[1]
1	1–5	1:1:0	33.20	81.82	92.77
2	8–13	1:3:0	27.89	86.53	95.81
3	17–22	1:5:0	24.24	86.72	84.92
4	25–30	1:4:1	21.85	89.97	80.61
5	34–37	1:4:1	22.75	92.56	80.82
Total.....	1–37	....	26.24	87.40	86.51

[1]Omitting Steer 656.

in the feces and urine, and the excretion of phosphorus in the feces and in the urine (for thirteen weeks only) were determined.

5. In Period 1, on a ration consisting of clover hay and ground corn in equal parts, 33 percent of the organic matter was recovered in the manure; in Period 2, on a ration consisting of 1 part clover hay and 3 parts ground corn, 28 percent was recovered; in Period 3, when the ration consisted of 1 part clover hay and 5 parts ground corn, 24 percent was recovered; in Periods 4 and 5, when the ration consisted of 1 part clover hay, 4 parts ground corn, and 1 part linseed meal, 22 percent and 23 percent, respectively, were recovered; during the entire experiment of thirty-seven weeks, 26 percent was recovered.

6. The amount of feed consumed had no influence upon the percentage of organic matter excreted, except in Period 1, and possibly in Period 2.

7. Slightly more organic matter was recovered in the manure than would have been recovered in a system of farming in which the corn is sold and the clover plowed under.

8. In Period 1, 82 percent of the nitrogen consumed was excreted, 69 percent of it being in the feces and 31 percent in the urine; in Period 2, 87 percent was excreted, 59 percent in the feces and 41 percent in the urine; in Period 3, 87 percent was excreted, 56 percent in the feces and 44 percent in the urine; in Period 4, 90 percent was excreted, 36 percent in the feces and 64 percent in the urine; in Period 5, 93 percent was excreted, 35 percent in the feces and 65 percent in the urine; during the entire experiment of thirty-seven weeks, 87 percent was excreted, 50 percent in the feces and 50 percent in the urine.

9. The amount of feed consumed had no influence upon the percentage of nitrogen excreted.

10. When linseed meal was introduced into the ration, the nitrogen balance of the soil was more than maintained, 160 percent as much nitrogen being excreted as was contained in the farm-grown feeds.

11. The nitrogen recovered in the manure averaged 326 percent of that which would have been recovered in a system of farming in which the corn is sold and the clover plowed under. In Period 1, the proportion was 131 percent; in Period 2, 260 percent; in Period 3, 391 percent; in Period 4, 702 percent; in Period 5, 680 percent.

12. In Period 1, 93 percent of the phosphorus consumed was excreted; in Period 2, 96 percent; in Period 3, 85 percent; in Period 4, 81 percent; in Period 5, 81 percent; and during the entire experiment, 87 percent. Practically all of the excreted phosphorus was in the feces, except in the case of one steer.

13. The amount of feed consumed had no influence upon the percentage of phosphorus excreted.

14. When linseed meal was introduced into the ration, the phosphorus balance of the soil was more than maintained, 141 percent as

much phosphorus being excreted as was contained in the farm-grown feeds.

15. The phosphorus recovered in the manure averaged 521 percent of that which would have been recovered in a system of farming in which the corn is sold and the clover plowed under. In Period 1, the proportion was 225 percent; in Period 2, 550 percent; in Period 3, 934 percent; in Period 4, 1,244 percent; and in Period 5, 1,067 percent.

16. Assuming that nitrogen costs 15 cents per pound, phosphorus 10 cents, and potassium 6 cents, if purchased in commercial fertilizers, the values of these elements excreted per head per week were as follows:

Period	Maintenance lot	One-third-feed lot	Two-thirds-feed lot	Full-feed lot
1	$0.20	$0.29	$0.38	$0.45
2	0.15	0.24	0.33	0.41
3	0.12	0.21	0.28	0.29
4	0.20	0.30	0.40	0.47
5	0.29	0.40	0.46	0.56
Total	$0.18	$0.28	$0.37	$0.40

17. The value of the manure varied directly with the amount of feed consumed. It also varied with the character of the ration, being greater the larger the proportion of clover hay in the ration, and greatest when linseed oil meal was introduced into the ration.

18. At the values assumed for fertilizing elements, no inconsiderable part of the cost of the feed was returned in the manure. In Period 1, the commercial value of the manure was 36 percent of the cost of the feed; in Period 2, 27 percent; in Period 3, 24 percent; in Period 4, 32 percent; in Period 5, 29 percent; and in the entire experiment, 29 percent.

CONCLUSIONS

1. By feeding two-year-old steers on clover hay and corn, and carefully conserving the resulting manure, it is possible to return to the soil one-fourth to one-third of the organic matter of the ration and three-fourths to four-fifths of the nitrogen and phosphorous of the ration.

2. It is possible to maintain, or even to increase, the nitrogen and phosphorus content of the soil by adding to the ration a nitrogenous supplement such as linseed or cottonseed meal.

3. When a three-year rotation is practiced (e. g., corn, oats, and clover), approximately two-thirds as much organic matter can be returned to the land by feeding two-year-old cattle and returning the

manure to the soil as can be returned in a system of farming in which the corn is sold and the clover plowed under. In a four- or five-year rotation, corn appearing twice (e. g., corn, corn, oats, and clover; or corn, corn, oats, clover, and wheat), as much organic matter can be returned by feeding the corn and clover as by selling the corn and plowing under the clover.

4. In the three-year rotation above mentioned, slightly more nitrogen can be returned by feeding the corn and clover than by selling the corn and plowing under the clover. In the four- and five-year rotations, about twice as much nitrogen can be returned.

5. In the three-year rotation, approximately twice as much phosphorus can be returned by feeding the corn and clover as by selling the corn and plowing under the clover. In the four- and five-year rotations, four or five times as much can be returned.

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