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KANSAS STATE AGRICULTURAL COLLEGE.

COMMERCIAL FERTILIZERS:

I. Analyses of Inspection Samples of Fertilizers.
II. Value and Use.

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COMMERCIAL FERTILIZERS.

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I. Analyses of Inspection Samples of Fertilizers.

The use of commercial fertilizers in Kansas is increasing rapidly, and the accompanying table shows the results of analyses made of samples taken in inspecting the fertilizers offered for sale in this state. The number of brands represented has increased. The American Fertilizer and Reduction Company is no longer doing business.

Inspection of the results shows, on the whole, a gratifying condition of the fertilizer business in this state. Of the samples taken from goods furnished by Swift and Company and the Armour Packing Company, who supply by far the greater proportion of the fertilizers sold in this state, very few show a deficiency in nitrogen, potassium or total phosphorus that exceeds the tolerance of one-fifteenth allowed by the law. A comparison of the numbers of those above the guaranties and those below the guaranties shows that there are far more which exceed their guaranty than there are which are below their guaranty. In respect to phosphorus some special comment may be made. The phosphates of fertilizers are subject to change, and in the case of the Armour Packing Company no guaranty is made concerning the "phosphorus in phosphates soluble in water," their guaranty in respect to "available phosphates" including under one head both "soluble" and "reverted" phosphates. As "reverted phosphates" are regarded as somewhat less valuable than soluble phosphates," we have placed the guaranty of the Armour Packing Company under the head of "reverted phosphates.'' An equitable comparison of the phosphates in the different samples of all the manufacturers requires that the phosphorus in "soluble phosphates" and in "reverted phosphates" be added together and compared with the total guaranteed for these two forms. The total phosphorus found is in excess of that guaranteed in almost every instance. In a number of cases, notably samples Nos. 142, 146, 186, 187, 188, 189, 192, 193 and 204, the sum of the phosphates in "soluble phosphates" and in "reverted phosphates" is less than it should be, even though the total phosphorus found is materially in excess of that guaranteed.

It seems advisable to make some brief statements concerning the terms used in giving the composition of fertilizers. The chemical elements considered in the fertilizer trade are usually nitrogen, potassium and phosphorus only. There are many compounds used in fertilizers which contain nitrogen. These may be nitrates, ammonium salts, organic matter from the packing houses, or other materials. Most of these compounds are very complex, and when the different compounds are mixed it is difficult or impossible to analyze the mixture so as to ascertain the amount of each compound, or even each class of compounds. It is therefore necessary in analysis to determine the percentage of nitrogen present, and any additional judgment concerning the value of the nitrogenous constituent of a fertilizer must be based upon information concerning the class of nitrogenous compounds used in compounding the fertilizer. In any case the comparative value of the fertilizer, as far as nitrogen is concerned, is shown approximately by the percentage of nitrogen present, provided that forbidden inert materials, such as hoof, horn, and feathers,have not been used.

In respect to potassium, remarks almost parallel to the preceding might be made. Several different potassium compounds used in fertilizers owe their efficacy as potassic fertilizers to the potassium which they contain, and it is impossible to determine the amount of each of the individual compounds. The best that we can do is to state the percentages of the essential element potassium, and here again the comparative value of fertilizers in respect to potassium will be indicated closely by the percentages of potassium present in compounds soluble in water.

The phosphates in fertilizers are the only compounds of phosphorus considered. The "insoluble" phosphates are of value, but are not readily available for immediate use by plants, and are sold at a much lower price than are the phosphates that are "soluble in water'' or in a solution of ammonium citrate. Those soluble in ammonium citrate and insoluble in water are classified as "reverted." While phosphates "soluble in water" are regarded as somewhat more valuable than "reverted" phosphates, they are so subject to change in the soil that there is not much practical difference in value between "soluble" and "reverted" phosphates. Because of the differences in the value of these classes of phosphates, and the possibility of approximately estimating them in analysis, the phosphorus in each is separately stated, and those fertilizers having the higher percentage of soluble plus reverted phosphates are the more valuable in respect to the element phosphorus.

Chlorine is an element which is found in common salt and in potassium chloride or kainit, which are used in making fertilizers. For certain crops, such as tobacco, potatoes and sugar beets, fertilizers containing chlorine are quite objectionable, hence the Kansas fertilizer law requires that manufacturers shall guarantee the maximum percentage of chlorine present in compounds soluble in water. Inspection of the table will show that in nearly all cases the chlorine found to be present is greater than the maximum guaranty; that is, the fertilizers contain more of this element than the manufacturers should permit under the guaranty. The quantities present are not large, and for most crops are not injurious. Most states do not require a guaranty in respect to this element, and the manufacturers doing business in this state have evidently not given this point the attention that conformity to the law requires.

TABLE 1. RESULTS OF ANALYSES OF INSPECTION SAMPLES OF FERTILIZERS.

No.	Brands and manufacturers.	Name of seller and place sampled.	Minimum percentage of total nitrogen.		Minimum percentage of phosphorus in phosphates. Soluble in water.		Reverted.		Insoluble.		Total.		Minimum percentage of potassium in compounds soluble in water.		Maximum percentage of chlorine in compounds soluble in water.	
			Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
	Swift & Co.:															
99	Pure Bone Meal	Oswego Milling Co., Oswego	2.65	2.47			4.63	4.92	6.02	5.56	10.65	10.48				
100	Pure Raw Bone Meal		4.18	3.75							10.18	10.04				
101	Pure Raw Bone Meal	Kelso Grain Co., Cherokee	4.07	3.75							10.58	10.04				
102	Pure Bone Meal	Runyan & Schaffer, Mound Valley	2.11	2.47							10.18	10.04				
103	Pure Bone Meal		2.67	2.47			3.26	4.92	5.83	5.56	9.09	10.48				
104	Pure Bone Meal	Union Hardware and Implement Co., Independence	2.36	2.47			3.56	4.92	6.60	5.56	10.16	10.45				
108	Superphosphate	J. H. Meyers, Elk City	1.82	1.65	2.02	1.50	1.85	2.00	0.54	0.43	4.41	3.93	1.78	1.66	1.65	1.51
109	Superphosphate	Harder, Weide Grain Co., Yates Center	1.86	1.65	1.56	1.50	2.64	2.00	0.36	0.43	4.56	3.93	1.73	1.66	2.05	1.51
110	Onion, Potato and Tobacco	Humboldt M. & Ele. Co., Humboldt	2.09	1.65	2.35	1.50	1.18	2.00	0.43	0.43	3.96	3.93	6.07	5.82	0.80	
111	Special Grain	Mead Grain Co., Fort Scott	2.10	1.65	1.22	1.75	2.61	2.62	1.30	0.43	5.13	4.80	1.91	1.66	2.30	1.51
112	Special Grain	MacGregor & Atkinson, Fredonia	1.81	1.65	2.14	1.75	2.41	2.62	0.61	0.43	5.16	4.80	1.64	1.66	2.30	1.51
113	Special Grain	Kelso Grain Co., Cherokee	2.07	1.65	1.40	1.75	2.89	2.62	1.05	0.43	5.34	4.80	1.64	1.66	1.88	1.51
114	Special Grain	Oswego Milling Co., Oswego	1.59	1.65	2.67	1.75	2.12	2.62	0.27	0.43	5.06	4.80	1.86	1.66	1.70	1.51
115	Special Grain	J. O. Tullos, Sedan	1.43	1.65	3.13	1.75	1.67	2.62	0.22	0.43	5.02	4.80	1.89	1.66	1.80	1.51
121	Pure Special Bone Meal	Muzzy & Lower, Edna	1.01	0.82							10.74	12.66				
122	Pure Bone Meal	E. B. Davis, Columbus	2.27	2.47			4.45	4.92	6.49	5.56	10.94	10.48				
123	Superphosphate	E. B. Davis, Columbus	1.72	1.65	0.54	1.50	2.83	2.00	0.75	0.43	4.12	3.93	1.73	1.66	2.20	1.51
124	Special Grain	E. B. Davis, Columbus	1.71	1.65	0.65	1.75	3.30	2.62	0.67	0.43	4.62	4.80	20.1	1.66	2.70	1.51
125	Onion, Potato and Tobacco	E. B. Davis, Columbus	1.71	1.65							3.97	3.93	5.20	5.82	6.20	
126	Special Grain	Muzzy & Lower, Edna	2.52	1.65	1.12	1.75	3.48	2.62	0.20	0.43	4.80	4.80	1.88	1.66	2.75	1.51
127	Onion, Potato and Tobacco	Muzzy & Lower, Edna	1.62	1.65	1.99	1.50	1.27	2.00	0.41	0.43	3.67	3.93	6.12	5.82	0.65	
128	Superphosphate		1.72	1.65	1.59	1.50	1.97	2.00	0.30	0.43	3.86	3.93	1.54	1.66	2.28	1.51
129	Special Grain	J. H. Meyers, Elk City	1.65	1.65	2.55	1.75	2.04	2.62	0.30	0.43	4.87	4.80	1.50	1.66	2.15	1.51
130	Superphosphate	J. H. Meyers, Elk City	1.89	1.65	1.60	1.50	2.17	2.00	0.09	0.43	3.86	3.93	1.58	1.66	2.42	1.51
131	Onion, Potato and Tobacco	Rockwell Mill & Grain Co., Junction City	2.03	1.65	1.65	1.50	1.85	2.00	0.42	0.43	3.92	3.93	3.85	3.82	1.20	
149	High Grade Acid Phosphate,	P. A. Stuewe, Alma	0.88	1.65	5.22	2.18	2.07	1.31	0.22	0.37	7.51	7.42				
150	Onion, Potato and Tobacco	P. A. Stuewe, Alma	1.92	1.65	2.19	1.50	1.34	2.00	0.32	0.43	3.85	3.93	4.85	5.82	1.25	
151	Pure Special Bone Meal	P. A. Stuewe, Alma	0.75	0.82							12.26	12.66				
152	Sulphate of Potash	P. A. Stuewe, Alma											42.00	5.82	0.60	1.00
156	Special Grain	G. H. Barker, Girard	1.72	1.65	2.17	1.75	2.05	2.62	0.72	0.43	4.94	4.80	1.43	1.66	1.75	1.51
160	Pure Raw Bone Meal	E. B. Davis, Columbus	3.80	3.75							10.50	10.04				

TABLE 1.—CONTINUED. RESULTS OF ANALYSES OF INSPECTION SAMPLES OF FERTILIZERS.

No.	Brands and manufacturers.	Name of seller and place sampled.	Minimum percentage of total nitrogen.		Minimum percentage of phosphorus in phosphates. Soluble in water.		Reverted.		Insoluble.		Total.		Minimum percentage of potassium in compounds soluble in water.		Maximum percentage of chlorine in compounds soluble in water.	
			Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
	Swift & Co.—concluded:															
163	Pure Special Bone Meal	Young & Son, Hutchinson	1.15	0.82	......	......	......	......	......	......	13.95	12.66	......	......	......	......
164	Pure Bone Meal	Libby Hardware Co., Altamont	2.06	2.47	......	......	......	......	......	......	11.68	10.48	......	......	......	......
165	Pure Bone Meal	L. H. Hiatt, Mound Valley	2.25	2.47	......	......	......	......	......	......	11.41	10.48	......	......	......	......
166	Pure Bone Meal	E. B. Davis, Columbus	2.82	2.47	......	......	......	......	......	......	10.66	10.48	......	......	......	......
170	Special Grain	Cherryvale Grain and Lumber Co	1.74	1.65	1.30	1.75	3.23	2.62	0.56	0.43	5.09	4.80	1.53	1.66	2.02	1.51
171	Special Grain	Rea-Patterson M. L. G. Co., Coffeyville	1.87	1.65	3.30	1.75	1.03	2.62	0.42	0.43	4.75	4.80	1.63	1.66	1.95	1.51
172	Special Grain	G. H. Barker, Girard	1.66	1.65	3.22	1.75	0.86	2.62	0.38	0.43	4.46	4.80	2.74	1.66	2.05	1.51
173	Special Grain	J. H. Meyer, Elk City	1.63	1.65	3.28	1.75	0.92	2.62	0.44	0.43	4.64	4.80	1.70	1.66	1.95	1.51
174	Special Grain	Young & Sons, Hutchinson	1.90	1.65	2.38	1.75	1.43	2.62	1.07	0.43	4.88	4.80	1.89	1.66	2.10	1.51
175	Special Grain	E. B. Davis, Columbus	1.53	1.65	3.16	1.75	0.90	2.62	0.42	0.43	4.48	4.80	1.83	1.66	1.95	1.51
176	Special Grain	Libby Hardware Co., Altamont	1.59	1.65	3.16	1.75	1.12	2.62	0.36	0.43	4.64	4.80	1.62	1.66	1.95	1.51
178	Superphosphate	Ash & Foulke, Wellington	1.66	1.65	2.36	1.50	1.58	2.00	0.64	0.43	4.58	3.93	2.10	1.66	1.95	1.51
179	Onion, Potato and Tobacco	Union Hardware and Implement Co., Independence	1.64	1.65	2.38	1.50	0.62	2.00	0.64	0.43	3.64	3.93	5.78	5.82	0.60	......
180	Superphosphate	Cherryvale Grain and Lumber Co., Cherryvale	1.64	1.65	0.87	1.50	2.84	2.00	0.62	0.43	4.33	3.93	1.83	1.66	2.55	1.51
181	Pure Special Bone Meal and Potash	L. H. Hiatt, Mound Valley	0.83	0.82	None.	None.	3.69	......	4.82	......	8.51	7.85	2.72	3.32	6.00	3.02
182	Special Bone Meal and Potash	G. H. Barker, Girard	1.02	0.82	None.	None.	3.46	......	4.27	......	7.73	7.85	3.52	3.32	8.30	3.02
183	Superphosphate	Belle Plaine Implement Co., Belle Plaine	1.59	1.65	2.52	1.50	1.17	2.00	0.56	0.43	4.25	3.93	2.10	1.66	1.85	1.51
184	Onion, Potato and Tobacco	Young & Sons, Hutchinson	1.68	1.65	2.46	1.50	1.37	2.00	1.01	0.43	4.84	3.93	4.56	5.82	4.70	......
185	No. 2 Manure Mixture	Young & Sons, Hutchinson	2.08	2.26	1.09	......	1.65	1.74	1.02	1.75	3.75	3.49	3.96	4.15	4.20	......
198	Pure Raw Bone Meal	Pittsburg M. & C. Co., Pittsburg	4.00	3.75	......	......	......	......	......	......	10.30	10.04	......	......	......	......
201	Onion, Potato and Tobacco	Pittsburg Elevator Co., Pittsburg	1.49	1.65	2.50	1.50	1.12	2.00	0.36	0.43	3.98	3.93	5.46	5.82	1.57	......
	Armour Packing Co.:															
105	Fine Ground Beef Bone	L. Belknap, Pittsburg	3.33	2.46	......	......	4.15	2.61	5.51	7.86	9.66	10.48	......	......	......	......
106	Fine Ground Beef Bone	......	2.76	2.46	......	......	4.26	2.61	5.63	7.86	9.89	10.48	......	......	......	......
107	Fine Ground Beef Bone	......	2.70	2.46	......	......	4.62	2.61	5.79	7.86	10.41	10.48	......	......	......	......
116	No. 2-8-2	L. Belknap, Pittsburg	1.78	1.64	......	......	3.75	3.49	1.86	......	5.61	3.49	1.68	1.66	2.15	1.65
117	Lawn and Garden	Ross Bros., Wichita	2.01	2.87	......	......	3.87	3.49	1.83	......	5.70	3.49	3.57	3.32	0.60	......
134	Special Potato	E. K. Gibbs, Hallowell	1.75	1.64	1.55	3.49	1.82	3.49	0.83	......	4.20	3.49	8.46	8.30	1.05	......

TABLE 1—CONTINUED. RESULTS OF ANALYSES OF INSPECTION SAMPLES OF FERTILIZERS.

No.	Brands and manufacturers.	Name of seller and place sampled.	Minimum percentage of total nitrogen.		Minimum percentage of phosphorus in phosphates.								Minimum percentage of potassium in compounds soluble in water.		Maximum percentage of chlorine in compounds soluble in water.	
					Soluble in water.		Reverted.		Insoluble.		Total.					
			Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
	Armour Packing Co.—concluded:															
135	Fine Ground Beef Bone	E. K. Gibbs, Hallowell	2.74	2.46	.....	.....	4.24	2.62	4.88	7.86	9.12	10.47	.....	.....	.....	.....
136	No. 2-8-2	A. R. Quigg, Elk City	1.66	1.64	0.67	3.49	2.50	3.49	1.10	.....	4.29	3.49	1.80	1.66	2.15	1.65
137	Lawn and Garden	F. M. Gust, Crestline	2.74	2.87	1.47	3.49	2.36	3.49	0.87	.....	4.70	3.49	3.52	3.32	0.80	.....
138	Lawn and Garden	F. H. Porter, Columbus	2.76	2.87	1.47	3.49	2.06	.....	1.40	.....	4.93	3.49	3.61	3.32	1.75	.....
139	Special Potato	F. H. Porter, Columbus	1.95	1.64	1.53	3.49	1.39	.....	1.24	.....	4.16	3.49	8.48	8.30	1.15	.....
140	Ammoniated Dissolved Bone and Potash	F. H. Porter, Columbus	1.82	1.64	1.20	4.36	2.16	.....	1.01	.....	4.37	4.36	1.87	1.66	2.30	1.65
141	Raw Bone Meal	F. H. Porter, Columbus	3.58	3.70	.....	.....	3.29	2.18	6.54	8.29	9.83	10.47	.....	.....	.....	.....
142	Ammoniated Dissolved Bone and Potash	F. M. Gust, Crestline	2.01	1.64	1.17	4.36	2.34	4.36	1.00	.....	4.51	4.36	1.79	1.66	1.35	1.65
143	Raw Bone Meal	E. K. Gibbs, Hallowell	3.42	3.70	.....	.....	2.99	2.18	6.86	8.29	9.85	10.47	.....	.....	.....	.....
144	Fine Ground Beef Bone	F. H. Porter, Columbus	2.64	2.46	.....	.....	3.84	2.62	5.82	7.86	9.66	10.48	.....	.....	.....	.....
145	Fine Ground Beef Bone	F. M. Gust, Crestline	2.50	2.46	.....	.....	2.70	2.62	7.05	7.86	9.75	10.48	.....	.....	.....	.....
146	Special Potato	F. M. Gust, Crestline	1.88	1.64	1.91	3.49	1.09	3.49	0.78	.....	3.78	3.49	8.49	8.30	0.80	.....
148	Lawn and Garden	W. S. Randle, Hutchinson	2.80	2.87	1.81	.....	2.48	3.49	0.85	.....	5.14	3.49	6.23	3.32	0.55	.....
157	Special Potato	Hackney & Son, La Harpe	1.60	1.64	1.50	3.49	1.48	3.49	0.77	.....	3.75	3.49	9.01	8.30	2.05	.....
161	Pure Raw Bone Meal	F. H. Porter, Columbus	3.46	3.70	.....	.....	.....	.....	.....	.....	9.55	10.47	.....	.....	.....	.....
162	Fine Ground Beef Bone	F. H. Porter, Columbus	2.99	2.46	.....	.....	.....	.....	.....	.....	11.80	10.47	.....	.....	.....	.....
168	Raw Bone Meal	E. K. Gibbs, Hallowell	3.57	3.70	.....	.....	.....	.....	.....	.....	9.91	10.47	.....	.....	.....	.....
186	No. 2-8-2	P. J. Morrison, Hillsdale	1.84	1.65	0.77	.....	1.90	3.49	2.07	.....	4.74	3.49	1.45	1.66	1.80	1.65
187	No. 2-8-2	A. R. Quigg, Elk City	1.74	1.65	0.64	.....	2.35	3.49	1.33	.....	4.32	3.49	1.82	1.66	2.40	1.65
188	No. 2-8-2	E. K. Gibbs, Hallowell	1.74	1.65	0.65	.....	1.96	3.49	1.66	.....	4.27	3.49	1.76	1.66	2.05	1.65
189	Special Potato	F. H. Porter, Columbus	1.70	1.64	1.10	.....	1.76	3.49	1.60	.....	4.52	3.49	8.26	8.30	1.40	.....
190	Ammoniated Dissolved Bone and Potash	F. H. Porter, Columbus	1.73	1.64	0.99	.....	3.31	4.36	0.66	.....	4.96	4.36	1.82	1.66	2.30	1.65
191	Lawn and Garden	Ross Bros., Wichita	3.06	2.87	1.26	.....	2.07	3.49	0.54	.....	3.87	3.49	3.59	3.32	4.55	.....
192	Lawn and Garden	W. S. Randle, Hutchinson	2.93	2.87	0.88	.....	1.71	3.49	2.17	.....	4.76	3.49	3.29	3.32	0.75	.....
193	Special Potato	F. H. Porter, Columbus	1.67	1.64	1.11	.....	1.72	3.49	1.76	.....	4.59	3.49	8.00	8.30	1.47	.....
203	Ammoniated Dissolved Bone and Potash	Pittsburg Modern Mfg. Co., Pittsburg	1.73	1.64	1.14	.....	2.44	4.36	1.78	.....	5.36	4.36	1.68	1.66	2.15	1.65
204	No. 2-8-2	Pittsburg Modern Mfg. Co., Pittsburg	1.68	1.64	0.87	.....	1.93	3.49	1.62	.....	4.42	3.49	1.77	1.66	2.35	1.65
205	Special Potato	Pittsburg Modern Mfg. Co., Pittsburg	1.55	1.64	1.54	.....	1.70	3.49	1.28	.....	4.52	3.49	8.78	8.30	0.62	.....

TABLE 1—Concluded. REULTS OF ANALYSES OF INSPECTION SAMPLES OF FERTILIZERS.

	Brands and manufacturers.	Name of seller and place sampled	Minimum percentage of total nitrogen.		Minimum percentage of phosphorus in phosphates.								Minimum percentage of potassium in compounds soluble in water.		Maximum percentage of chlorine in compounds soluble in water.	
					Soluble in water.		Reverted.		Insoluble.		Total.					
			Found...	Guaranteed.	Found...	Guaranteed.	Found...	Guaranteed.	Found...	Guaranteed.	Found...	Guaranteed.	Found...	Guaranteed.	Found...	Guaranteed.
	Sulzberger & Sons Co.:															
153	Pure Raw Bone Meal	Sulzberger & Sons Co., Kansas City	3.64	3.75	......	......	......		......	......	10.62	10.00		......	......	......
154	Pure Bone Meal	Sulzberger & Sons Co.	3.19	2.47	......	......	6.68	5.88	3.99	5.85	12.61	10.85	......	......	......	......
159	Pure Bone Meal	J. C. Ebenstein, Columbus	3.11	2.47	......	......	......	......	......	......	10.75	10.85	......	......	......	......
197	Raw Bone Meal and Potash	J. C. Ebenstein, Columbus	1.80	......	None.	......	4.11	......	3.86	......	7.97	......	2.35	......	0.85	......
199	Pure Raw Bone Meal	Baxter Mill & Elc. Co., Baxter	4.17	3.75	......	......	......	......	......	......	10.70	10.00	......	......	......	......
200	Bone Grain Grower	Baxter Mill & Elc. Co., Baxter	1.85	......	None.	......	2.92	......	3.06	......	5.98	......	3.32	......	1.55	......
	Cudahy Packing Co.:															
155	Ground Cattle Tankage	Cudahy Packing Co., Kansas City	7.37	5.35	0.11	2.10	2.90	......	2.99	3.89	6.00	5.99	......	......	......	......
177	Ground Cattle Tankage	Cudahy Packing Co., Kansas City	6.02	5.35	None.	2.10	3.86	......	3.94	3.89	7.80	5.99	......	......	......	......
	Hull & Dillon:															
120	Enterprise Brand	Hull & Dillon, Pittsburg	4.95	6.74	......	......	2.86	2.95	3.60	1.07	6.46	4.02	0.34	0.44	0.25	
147	Enterprise Brand	Hull & Dillon, Pittsburg	5.07	6.74	0.09	......	2.17	2.95	3.37	1.07	5.63	4.02	0.30	0.44	0.35	......
202	Enterprise Brand	Hull & Dillon, Pittsburg	5.63	6.74	None.	......	2.36	2.95	2.50	1.07	4.86	4.02	0.45	0.44	0.35	......
	American Fertilizer and Reduction Company:															
118	Potato Grower	J. C. Ebenstein, Columbus	1.01	......	*	......	1.29	......	0.91	......	2.20	......	4.86		3.10	
119	Kaw Special	....	1.48	1.65	*	0.66	1.81	0.30	1.23	0.79	3.04	1.75	5.26	4.00	0.90	2.50
132	Kaw Special	J. C. Ebenstein, Columbus	1.51	1.65	None.	0.66	2.09	0.30	1.22	0.79	3.31	1.75	6.40	4.00	1.95	2.50
133	Raw Bone Meal and Manure Potash	J. C. Ebenstein, Columbus	1.37	1.64	0.05	0.87	2.48	1.50	2.89	4.80	5.42	5.67	5.26	2.49	1.45	1.20
	Empire Carbon Works:															
167	Pure Raw Bone Meal	G. F. Cotter, Mound Valley	3.64	3.29	......	......	......	......		......	8.00	8.75	......	......	......	......
194	Crop Grower	G. F. Cotter, Mound Valley	1.71	1.65	2.27	2.50	1.44	1.00	0.76	0.50	4.47	4.00	1.71	1.66	2.15	2.00
195	Bone Black Fertilizer	A. M. Smith & Son, Girard	2.01	2.05	2.40	3.49	1.07	3.49	0.74	0.87	4.21	4.63	1.27	1.25	1.65	......
196	Bone Black Fertilizer	G. F. Cotter, Mound Valley	1.92	2.05	2.38	3.49	1.33	3.49	0.43	0.87	4.14	4.63	1.30	1.25	1.70	......

*Trace.

We also submit herewith a statement of the receipts and expenditures from January 1, 1913, to June 30, 1914. The increased sale of tax tags and the registration of several additional brands of fertilizers show that the consumption of commercial fertilizers in this state is increasing rapidly. The importance of using such fertilizers intelligently and economically is thus constantly becoming of greater importance. The remainder of this bulletin contains an article by Professor Swanson, which is designed to assist farmers in such intelligent use of fertilizers.

FINANCIAL STATEMENT.

January 1, 1913, to June 30, 1914.

RECEIPTS.

	1913.	Balance January 1, 1913	$838.29
76	Jan. 4	Armour & Co., Kansas City, Kan., tax tags	100.00
77	Feb. 24	Amer. Red. & Fertilizer Co., Kansas City, Mo., registration fee	25.00
78	Mar. 4	Swift & Co., Kansas City, Kan., registration fee	25.00
79	Mar. 12	Armour Fertilizer Works, Kansas City, Kan., tax tags	100.00
80	Mar. 22	Amer. Red. & Fertilizer Co., Kansas City, Mo., tax tags	10.00
81	Apr. 5	Swift & Co., South St. Joseph, Mo., tax tags	125.00
82	Apr. 14	Swift & Co., Kansas City, Mo., registration fees	125.00
83	May 6	Swift & Co., Kansas City, Kan., tax tags	25.00
84	May 6	Swift & Co., South St. Joseph, Mo., tax tags	125.00
85	July 14	Armour & Co., Kansas City, Kan., tax tags	100.00
86	Aug. 1	Sulzberger & Sons Co., Kansas City, Kan., tax tags	50.00
87	Aug. 1	Amer. Red. & Fertilizer Co., Kansas City, Mo., tax tags	10.00
88	Aug. 6	Amer. Red. & Fertilizer Co., Kansas City, Mo., tax tags	10.00
89	Aug. 6	Empire Carbon Works, St. Louis, Mo., tax tags	125.00
90	Aug. 19	Amer. Red. & Fertilizer Co., Kansas City, Mo., tax tags	15.15
91	Aug. 21	Swift & Co., Kansas City, Kan., tax tags	125.00
92	Aug. 27	Sulzberger & Sons Co., Kansas City, Kan., tax tags	50.00
93	Sep. 4	Empire Carbon Works, St. Louis, Mo., tax tags	62.50
94	Sep. 5	Sulzberger & Sons Co., Kansas City, Kan., tax tags	50.00
107	Sep. 17	Swift & Co., South St. Joseph, Mo., tax tags	100.00
95	Sep. 20	Armour & Co., Kansas City, Kan. tax tags	100.00
96	Sep. 20	Empire Carbon Works, St. Louis, Mo., tax tags	25.00
97	Sep. 20	Empire Carbon Works, St. Louis, Mo., tax tags	25.00
98	Sep. 20	Empire Carbon Works, St. Louis, Mo., tax tags	25.00
99	Sep. 20	Empire Carbon Works, St. Louis, Mo., tax tags	25.00
100	Sep. 20	Hirsh Stein & Co., Chicago, Ill., tax tags	57.50
101	Sep. 23	Armour & Co., Kansas City, Kan., tax tags	100.00
102	Sep. 24	Hirsh Stein & Co., Chicago, Ill., tax tags	25.00
103	Sep. 24	Amer. Red. & Fertilizer Co., Kansas City, Mo., tax tags	5.00
104	Sep. 29	Sulzberger & Sons Co., Kansas City, Kan., tax tags	25.00
108	Oct. 8	Swift & Co., South St. Joseph, Mo., tax tags	125.00
105	Oct. 10	Swift & Co., South St. Joseph, Mo., tax tags	125.00
	1914.		
106	Jan. 3	Armour & Co., Kansas City, Kan., tax tags	100.00
109	Mar. 2	Swift & Co., South St. Joseph, Mo., tax tags	125.00
110	Mar. 6	Sulzberger & Sons Co., Kansas City, Kan., tax tags	25.00
111	Mar. 12	Empire Carbon Works, St. Louis, Mo., tax tags	50.00
112	Mar. 26	Swift & Co., South St. Joseph, Mo., tax tags	125.00
113	Apr. 8	Swift & Co., South St. Joseph, Mo., registration fees	50.00
114	Apr. 16	Armour Fertilizer Works, Chicago, Ill., registration fee	25.00
115	May 6	Swift & Co., South St. Joseph, Mo., registration fee	25.00
116	May 19	Sulzberger & Sons Co., Chicago, Ill., registration fees	100.00
		Total receipts	$3,483.41

DISBURSEMENTS.

1913.		
Jan. 13	E. N. Rodell, Manhattan, Kan., printing index cards	$3.15
Jan. 1	Manhattan Gas Co., Manhattan, Kan., gas	9.60
Jan. 28	F. P. Burnap, Kansas City, Mo., letter clips	.90
Feb. 8	Margaret Butterfield, Manhattan, Kan., freight	6.39
Apr. 1	Wareham Telephone Co., Manhattan, Kan., long-distance calls	1.45
Mar. 8	Margaret Butterfield, Manhattan, Kan., freight	1.10
Feb. 5	Grasselli Chemical Co., St. Louis, Mo., acid	36.82
Mar. 9	R. C. Wiley, Manhattan, Kan., traveling expenses	72.49
Apr. 18	R. C. Wiley, Manhattan, Kan., traveling expenses	6.30
Jan. 8	Eimer & Amend, New York, N. Y., filter paper	33.50
May 7	Wareham Telephone Co., Manhattan, Kan., long-distance calls	.30
Mar. 4	W. W. Carlson, Manhattan, Kan., brass washers	.35
Apr. 18	J. T. Willard, Manhattan, Kan., alcohol	3.25
May 1	Manhattan Gas Co., Manhattan, Kan., gas	21.80
May	Labor pay roll, from soils	28.42
May	R. I. Throckmorton, Manhattan, Kan., salary	91.67
May	R. C. Wiley, Manhattan, Kan., salary	110.00
May 15	Labor pay roll	60.00
June 2	L. L. Brown, Manhattan, Kan., celluloid	1.00
May 31	E. L. Knostman, Manhattan, Kan., sample case	3.50
June 14	W. W. Carlson, Manhattan, Kan., sandpaper	.10
May 29	E. N. Rodell, Manhattan, Kan., cardboard	.15
May 5	J. O. Hamilton, Manhattan, Kan., fuses	.30
June 21	Palace Drug Store, Manhattan, Kan., films, etc.	3.90
May 31	Students' Cooperative Book Store, Manhattan, Kan., record book	.30
May 24	Margaret Butterfield, Manhattan, Kan., colored map	8.00
May 23	E. B. Paslay, Manhattan, Kan., prints	3.31
May 10	College Book Store, Manhattan, Kan., ink	.75
June 15	Labor pay roll	15.66
June 15	Labor pay roll from soils	32.74
June	R. I. Throckmorton, Manhattan, Kan., salary	91.67
June	R. C. Wiley, Manhattan, Kan., salary	110.00
June 30	Labor pay roll	23.62
July 15	Labor pay roll	28.50
July 19	C. O. Swanson, Manhattan, Kan., traveling expenses	57.29
July 28	Ira Evans, Manhattan, Kan., drayage	.20
July 23	Margaret Butterfield, Manhattan, Kan., freight	1.73
Aug. 15	Labor pay roll	65.80
Aug. 21	B. L. Strother, Manhattan, Kan., printing blanks	5.41
Aug. 6	Henry Heil Chemical Co., St. Louis, Mo., rubber tubing	10.27
Aug. 29	James T. Lardner, Manhattan, Kan., tags	4.70
Sep. 15	Labor pay roll	52.63
Sep. 15	Grasselli Chemical Co., St. Louis, Mo., ammonia	9.74
Sep. 5	Dennison Mfg. Co., Kansas City, Mo., tags	42.30
Sep.	Manhattan Gas Co., Manhattan, Kan., gas	5.90
Oct. 28	Dennison Mfg. Co., Kansas City, Mo., prepaid freight	3.43
Oct. 4	Carpenter Paper Co., Omaha, Neb., paper	1.93
Oct. 15	Labor pay roll	45.54
Nov. 11	L. R. Eakin, Manhattan, Kan., Mason jars	2.75
Nov. 11	Woldenberg & Schaar, Chicago, Ill., apparatus	4.70
Nov. 26	Bausch & Lomb Optical Co., Rochester, N. Y., chemicals	9.18
Dec. 15	Labor pay roll	64.13
Oct.	James T. Lardner, Manhattan, Kan., gas	10.00
Dec. 5	Woldenberg & Schaar, Chicago, Ill., apparatus	74.07
Dec. 20	Grasselli Chemical Co., St. Louis, Mo., acid	47.76
Nov. 15	Labor pay roll	30.76
Nov. 26	Eimer & Amend, New York, chemicals and appratus	31.87
Dec. 22	Woldenberg & Schaar, Chicago, Ill., apparatus	6.70
Dec. 31	B. L. Strother, Manhattan, Kan., paper	3.45
Dec. 31	J. T. Willard, Manhattan, Kan., alcohol	3.25
1914.		
Jan.	Labor pay roll	60.95
Feb.	Labor pay roll	31.59
Mar. 10	Labor pay roll	52.82
Mar. 23	R. C. Wiley, Manhattan, Kan., traveling expenses	55.83
Feb. 17	Eimer & Amend, New York, N. Y., chemicals	16.00
Mar.	Manhattan Gas Co., Manhattan, Kan., gas	4.60
Apr.	Labor pay roll	60.51
Feb. 18	Eimer & Amend, New York, N. Y., apparatus	50.71
Mar. 31	Jacob Lund, Manhattan, Kan., material and labor	20.04
Mar. 17	J. O. Hamilton, Manhattan, Kan., material and labor	19.62
Mar. 21	Henry Heil Chemical Co., St. Louis, Mo., chemicals	3.54
Mar. 31	W. W. Carlson, Manhattan, Kan., material and labor	7.61
Apr. 17	J. T. Willard, Manhattan, Kan., chemicals and apparatus	75.20
May 10	Labor pay roll	75.52
June 1	Jacob Lund, Manhattan, Kan., material and labor	3.57
June 10	Labor pay roll	145.49
June 29	Jacob Lund, Manhattan, Kan., material and labor	29.67
June 30	Labor pay roll	130.47
	Total disbursements	$2,250.22

II. The Value and Use of Commercial Fertilizers.

C. O. SWANSON, Associate Chemist.

INTRODUCTORY REMARKS.

Why should a farmer in Kansas bother himself with the problem of commercial fertilizers? The figures compiled by the State Board of Agriculture show an average gradual decrease in crop production per acre in all the leading crops. In the forty-year period, 1872-1911, the first twenty years show a larger average crop production per acre than the second twenty years. In such long periods of time the bad years are averaged with the good. In the years 1872-1891 the corn crop in Allen county averaged 29 bushels per acre, and for the years 1892-1911 the average was 20 bushels. In Brown county for the first twenty-year period the average was 36 bushels, and for the second twenty-year period 30 bushels. In Russell county the first period shows an average of 24 bushels, and the second 17 bushels. Riley county had an average of 33 bushels in the first period and 25 bushels in the second. Sedgwick county shows an average of 32 bushels in the first period and 21 bushels in the second period. If these facts are coupled with the fact that the farmer has continually improved his seed and methods of farming, it makes the thoughtful man stop and consider.

The farmers of the United States spend annually $120,-000,000 for commerlcial fertilizers.* The sale of tax tags shows that in 1913 the Kansas farmers bought 7380 tons. At an average, price of $30 per ton, this would amount to $221,-400. By far the greater amount was spent in southeastern Kansas.

To use fertilizers profitably is not an easy problem. It is probably one of the most difficult problems to master in connection with the farming occupation. Before a farmer decides to spend money for fertilizers it will pay him to make a careful study of this problem. The following pages are written with a view to help the farmer. What is permanently best for the farmer is also permanently best for the manufacturer. In such a brief space it is impossible to cover the ground entirely.

* Senate Document, 190.

Information in regard to Kansas soils is given in Bulletin 199, copies of which may be had on application to Director W. M. Jardine, Manhattan, Kan. The following books will also be helpful :

"The Fertility of the Land," by I. P. Roberts.

"Fertilizers," by E. B. Voorhees. Sold by MacMillan Co., New York.

Fertilizers and Crops," by L. L. Van Slyke. Sold by Orange Judd Co., New York.

"Soil Fertility and Permanent Agriculture," by C. G. Hopkins. Sold by Ginn & Co., Chicago.

The addition of these books to the farmer's library will be a profitable investment. It should be remembered, however, that these books were written for conditions prevailing in a more humid climate than found in Kansas. While the general principles hold good, the specific directions may not always apply to Kansas conditions.

WHY IS IT NECESSARY TO ADD FERTILIZERS TO THE SOIL?

If soils decrease in crop-producing power when they are made to produce crops, it means that something necessary for crop production is removed from the soil. If the addition of certain substances to the soil increases the crop-producing power of the soil it means that the soil needs these substances and that to a certain extent these substances supply what has been removed from the soil.

WHAT ARE COMMERCIAL FERTILIZERS?

Commercial fertilizers are substances which by the nature of their chemical composition are sold for the distinct purpose of increasing the crops produced by land. This statement is broad enough to include all commercial fertilizers, and it also includes some substances which are not commercial fertilizers as that term is used. The dung of domestic animals, or barnyard manure, lime and gypsum are used for the distinct purpose of increasing the crops produced by land, but these are not commercial fertilizers.

THE ELEMENTS OF VALUE IN FERTILIZERS.

Commercial fertilizers always contain one or more of three elements, and the amounts of these elements present is the basis for the valuation of commercial fertilizers. These three elements are nitrogen, phosphorus, and potassium. Nitrogen is a gas present in the air to the extent of about 1500 pounds per square foot. In this form it can be used only by leguminous plants, and not at all by cereal crops. Phosphorus and potassium are solids, poisonous and dangerous to handle, but chemically so active that they are never found free in nature; that is, they rapidly form compounds, and in the form of compounds these elements are found in the soil, in farm products, and in commercial fertilizers. After nitrogen has been taken up by the leguminous plants and has become a part of the compound, it enters upon that cycle of changes by which it is made useful to other plants.

In all the discussion which follow it should be clearly understood that while we speak of the elements as though we handled them, it is the compounds containing these elements which are handled.

ELEMENTS ESSENTIAL FOR CROP PRODUCTION.

Carefully conducted experiments have shown that there are ten chemical elements which are absolutely essential to the production of crops. These are *(a)* carbon, hydrogen, and oxygen; *(b)* nitrogen, phosphorus, potassium, and calcium; *(c)* sulphur, magnesium, and iron.

The three elements in group *(a)* are obtained by the plant from the air and water. The ultimate source is unlimited, and therefore they have no commercial value. These three elements are the only ones found in such materials as fats, oils, sugars, and starches. To sell butter fat or sugar means, from the standpoint of soil fertility, to sell transformed sunshine, air and water. This is the fundamental reason why a system like dairy farming can be managed so as to keep up the fertility of the soil better than other systems of farming.

The elements in groups *(b)* and *(c)* are obtained directly from the soil by most plants. There is a fundamental difference between the supply and the demand of the elements in these two groups. The elements in group *(c)* are used to a very small extent by the crops, while the supply in the soil is very large, The situation is one of large capital and small expenditure. With the elements in group *(b)* the situation is the reverse. The amount present in the soil is small in proportion to the amounts used. The situation is one of large expense and small supply. This is the fundamental reason why the elements nitrogen, phosphorus, potassium and calcium are bought in the form of compounds and added to the land for the purpose of increasing crop production.

THE PECULIAR PLACE OF CALCIUM OR LIME.*

Calcium is not included in the valuation of commercial fertilizers. It is, however, bought and added to land for the purpose of increasing the crop production. The position of calcium, however, is entirely different from that of nitrogen, phosphorus, and potassium. These are put on land primarily to feed the crops. Calcium has two functions. It is one of the elements necessary for crop production, but the amount so used is small compared with the amount needed to correct certain deficiencies in the soil. It corrects acidity, it helps to give heavy soils a better texture or tilth, it helps to liberate plant food. The amount of calcium needed to perform these functions is so great that when this is supplied the food requirements are more than satisfied. Calcium is found in a large number of substances used in the manufacture of commercial fertilizers. This calcium is not without value, but the amount which can be added in this way is too small even for the needs of the crop.

FERTILIZER ELEMENTS IN TYPICAL CROPS : WHEAT AND ALFALFA.

Wheat and alfalfa are typical Kansas crops. In forty bushels of wheat there are 56.8 pounds of nitrogen, 9.6 pounds of phosphorus, and 10.4 pounds of potassium. In the two tons of wheat straw which bears this grain there are 20 pounds of nitrogen, 3.2 pounds of phosphorus, and 36 pounds of potassium. These figures teach this fundamental fact: the nitrogen and phosphorus accumulate to the largest extent in the grain, while potassium accumulates to the largest extent in the straw. The same relative proportion is true for all grain crops,

In three tons of alfalfa there are 150 pounds of nitrogen, 14 pounds of phosphorus, and 145 pounds of potassium. Alfalfa, as a typical legume, differs from grain crops in this fundamental respect: it can take up nitrogen from the air, but it will also take it from the soil if the conditions are favorable. Just how much nitrogen a typical legume like alfalfa takes from the air and how much it may take from the soil is a question not very easy to determine. Dr. C. G. Hopkins of the Illinois Experiment Station makes the following statement: †

* It should be said in this connection that the terms calcium and lime are used interchangeably. Calcium is the element, while lime is strictly the oxide of calcium, also known as quicklime. The term lime is sometimes made to include all compounds of calcium, such as limestone, or calcium carbonate, and gypsum, or calcium sulphate.

† Soil Fertility and Permanent Agriculture, page 217.

"From the experimental data here presented or referred to, and from many other calculations approximating exactness, the conclusion may be drawn that on normally productive soils at least one-third of the nitrogen contained in legume plants is taken from the soil and not more than two-thirds secured from the air. This proportion would apply to the nitrogen content of the roots as well as to the top; so that, if one-third of the nitrogen of the entire plant is in the roots and stubble and two-thirds in the crop harvested, the soil would neither gain nor lose in nitrogen because of the legume crop having been grown." This means that it is possible to grow alfalfa, and by selling the crop leave the soil as poor in nitrogen as before the alfalfa was grown. Besides, it should be noted that alfalfa removes several times as much phosphorus and potassium from the soil as does wheat or corn. Unless alfalfa is fed and the manure returned to the land we are not so sure that alfalfa increases the stock of nitrogen in the soil. (See also, page 640, Bulletin 199, Kansas Experiment Station.)

THE FIRST FUNDAMENTAL REASON FOR USING COMMERCIAL FERTILIZERS.

Fertilizer elements in soils are limited in quantity. The removal of plant food from the soil would not affect its fertility if the amount present in the soil was very large. The average of several analyses of typical soils in the state are as follows:

Pounds of elements in the soil to the depth of seven inches.

Class of soil.	Nitrogen.	Phosphorus.	Potassium.	Calcium.	Carbon.
Gray silt loam.........	3,740	860	28,400	11,000	43,000
Limestone clay loam....	4,040	1,040	36,000	15,000	47,800
Alluvial loam	3,160	1,020	39,000	13,000	33,800
Alluvial clay	4,380	1,240	40,400	11,800	46,800
Sandy loam	2,440	640	29,200	19,000	25,000
Alluvial silt loam......	3,980	1,240	37,400	23,200	60,600
Brown silt loam........	3,312	1,060	39,200	12,200	36,600
General average	3,400	940	35,600	13,600	37,200

Nitrogen and phosphorus are to a large extent the limiting elements in crop production in comparison with the other elements. If these figures are compared with the figures for the amounts used by crops, it is at once apparent that crop production is limited by the quantities of these elements in the soil. If the number of pounds present in the soil be divided by the amounts used by a crop, it will be found that nitrogen is used up fastest, phosphorus next, and that potassium will last the longest. If only the amounts of these elements which are present in the grain be considered, the quantities in the soil will last much longer than if both grain and straw or stalks are removed.

Nitrogen and phosphorus are found in larger amounts in the grain than in the straw, while potassium is found in larger amounts in the straw. Therefore if both grain and straw are removed, the loss of potassium becomes much more serious than when the grain only is removed. If only the grain is removed, the supply of potassium in the soil is so large that it will last for several thousand years; in fact, so large that if all the roughage is returned to the soil, together with what is furnished by weathering changes, it will last indefinitely. But when straw is burned in piles and the ash is leached into the drainage, and when alfalfa and other roughage is sold, potassium will be one of the limiting elements of crop production.

The apparently simple fact that there is a limited amount of nitrogen, phosphorus and potassium in the soil, and that crops remove definite quantities of these elements, is at the basis of the problem of soil fertility. This problem is complicated by seasonal variation and crop rotations. It is furthermore a problem incapable of direct demonstration, as the plants use only a certain per cent of what is present in the soil. *But the first fundamental reason for using the elements nitrogen, phosphorus and potassium in commercial fertilizers is that they occur only to a limited extent in the soil.*

THE SECOND FUNDAMENTAL REASON FOR USING COMMERCIAL FERTILIZERS.

Crops need these elements in an available form. In general terms, we may say that a soil consists of three portions — the organic matter, the soil water, and the mineral portion. The mineral portion has come from rock. These rocks contained phosphorus and potassium, and this is the ultimate source of these two elements. The organic portion has come from plant residues. As all plant substances contain nitrogen, phosphorus, and potassium, these elements are present in the organic matter of the soil. All the reserve nitrogen in the soil is found in the organic matter, as there was no nitrogen in the rock material.

If a spoonful of common salt is put into a tumbler of water, it all goes into solution. If a like amount of powdered limestone is put into the same amount of water, apparently none goes into solution. But if this is allowed to settle and a portion of the clear liquid is evaporated, we shall find a very small residue, which is limestone. The difference between the solubility of limestone and salt is one of degree. One is very soluble, and the other is only slightly soluble. All rock material in the soil is slightly soluble and the soil water contains this dissolved matter. The soil water also contains dissolved matter which has come from organic matter.

The nitrogen, phosphorus and potassium present in the organic matter is said to be in the organic form, while the phosphorus and the potassium present in the rock material is in the inorganic form. When any element is present in a compound which is soluble, it is in the soluble form, and when present in a compound which is insoluble it is in the insoluble form. In commercial fertilizers the elements nitrogen, phosphorus and potassium are either present in a soluble form or in a compound that is rapidly changed into a compound that is soluble. *This is the second fundamental reason for using commercial fertilizers.*

HOW FERTILIZERS ARE MANUFACTURED.

All substances sold as fertilizers have been subjected to some process which makes them more useful. The crude potash salts which are dug from the Stassfurt mines in Germany contain a large amount of impurities which have no value for crop production. The same is true for the nitrate deposits in Chile. These impurities must be removed. Even rock phosphate must first be ground to a very fine powder before it has any value for crop production. The bones and bone products of packing houses must be specially prepared. All these processes require labor, capital and business ability. This, together with the cost of the original materials, determines the cost of the fertilizers at the place of manufacture. The manufacture of fertilizers can be divided into two stages: (1) the purification and preparation of the raw material, and (2) the mixing of these raw materials into brands called complete fertilizers. This last does not apply to substances containing only one element, such as acid phosphate or muriate of potash.

RAW MATERIAL USED IN THE MANUFATURE OR MIXING OF FERTILIZERS.

The raw materials used in the manufacture or mixing of commercial fertilizers are obtained principally from the by-products of packing establishments, from phosphate mines, and potassium salts imported from Germany, and nitrate salts from South America.

The packing-house materials are principally:

Dried blood.
Raw bone.
Steamed bone.
Tankage.
Blood and tankage.

From phosphate mines are obtained:

Raw rock phosphates or floats.
Acid phosphates (manufactured from raw rock phosphate).

The imported potassium salts are:

Sulphate of potash.
Muriate of potash.
Kainit.
Hartsalz.
Manure salts.

Sodium nitrate is the principal nitrate salt imported from South America.

For an intelligent understanding of fertilizers and their use it is necessary to know the nature and composition of these different materials, Therefore a brief description follows:

Dried blood is the evaporated and finely ground blood obtained from slaughtered animals. It contains about 13 per cent of nitrogen.

Rawbone and steamed bone. Only such porous bones as the ribs and the joints are used for fertilizers. The bone as it is taken from the Carcass is composed of three classes of compounds—fats, nitrogenous material, and mineral matter. The fat has no fertilizing value. It is, however, a valuable commercial product and is therefore removed. Most of the nitrogenous matter is more valuable for the manufacture of gelatine and glue, and most of it, therefore, is removed by boiling or steaming. Those bones which have been boiled are known as raw bone, and those which have been steamed as steamed bone. The steaming removes the fat and the nitrogenous matter more thoroughly than the boiling. After either of these treatments the residue is easily reduced to a fine powder by grinding, and the product is known as bone meal. It averages about 3 per cent of nitrogen and 10 per cent of phosphorus.

Tankage is made up of small pieces of bones, tendons, flesh, blood, and other waste materials. This is cooked, evaporated, dried, and ground. What can be used for animal feed is so sold, and the residue is used for fertilizers. Tankage contains nitrogen and phosphorus. Because of the varying nature of the materials used in its manufacture, it is variable in composition. Blood and tankage is a mixture of blood and the tankage just described. Slaughterhouse products as a source of both phosphorus and nitrogen are necessarily limited.

Roch phosphate is the principal source of phosphorus. The principal mines are in South Carolina, Florida, and Tennessee. The largest deposits in the United States are in western Wyoming, northern Utah, and southern Idaho. These are not worked at present, but the phosphate lands are withdrawn from public entry, and can not, therefore, fall into the hands of speculators. These deposits contain as much phosphorus as would be used in a thousand years at the present rate of consumption. Rock phosphate, finely ground, is known on the market as floats. It contains from 12 to 14 per cent of phosphorus. This material is not at present sold as a commercial fertilizer under the current meaning of that term, but it is the original source of most of the phosphorus found in commercial fertilizers.

Acid phosphate is made from ground rock phosphate. Speaking in round numbers, one ton of the finely ground rock phosphate containing 14 per cent of phosphorus is mixed with one ton of sulphuric acid, and two tons of acid phosphate are obtained, which contains 7 per cent of phosphorus. The purpose of this treatment is to convert the insoluble form of phosphorus in the rock phosphate into soluble form in the acid phosphate. Because it is made in this way, or because of its method of manufacture, it must not be concluded that the material contains any free acid. A little less sulphuric acid is used than is necessary to convert all the phosphorus into the soluble form. Therefore, all acid phosphates contain a small per cent of phosphorus in the insoluble form. Whether it is best to use acid phosphate or the original material from which it is made will be discussed later.

Muriate of potash, or *potassium chloride,* is a compound of potassium and chlorine. It is manufactured from salts dug from the mines at Stassfurt, Germany. It usually contains a little over 40 per cent of potassium. At the present time the element potassium can be bought most cheaply in this form, and this salt is the source of most of the potassium found in mixed fertilizers. Because it contains chlorine, this form of potassium fertilizer is not considered as valuable for potatoes as the sulphate.

Sulphate of potash, or *potassium sulphate,* is also manufactured from salts obtained from the Stassfurt mines. It contains slightly less potassium than the potassium chloride, but this form is considered more valuable for such crops as potatoes, and the market price of potassium in this form is higher than that of potassium chloride.

Kainit is one of the crude salts obtained from the potassium mines. It contains, besides potassium chloride, magnesium chloride and sodium chloride, or common salt. Because of the large amount of these compounds which have no fertilizer value, potassium in kainit is usually more expensive than in any other form, This salt is often used by manufacturers as a source of potassium because it lessens the amount of filler necessary.

Hartsalz is a mixture of potassium chloride, magnesium sulphate, and sodium chloride. It is used by manufacturers for the same purpose that they use kainit.

Manure salts. These are mixtures of potassium sulphate, potassium chloride, and magnesium sulphate. They are used as sources of potassium in mixed fertilizers.

Nitrate of soda. This salt contains nitrogen in the most available form. It is therefore used as a standard for the comparison of the availability of nitrogen in other nitrogenous fertilizers.

GENERAL PROPERTIES OF SUBSTANCES USED IN THE MANUFACTURE OR MIXING OF FERTILIZERS.

All these substances are valuable for the making of commercial fertilizers, because they contain one or more of the elements nitrogen, phosphorus or potassium in relatively large amounts, and in a form that is either already soluble or is rapidly made so under the conditions which exist in the soil.

All the potassium is found in compounds soluble in water. This is so important that the fertilizer law does not recognize any other form.

In acid phosphate most of the phosphorus is soluble in water. In bone and other animal products the phosphorus is in a form that is insoluble in water, but because of the physical condition of these products the phosphorus is readily made soluble under the conditions which exist in the soil. When the fat and most of the nitrogenous material have been removed from bone, the residue is a spongy substance. When this is ground to a powder it consists, not of a mass of very fine particles which are solid, but of very small particles which themselves are spongy. That is the reason phosphorus in all bone products is quickly available. In rock phosphate the particles may be as small as those in bone meal, but they are solid, and therefore the phosphorus in this form is more slowly available.

In sodium nitrate and ammonium sulphate all the nitrogen is in a soluble form. For this reason the nitrogen in sodium nitrate is used as a standard with which other forms of nitrogen are compared. The nitrogen in dried blood and other slaughterhouse products is in an insoluble form, which, however, is quickly changed into the soluble form under the conditions in the soil.

TABLE III.—COMPOSITION AND VALUATION OF COMPLETE FERTILIZERS AND PRODUCTS FROM WHICH THEY MAY BE MADE.

Names of Brands of Fertilizers and Materials used in Mixing.	Formula.			Equivalent value.			Price per ton.	Price per pound.		
	Ammonia.	Phosphoric acid.	Potash.	Nitrogen.	Phosphorus.	Potassium.		Nitrogen.	Phosphorus.	Potassium.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*				
Complete fertilizers:										
No. 2-8-2 Fertilizer	2	8	2	1.65	3.5	1.66	$22.00	$0.20	$0.186	$0.07
Lawn and Garden Fertilizer	3.125	8	4	3.09	3.5	3.32	29.50	.20	.18+	.07
Special Potato Fertilizer	2	8	10	1.65	3.5	8.3	30.00	.20	.168	.07
Ammoniated Dissolved Bone and Potash	2	10	2	1.65	4.37	1.66	23.75	.20	.17—	.07
Products used in mixing:										
Fine ground beef bone	3	24	....	2.5	10.5	....	27.50	.15	.095	....
Raw bone meal	3.5	22	....	3.08	9.61	....	31.00	.15	.112	....
Acid phosphate	....	16	....	....	7	....	17.00	....	.12—	....
Muriate of potash	....	....	50	....	....	41.5	46.00	....	....	.055
Kainit	....	....	12	....	9.96	....	17.00	....	....	.09
Nitrate of soda	18	....	....	15	....	....	60.00	.20	....	....
Sulphate of ammonia	25	....	....	22.03	....	....	75.00	.17	....	....
Sulphate of potash	....	....	48	....	....	39.9	55.00	....	....	.07

MEANING OF THE TERMS AMMONIA, PHOSPHORIC ACID, AND POTASH.

These various substances which have been described are used to mix commercial fertilizers. The names of the first four brands in Table III are typical samples of complete fertilizers. The substances named below these four brands are typical substances which may be used in the mixing of complete fertilizers. Under "formula" are found the three words ammonia, phosphoric acid, and potash. These terms are very common in books and literature relative to commercial fertilizers. In fact, they are more common than the words nitrogen, phosphorus, and potassium. Ammonia is a compound which contains 14 parts by weight of nitrogen and 3 parts by weight of hydrogen. Posphoric acid is a compound which contains 62 parts by weight of phosphorus and 80 parts by weight of oxygen. Potash is a compound which contains 78.2 parts by weight of potassium and 16 parts by weight of oxygen. Hydrogen and oxygen are the elements of which water is made, and so have no commercial value in fertilizers. The rational basis of valuation is, therefore, to use the percentage of the elements. But because these terms are found in the literature, every user of fertilizers should know how to convert percentages of ammonia, phosphoric acid and potash into the equivalent percentages of nitrogen, phosphorus and potassium. Ammonia multiplied by $^{14}/_{17}$ gives the equivalent in nitrogen; phosphoric acid multiplied by $^{62}/_{142}$ gives the equivalent in phosphorus; potash multiplied by $^{78.2}/_{92.2}$ gives the equivalent in potassium. Working these relations into their equivalent decimals we have the following:

Per cent phosphoric acid multiplied by .437 = per cent phosphorus.
Per cent phosphorus multiplied by 2.290 = per cent phosphoric acid.
Per cent potash multiplied by .830 = per cent potassium,
Per cent potassium multiplied by 1.205 = per cent potash.
Per cent ammonia multiplied by .823 = per cent nitrogen.
Per cent nitrogen multiplied by 1.216 = per cent ammonia.

The figures in the columns under "Formula," Table III, indicate the percentages of the compounds ammonia, phosphoric acid and potash. The equivalent values of these compounds in terms of percentages of the valuable elements is given in the next three columns of the table. They are obtained by using the figures just given. Two per cent ammonia multiplied by

.823 gives 1.65 per cent nitrogen; 8 per cent phosphoric acid multiplied by .437 gives 3.5 per cent phosphorus; 2 per cent potash multiplied by .830 gives 1.66 per cent potassium. In this way all the figures under "Equivalent value'' are obtained from the figures under "Formula." In all valuations of commercial fertilizers it should be remembered that the element is the ultimate and real basis of valuation. A statement that a fertilizer contains 10.5 per cent of phosphorus, equivalent to 24 per cent phosphoric acid and 52.5 per cent of bone phosphate, is entirely correct from the chemical standpoint, but the figures 24 and 52.5 do not create any value in the fertilizer. The same argument applies to the valuation of nitrogen and potassium.

HOW A COMPLETE FERTILIZER MAY BE MADE.

The four complete fertilizers mentioned in 'Table III can be made by using the raw materials mentioned in the preceding pages. Suppose we want to make a fertilizer having the formula 2-8-2, or the equivalent 1.65-3.5-1.66, and that we decide to use nitrate of soda, acid phosphate, and muriate of potash. How much of these substances are required to make a ton of the above formula? The same method of figuring will hold for other substances. It is only necessary to use the right figures for the composition of the substances used in mixing the'fertilizers. If the ready-mixed fertilizer shall contain 1.65 per cent nitrogen, 3.5 per cent phosphorus, and 1.66 per cent potassium, one ton will contain 33 pounds of nitrogen, 70 pounds of phosphorus, and 33.2 pounds of potassium. One hundred pounds each of nitrate of soda, acid phosphate and muriate of potash contain, respectively, 15 pounds of nitrogen, 7 pounds of phosphorus, and 41.5 pounds of potassium. The calculation involves this simple arithmetical process: If 100 pounds of nitrate of soda contains 15 pounds of nitrogen, how much nitrate of soda is required to contain 33 pounds?

35 ÷ 15 multiplied by 100 = 220 pounds nitrate of soda.
70 ÷ 7 multiplied by 100 = 1000 pounds acid phosphate.
33.2 ÷ 41.5 multiplied by 100 = 80 pounds muriate of potash.

This is equal to 1291 pounds of material, and to make this material equal to one ton it is necessary to add 609 pounds of some inert material as filler.

THE MEANING AND VALUE OF "FILLERS."

The fillers used in the fertilizers sold in Kansas are pulverized manure, dried sheep manure, and baked clay or sand. In reality, the only real filler is baked clay or sand. Pulverized manure or sheep manure contains a certain amount of nitrogen, phosphorus, and potassium. Ordinary mixed farm manure contains 10 pounds of nitrogen, 2 pounds of phosphorus, and 8 pounds of potassium. Dried sheep excrement, according to Prof. L. L. Van Slyke {solid portion only), contains in one ton 38 pounds of nitrogen, 11 pounds of phosphorus, and 19 pounds of potassium. The 600 pounds of filler, if it is composed of the dried solid excrement from sheep, would contain 11 pounds of nitrogen, 3.3 pounds of phosphorus, and 6.7 pounds of potassium. At 15 cents per pound for nitrogen, 12 cents for phosphorus, and 5.5 cents for potassium, these elements in the filler are worth $1.65 for the nitrogen, 40 cents for the phosphorus, and 30 cents for the potassium, or $2.35 for the 600 pounds of dried sheep manure.* At the same prices, a ton of average mixed manure would be worth $2.18. This emphasizes the value of farm manure, and is actually the price paid by the farmer for fillers in fertilizers when these fillers are some form of excrement from domestic animals. Obviously, in the strict sense of the term, the only filler that should be used is baked clay or sand. While these may contain traces of phosphorus and potassium, the amounts in such forms as give value to fertilizers are so small that they are entirely negligible. The fertilizer elements found in the manure used as fillers are valuable, but this value is different from that of the elements in the materials used to compound fertilizers. At the maximum, only 50 per cent of the value of these elements is obtained the first year, while in fertilizers the full value of the elements is expected.

COMPARATIVE COST OF FERTILIZERS.

The cost of commercial fertilizers depends on the cost of the materials used in their manufacture, the labor and capital necessary to carry on the process, transportation to the consumer, and the profit of those engaged in the business.

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* This valuation for potassium in manure may be high when considered from the standpoint of commercial fertilizers, as very little of this potassium is soluble in water and so obtained by the methods of analysis used. But the valuation for phosphorus and nitrogen are low to make up for this excess valuation of potassium.

TRADE VALUES OF ELEMENTS IN DIFFERENT SUBSTANCES.

Men charged with the inspection of commercial fertilizers in the eastern states adopt annually a schedule of trade values. The following schedule was adopted for use in 1913. The data are taken from Bulletin 261 of the New Jersey Experiment Station.

	Cents per pound.
Nitrogen in nitrates	18.50
Nitrogen in ammonium salts	18.50
Organic nitrogen in fine ground meal, fish and blood	20.00
Organic nitrogen in cottonseed meal and castor pomace	20.00
Organic nitrogen in fine bone, tankage and mixed fertilizers	19.00
Organic nitrogen in coarse bone and tankage	15.00
Phosphorus in phosphates soluble in water	10.31
Phosphorus in phosphates soluble in ammonium citrate	9.16
Phosphorus in phosphates in fine* bone and tankage	9.16
Phosphorus in phosphates in cottonseed meal and castor pomace,	9.16
Phosphorus in phosphates in coarse bone, tankage and ashes	8.02
Phosphorus in phosphates insoluble in water and ammonium citrate solution	4.58
Potassium in high-grade sulphates and free from muriate (chloride)	6.33
Potassium in muriate (potassium chloride)	5.12
Potassium in cottonseed meal and castor pomace	6.02

MEANING OF TERMS USED IN THE "TRADE VALUES" OF ELEMENTS IN DIFFERENT SUBSTANCES.

In the preceding paragraph nitrogen is given as occurring in six different kinds of substances. The nitrogen in nitrates and in ammonium salts is in the soluble form. The nitrogen in nitrates is in a form that can be used immediately by the plants. While some nitrogen can be used by the plants in the form of ammonium salts, not much is so used, because these are rapidly changing to the nitrate form. The nitrogen in the different organic substances is not soluble. But these substances undergo rapid decay as soon as they are put on the soil. The nitrogen is rapidly changed to nitrates, in which form it is used by plants. The nitrogen in crop residues is as valuable as the nitrogen in any of these substances after it has been changed to the nitrate form, but crop residues undergo decay and nitrification much slower than these substances. This is one reason the effect of barnyard manure persists so long and why it takes several years to obtain the full value.

Phosphorus is given as occurring in six different kinds of substances. The phosphorus in phosphates soluble in water

* "Fine" signifies such as will pass through a sieve with circular holes one-fiftieth of an inch in diameter, and "coarse" such as will not.

is in the most available form, This is the form of the phosphorus in acid phosphates. This is the form in which it is used by the plants and into which all other forms are changed before they are used. The phosphorus soluble in ammonium citrate is also known as phosphorus in reverted phosphates. This form is found to a small extent in acid phosphate, and to a larger extent in the bone preparations. By some it is considered almost, if not quite, as valuable as the water-soluble form. The phosphorus in phosphates obtained from bone and seeds is largely in an insoluble form; but because of the peculiar physical structure of bone, this form of phosphorus is changed in the soil into soluble forms as fast as the plants need it. Phosphorus in phosphates insoluble in water is the form it has in rock phosphate. This form is made soluble by decaying organic matter; but this takes time, and if the decaying organic matter is not in the soil the phosphorus will not be of much use to the crop.

Potassium is given as occurring in three different kinds of substances. The potassium in sulphates and muriate is soluble, and therefore immediately available. The potassium in the muriate (chloride) form is considered less valuable because it can not be used for some vegetables. The potassium in cottonseed and castor pomace is insoluble. But these organic materials decay rapidly and the potassium becomes available.

THE COST OF DIFFERENT ELEMENTS IN COMMERCIAL FERTILIZERS.

The above valuations are based on the prices of raw materials at the Atlantic seaboard. In Table III an attempt is made to calculate the values of the elements in fertilizers based on the prices f. o. b. Kansas City, Kan., ton lots.* With substances that contain only one element the problem is simple. It is only necessary, on the basis of composition, to calculate the number of pounds of that element in a ton, and divide this into the cost. In this way we find potassium in muriate of potash is worth 5½ cents per pound, in sulphate of potash 7 cents per pound, in kainit 9 cents per pound. Nitrogen in nitrate of soda is worth 20 cents per pound, and in ammonium sulphate 17 cents per pound. Phosphorus in acid phosphate is worth a little less than 12 cents per pound.

With complete fertilizers containing two or three elements the problem of calculating the cost of each element is more

* These figures are based on quotations obtained in the early summer of 1914.

complicated. It is necessary to assume a value for one or two elements. Muriate of potash or potassium chloride is the substance mostly used as a source of potassium. The large amount of chlorine found in the inspection samples are evidence of this. In the muriate of potash the price is 5½ cents per pound. The manufacturer is entitled to profit on labor, investment and risk. To allow for this, 7 cents per pound is the assumed valuation of potassium in the complete fertilizer. Nitrogen in sulphate of ammonia is worth 17 cents per pound, and 20 cents per pound in nitrate of soda, but only 15 cents in bone and tankage. Whatever nitrogen there may be present in the filler is given full value in the analysis. For these reasons an assumed valuation of 20 cents per pound in complete fertilizers is not unreasonable. On these assumptions in regard to the valuation of nitrogen and potassium, we find that phosphorus varies in value from 18.6 cents to a little less than 17 cents per pound in complete fertilizers If we assume a price of 15 cents per pound for nitrogen in the bone fertilizers, then the phosphorus is worth 9.5 cents per pound in fine ground beef bone and 11.2 cents per pound in raw bone meal. This shows that at the prices given, the elements nitrogen and phosphorus are cheapest in the bone fertilizers, and that all elements are most expensive in the complete fertilizers. If it is remembered in this connection that a part of the nitrogen and phosphorus in some ready-mixed fertilizers comes from sheep manure, the price is rather high for using with field crops.

THE COST OF PHOSPHORUS IN ROCK PHOSPHATE.

In the schedule of trade values the insoluble phosphorus is rated at one-half the value it has in the reverted form. The price of phosphorus in the form of rock phosphate is the cheap: est form in which it can be bought. At $9.20 per ton, analyzing 12½ per cent phosphorus, the price is 3.7 cents per pound. In this form it takes a long time for it to become available, but at this price the farmer can afford to put on very much larger quantities.

WILL IT PAY TO USE FERTILIZERS?

Will it pay a farmer to buy commercial fertilizers at present current prices and apply to land for the purpose of increasing the crop? This is one of the most difficult questions to answer directly. Obviously, if the crop produced gives a return whose value is over and above that paid for the fertilizer and the cost of application, then it pays to that extent. But the problem is not so simple as that.

THE PROBLEM OF POTASSIUM.

Above it was shown that the soils of Kansas which have been analyzed contain from 28,400 to 40,000 pounds of potassium in the surface soil.* A ton of mixed fertilizers of the formula 2-8-2 contains thirty-three pounds of potassium. It is a fair question to ask, How can this small amount affect crop production when the soil already contains 30,000 pounds? The most obvious answer would be that the potassium applied in the commercial fertilizer is in the soluble form, while that in the soil is in the insoluble form. The straw from a twenty-blushel wheat crop contains 18 pounds of potassium, and the cornstalks from a forty-bushel corn crop contains 20.8 pounds of potassium, while one ton of alfalfa contains 48 pounds. This potassium has come from the soil, and before it can be used by the plant it must be converted into a soluble form.

The only reason for adding potassium to the soil in a soluble form would be that the potassium in the soil is not made soluble fast enough to meet the needs of the crop. From this it follows that a crop which has a long growing season needs the application of potassium in the soluble form much less than one which has a short growing season. Also, if the soil conditions are poor, the application of potassium in the soluble form may help the plant in its first stages of growth. But if the soil contains 30,000 pounds of potassium it should be the first concern of the farmer to convert this into usable forms before he invests his money in forms that are already usable. Practically every soil in the state of Kansas which has been analyzed by the Agricultural College will have sufficient potassium for the use of the ordinary field crop if the organic matter in that soil is not allowed to be depleted. With a crop like potatoes, which has a short growing season, and when it is desired to produce a very large crop, it would be rational to use potassium to increase crop production. Manufacturers have recognized this need by putting five times as much potassium in special potato fertilizers as they put in fertilizers intended for grain crops

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* Some soils in southeast Kansas contain much less than this.

THE PROBLEM OF NITROGEN.

The soils in the state of Kansas which have been analyzed average from 2440 to 4040 pounds of nitrogen in the surface soil. A ton of mixed fertilizer of the formula 2-8-2 contains 33 pounds of nitrogen, and 400 pounds would contain 6.6 pounds of nitrogen. Will it pay to apply this small amount to soil that already contains from 2500 to 3500 pounds of nitrogen? As with potassium, the answer would be to supply the soil with some nitrogen in a soluble form. But the nitrogen in the ordinary mixed commercial fertilizer is not all in the form of sodium nitrate, Some of it is in the form of dried blood, and when sheep manure is used as filler, this is no more soluble than the nitrogen in farm manure. All nitrogen must be converted into soluble forms before it can be used by the plants. This change occurs rapidly in all substances which decay rapidly. The nitrogen in that portion of farm manure or plant residue which decays most rapidly is first changed to soluble forms. The more resistant portion remains as part of the organic matter of the soil. Nitrogen in dried blood and similar substances is changed into the soluble form very quickly.

Twenty bushels of wheat (grain) contains 28.4 pounds of nitrogen, and twenty-five bushels of corn (grain) contains 25 pounds of nitrogen, This must all come from the soil during the growing season. If the growing season is long, as in the case of corn and wheat, it is better to have conditions such that the necessary transformations can be made. At 15 cents per pound, which is less than nitrogen can be bought for, the nitrogen in a bushel of corn is worth 15 cents, and in a bushel of wheat it is worth 21 cents. At these prices the farmer can not afford to buy nitrogen that goes into his corn and wheat.

One ton of alfalfa contains 50 pounds of nitrogen. At 15 cents per pound this is worth $7.50. With careful handling of the manure the farmer can recover three-fourths of this. Obviously, the source of nitrogen for farm crops is some legume like alfalfa. For garden and the truck farm the high-priced nitrogen may pay.

THE PROBLEM OF PHOSPHORUS.

The amount of phosphorus in those Kansas soils which have been analyzed averages from 640 pounds to 1240 pounds per acre to the depth of seven inches. A crop of forty bushels of wheat, both grain and straw, contains 12.8 pounds of phosphorus, and a fifty-bushel crop of corn, both grain and stalks, contains 11.6 pounds of phosphorus. At 12 cents per pound, the price of phosphorus in acid phosphate, the cost for all the phosphorus which goes into the crop is $1.54 for the wheat crop and $1.40 for the corn crop. As far as the expense goes the farmer can afford to buy all the phosphorus which goes into his wheat crop or corn crop, even if the increased crop production is relatively small.

All the complete fertilizers which are intended for grain fertilizers contain more phosphorus than nitrogen or potassium. A few of those intended for potato or truck farming have more potassium than phosphorus or nitrogen.

On the basis of soil composition, and on the basis of the amounts of nitrogen, phosphorus and potassium used by crops, the first two are likely to be the limiting elements in crop production. Most soils contain a sufficiency of potassium for the needs of farm crops, and this will be available if the soil is kept in good tilth by cultivation and the application of organic matter. Nitrogen and phosphorus would pay if judgment was based on soil composition. To answer this question it is best to turn to experience. (See further on, "The Lesson from Experience.")

THE PROBLEM OF CALCIUM OR LIME.

The amount of calcium in Kansas soils averages from 11,000 pounds to 23,200 pounds per acre. If this was all in the form of carbonate it would be equivalent to from 13 to 29 tons of limestone per acre in the surface soil. The entire absence of inorganic carbon in many Kansas soils, shown by the soil analysis reported in Bulletin 199, shows that in many soils calcium is not present in the carbonate form, but in some unavailable form such as silicate. The leading grain crops, such as corn, wheat and oats, do not use any more calcium than of phosphorus, and the smaller portion of calcium goes to the seed. Alfalfa takes more calcium from the soil than any other crop. In one ton there are 26 pounds, but this is a small amount compared with the large amount present in the soil.

As was pointed out in a preceding paragraph, calcium is added to the soil not so much to feed the crops as to correct certain soil deficiencies, and when enough is applied to the soil for this purpose more than enough is supplied for the food requirements of the plant. When calcium is found in comparatively insoluble forms it does not correct these soil deficiences, and it is necessary to add calcium in forms that will bring about the desired results.

Calcium may be obtained in three forms—ordinary quicklime, slaked lime, and ground limestone. Quicklime is obtained from limestone by burning. This is an expensive process. Quicklime is caustic (burning), and if added to the soil would have a tendency to burn up the organic matter. Slaked lime is obtained from quicklime by adding water or exposure to the air. This is a quick-acting form. But for farm purposes it is too expensive. For experimental purposes on a small scale this form can be used profitably. The safest and cheapest form of calcium is in the form of ground limestone. The only expense is that of grinding and transportation. For acid soils an application of two to four tons per acre is recommended. The ground limestone can be applied to the soil by the ordinary fertilizer drills.

THE PROBLEM OF ORGANIC MATTER.

The importance of keeping up the organic matter in the soil can not be overemphasized. The addition of fertilizers or of lime will not keep up the organic matter. It can only be kept up by the addition of crop residues or barnyard manure. At 15 cents per pound for nitrogen, 12 cents for phosphorus, and 5.5 cents for potassium, these elements in a ton of average barnyard manure are worth $2.18. When the barnyard manure decays in the soil these elements will be as valuable for crop-producing purposes as those obtained from fertilizers. In addition the barnyard manure adds organic matter to the soil. This organic matter increases the drainage and water-holding properties of the soil, it helps to liberate the phosphorus and potassium locked up in insoluble compounds in the soil, and it improves the tilth—that is, the handling properties of the soil. When barnyard manures and crop residues are wasted, and fertilizers are added to the soil in their place, a condition arises which has given rise to the saying, "Fertilizers kill the soil."

THE LESSONS FROM EXPERIENCE.

Teaching by experience is an expensive method, but such a complicated problem as the profitable use of commercial fertilizers can at present be studied in no other way. Because the method is expensive the experiment stations have undertaken to do the work for the farmer. As compared with the eastern states, very few fertilizer tests have been made so far west as to be comparable with Kansas conditions.

EXPERIMENTS WITH FERTILIZERS IN SOUTH DAKOTA.

Bulletin 145 of the South Dakota Experiment Station reports a series of fertilizer tests extending over several years. In the summary, page 256, occurs this statement: "No application of plant food except phosphorus alone paid any profit, and the average value of the crop produced on the phosphorus plots of both rotations was 31.1 per cent greater than the value of the crop produced on the untreated plots of both rotations for a period of five years."

EXPERIMENT WITH FERTILIZERS IN INDIANA.

In 1913 the Indiana Experiment Station published Bulletin 155, entitled "Results of Cooperation Fertilizer Tests on Clay and Loam Soils," by J. B. Abbott and S. D, Connor. This report includes eighteen different tests in sixteen different counties with the use of 4-8-4 fertilizer on wheat; six different tests in four different counties with the use of complete commercial fertilizer on oats; and thirteen different tests in seven different counties with the use of 4-8-4 fertilizer on potatoes. These experiments covered a series of years and a variety of conditions, as can be seen by the number of tests and counties included. In the summary, on page 131, these statements occur: "In the amounts used on corn, nitrogen caused a small average increase and was used at a loss, potash (potassium)* caused a larger average increase and was used at a profit, and phosphoric acid (phosphorus)* caused the largest average increase and was used at the greatest average profit per acre." "Phosphoric acid and potash gave a greater profit per dollar invested in fertilizers on both corn and wheat." "In nearly all experiments on clay and loam soils, phosphoric acid was found to be the most effective of the fertilizer elements."

In discussing the relative merits of acid phosphate and rock phosphate the authors make this statement: "It is to be noted that acid phosphate showed the greatest efficiency in practically every case, particularly in the first years of the experiment. The showing made by rock phosphate in the third and fourth years . . . was much better than in the earlier

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* Parentheses inserted by us.

years, . . . , but even so the acid phosphate showed the greatest profit over the whole period. If no other phosphate were available, the profit secured from the use of rock phosphate would be regarded as fairly satisfactory, *so no question can be raised as to the positive efficiency of rock phosphate under favorable conditions.*"*

EXPERIMENTS WITH FERTILIZERS. IN ILLINOIS.

The striking results secured by Dr. C. G. Hopkins with the use of rock phosphate on Illinois soils are familiar to all students of soil-fertility problems. These experiments have shown that the great needs of Illinois soils are phosphorus in bone meal or rock phosphate, lime in ground limestone, and organic matter from farm manures and legumes furnishing nitrogen.

EXPERIMENTS WITH FERTILIZERS IN KANSAS.

The Kansas Experiment Station has conducted a few fertilizer tests. The following data and comments were furnished by Prof. L. E. Call of the Agronomy Department.

Results Obtained in a Fertilizer Test Conducted by O. A. Rhoads, Columbus, Kan.

"Last year Mr. O. A. Rhoads, who lives five miles south of Columbus, conducted a fertilizer test in cooperation with the Agronomy Department of the Kansas State Agricultural College. The fertilizers were furnished by the Agronomy Department and Mr. Rhoads conducted the experiment according to the directions sent out by that department.

The results are given in the following table:

Plot No.	Fertilizers used and amount applied per acre.	Yield of wheat per acre.	Increase in yield per acre.	Cost of fertilizer per acre.	Value of crop less cost of fertilizer.	Net profit or loss per acre.
		bushels.	*bushels.*			
1	Barnyard manure .... 10 tons	23.3	13.3	$4.00	$14.64	$6.64
2	Sulphate of potash .... 100 lbs. Acid phosphate .... 250 lbs.	24.3	14.3	5.75	13.69	5.69
3	Sulphate of potash .... 100 lbs. Acid phosphate .... 250 lbs. Sodium nitrate .... 100 lbs.	16.0	6.0	8.75	4.55	—3.45
4	Acid phosphate .... 250 lbs.	22.0	12.0	2.75	14.85	6.85
5	Sulphate of potash .... 100 lbs.	11.0	1.0	3.00	5.80	—2.20
6	Ground limestone .... 2000 lbs.	14.3	4.3	4.00	7.44	—5.60
7	No fertilizer	10.0	....	....	8.00	....
8	Pure bone meal .... 75 lbs.	17.3	7.3	1.24	12.60	4.60

* Italics by us.

"Prices: Sulphate of potash, $60 per ton; acid phosphate, $22 Per ton; sodium nitrate, $50 per ton; pure bone meal, $33 per ton.

"The results of this test indicate that phosphorus is lacking in the Soil on Mr. Rhoads' farm, and that fertilizers containing this element in available form can be used with profit. Where 250 pounds of acid phosphate were applied per acre, a profit of $6.85 was realized. Where an equal amount of the acid phosphate was applied with 100 pounds of sulphate of potash, the profit was not as great because the sulphate of potash failed to increase the yield sufficiently to meet the increase in the cost due to the use of the fertilizer. It will be noted that a combination of fertilizers containing acid phosphate, sulphate of potash and sodium nitrate failed to increase the yields as much as did the acid phosphate alone, or the combination of the acid phosphate and the sulphate of potash. As a rule, nitrates in any form tend to produce an increased growth of foliage. In this case there was probably a comparatively rank growth of straw produced on this plot, and the wheat did not fill properly as a result.

"Sodium nitrate and sulphate of potash did not increase the yield of wheat enough to pay for the expense involved in applying them, and a loss was incurred where these fertilizers were used.

"Barnyard manure applied at the rate of about ten, tons per acre gave results equally as good as the acid phosphate. Probably only about fifty per cent of the benefit of this manure was obtained for the first season. As a rule, manured ground will continue to show the beneficial effect of the manure for several years, and the total benefit derived in this case will probably be as much again as it was for the first season. This goes to show that it pays to make use of barnyard manure, and that this material has a value as a fertilizer that will justify considerable care and work in obtaining it.

"The limestone caused an increase of 4.3 bushels per acre, but, as the table shows, this was not enough to pay for the expense of applying this material. However, the effect of the limestone on the soil will continue for several years, and for the entire period the increase in yields will undoubtedly be enough to pay for the liming of the soil and leave a good profit.

"Several types of soil are represented in Cherokee county, and the fertilizers that give the best results on one kind of soil may not be the ones that are needed on another type. For instance, on a heavy clay soil results may be obtained entirely different from those secured on a clay loam or on a sandy loam, and *vice versa.* For this reason, the results obtained on Mr. Rhoads' farm might not apply for all the soils in Cherokee county.

"The soil survey that is now being made of Cherokee county by the Agronomy Department of the Kansas State Agricultural College and the Bureau of Soils, United States Department of Agriculture, shows that the soil on .a large portion of the county is similar to that on Mr. Rhoads' farm. Thus these results are of more than local interest for they apply to many other farms in the county."

CONCLUDING REMARKS.

The careful reader of the preceding pages will note that the problem of the profitable use of commercial fertilizers is not an easy one. These facts stand out clearly. If it pays to apply any element, that element is phosphorus. The soils are in need of nitrogen, and the application of nitrogen will increase crop production. However, in the form of commercial fertilizers, nitrogen is too expensive to make it profitable for ordinary farm crops. The application of potassium has not paid when used on ordinary crops either in Kansas or in South Dakota. It pays better to so handle the soil that the plant is abundantly supplied from the large stores of potassium already in the soil.

The great difference between the Kansas climate and the climate further east can not be overemphasized. If soluble plant food is supplied to the plant in its early stages, the growth of leaves and stems may be too large for the amount of rainfall, and a short dry spell at a critical period in the plant's life may give it such a set-back that a smaller crop is produced when fertilizers were used than when not used. This fact is recognized in some of the methods of corn and cotton growing in the South. The soluble fertilizer is applied in the later stages of the plant's growth. In Kansas the tendency will, in all probabilities, be toward the use of more slowly available plant food rather than toward that which is more quickly available.

APPENDIX.

List of Kansas Dealers in Fertilizers, 1914.

Place.	*Dealer.*	*Manufacturer.*
Abilene	Rice-Johntz-Nicolay Lbr. Co	Armour Fertilizer Works
Alden	Alden Lbr. & Supply Co	Armour Fertilizer Works.
Altamont	Rush & Call	Armour Fertilizer Works.
Altamont	Oscar Johnson	Empire Carbon Works.
Altamont	Libby Bros	Swift & Co.
Arcadia	W. D. Konantz	Armour Fertilizer Works.
Argonia	W. A. Schreier & Son	Armour Fertilizer Works.
Arlington	Arlington Merc. Co	Armour Fertilizer Works.
Atchison	W. P. Lane	Armour Fertilizer Works.
Atchison	Mangelsdorf Bros	Swift & Co.
Atlanta	Wm. Steinhoff	Armour Fertilizer Works.
Attica	J. A. Holland	Armour Fertilizer Works.
Augusta	J. J. Mannion	Armour Fertilizer Works.
Axtell	W. H. Connet	Swift & Co.
Basehor	J. W. Tredway	Armour Fertilizer Works.
Baxter Springs	H. L. Jaqueth	Armour Fertilizer Works.
Baxter Springs	H. L. Jaqueth	Sulzberger & Sons Co.
Baxter Springs	E. B. Davis	Swift & Co.
Bern	John A. Minger	Armour Fertilizer Works.
Bethel	W. D. Waldron	Swift & Co.
Boicourt	Calvin & Beven	Swift & Co.
Brazilton	C. H. Ryan	Swift & Co.
Bucyrus	D. C. Hefflebower	Swift & Co.
Bucyrus	Springhill Cooperative Association	Swift & Co.
Burlington	Ralph A. Woodford	Swift & Co.

Place.	*Dealer.*	*Manufacturer.*
Chanute	C. D. Resler	Armour Fertilizer Works.
Chanute	Wickard Grain Co	Armour Fertilizer Works.
Chanute	Truitt's Greenhouse	Swift & Co.
Cherokee	Kelso Grain Co	Armour Fertilizer Works.
Cherokee	Kelso Grain Co	Swift & Co.
Cherryvale	Jas. M. Davidson	Armour Fertilizer Works.
Chetopa	St. Elmo Porter	Swift & Co.
Clay Center	Home Lbr. & Coal Co	Armour Fertilizer Works.
Clay Center	C. Humfeld	Armour Fertilizer Works.
Clay Center	L. P. Schrader	Swift & Co.
Clifton	McInturff & Son	Armour Fertilizer Works.
Clyde	Crumrine & Co	Armour Fertilizer Works.
Clyde	Hermon Bros	Armour Fertilizer Works.
Coffeyville	Isham Hdw. Co	Armour Fertilizer Works.
Colony	A. F. Huskey	Armour Fertilizer Works.
Columbus	J. C. Ebenstein	Armour Fertilizer Works.
Columbus	J. C. McKee	Armour Fertilizer Works.
Columbus	Frank H. Porter	Armour Fertilizer Works.
Columbus	T. P. Bumgardner	Empire Carbon Works.
Columbus	J. E. Laubach	Empire Carbon Works.
Columbus	J. C. Mckee	Empire Carbon Works.
Columbus	J. C. Ebenstein	Sulzberger & Sons Co.
Columbus	E. B. Davis	Swift & Co.
Columbus	J. M. Mason	Swift & Co.
Concordia	Robinson & McCrary	Armour Fertilizer Works.
Crestline	F. M. Gust	Armour Fertilizer Works.
Cummings	F. W. Kauffman	Swift & Co.
Delphos	P. C. Hull	Armour Fertilizer Works.
De Soto	Davis & Ore	Armour Fertilizer Works.
De Soto	Kaw Valley Merc. Co	Armour Fertilizer Works.
Dodge City	Ralph Burnett	Swift & Co.
Earlton	J. F. Kellogg	Swift & Co.
Earlton	Lewis Taylor	Swift & Co.
Edgerton	W. H. Kelly	Swift & Co.
Edna	Muzzy & Lower	Swift & Co.
Effingham	A. E. Mayhew	Armour Fertilizer Works.
El Dorado	American Grain & Seed Co	Swift & Co.
Elk City	A. R. Quigg	Armour Fertilizer Works.
Elk City	J. H. Meyer	Swift & Co.
Ellis	Ross & Waldo	Armour Fertilizer Works.
Elmont	Will Griffith	Swift & Co.
Elsmore	Krokstrom Bros	Armour Fertilizer Works.
Erie	Alderson Bros	Armour Fertilizer Works.
Eudora	Chas. Pilla	Armour Fertilizer Works.
Eudora	F. W. Kraus	Swift & Co.
Eureka	C. V. Lodge	Armour Fertilizer Works.
Eureka	A. F. Jenne	Swift & Co.
Everest	J. A. Larson	Armour Fertilizer Works.
Fall River	B. M. Brown	Armour Fertilizer Works.
Faulkner	A. R. Nash	Empire Carbon Works.
Fort Scott	Mead Grain Co	Armour Fertilizer Works.
Fredonia	J. N. Shannon Imp. Co	Armour Fertilizer Works.
Fredonia	J. N. Shannon Imp. Co	Swift & Co.
Fulton	Fulton Lbr. Co	Armour Fertilizer Works.
Fulton	L. E. Lyons	Empire Carbon Works.
Furley	C. F. Wright	Swift & Co.
Galena	H. L. Jaqueth	Empire Carbon Works.
Galena	E. B. Davis	Swift & Co.
Girard	A. M. Smith	Armour Fertilizer Works.
Girard	A. M. Smith & Son	Empire Carbon Works.
Girard	Farmers' Co-operative Union Association	Sulzberger & Sons Co.
Girard	G. H. Barker	Swift & Co.
Goodland	John W. Bock	Armour Fertilizers Wokr.
Goodrich	C. W. Conrad	Swift & Co.

Place.	*Dealer.*	*Manufacturer.*
Great Bend	E. R. Moses Merc. Co	Armour Fertilizer Works.
Hallowell	J. M. Forbes	Armour Fertilizer Works.
Hallowell	E. K. Gibbs	Armour Fertilizer Works.
Hallowell	E. B. Davis	Swift & Co.
Hamilton	Perry Clemans	Armour Fertilizer Works.
Hamlin	L. J. Smith	Swift & Co.
Harding	W. Post	Armour Fertilizer Works.
Hiawatha	J. H. Brigham & Son	Armour Fertilizer Works.
Hillsdale	Morrison Barker Merc. Co	Armour Fertilizer Works.
Holton	Fred Hinnen	Swift & Co.
Horton	F. J. Dori	Swift & Co.
Humboldt	Dickinson Bros. Grain & Hay Co	Armour Fertilizer Works.
Huron	A. M. Kinney	Swift & Co.
Hutchinson	N. T. Barrett	Armour Fertilizer Works.
Hutchinson	Peterson Brok. Co	Armour Fertilizer Works.
Hutchinson	Underwood Greenhouses	Swift & Co.
Hutchinson	Young & Sons	Swift & Co.
Independence	The Ideal Supply Co	Armour Fertilizer Works.
Jefferson	Geo. S. Taylor	Armour Fertilizer Works.
Junction City	Junction City Floral Co	Swift & Co.
Junction City	B. Rockwell M. & G. Co	Swift & Co.
Kirwin	G. W. Simon	Armour Fertilizer Works.
La Cygne	C. J. Milton	Swift & Co.
La Harpe	Hackney & Son	Armour Fertilizer Works.
La Harpe	C. L. Wilson & Son	Swift & Co.
Lansing	John M. Gable	Swift & Co.
Larned	Sorrell & Massen Bros	Armour Fertilizer Works.
Lawrence	W. J. Busch Seed Co	Armour Fertilizer Works.
Leavenworth	Peter F. Bubb	Armour Fertilizer Works.
Leavenworth	M. S. Grant	Armour Fertilizer Works.
Leavenworth	P. F. Bubb	Swift & Co.
Leavenworth	Sunnyside Floral Co	Swift & Co.
Lenexa	L. O. Krumm	Armour Fertilizer Works.
Lincoln Center	J. C. Cooper	Armour Fertilizer Works.
Lindsborg	J. M. Nelson & Co	Armour Fertilizer Works.
Linn	H. C. Hoerman	Swift & Co.
Linwood	Matt Grob	Armour Fertilizer Works.
Linwood	Meinke Bros	Swift & Co.
McCune	J. M. Stewart	Armour Fertilizer Works.
McCune	M. L. Westervelt	Empire Carbon Works.
McLouth	Casebier Elev. Co	Armour Fertilizer Works.
Macksville	Willis Decker	Swift & Co.
Mankato	Ambrose D. Falker	Swift & Co.
Marion	T. Jensen Bros	Armour Fertilizer Works.
Mayetta	W. A. Cooney	Swift & Co.
Mineral	E. B. Davis	Swift & Co.
Minneapolis	J. E. Ewart	Armour Fertilizer Works.
Morganville	R. E. Miller	Armour Fertilizer Works.
Mound Valley	George Hammett	Empire Carbon Works.
Muscotah	Calvert & Beven	Armour Fertilizer Works.
Muscotah	Calvert & Beven	Swift & Co.
Neodesha	Litten Goodson Gro. & Prod. Co	Armour Fertilizer Works.
Neodesha	Bauman Grain Co	Swift & Co.
Neosho Falls	D. C. Diver	Armour Fertilizer Works.
Norcatur	C. E. Brower	Armour Fertilizer Works.
Nortonville	J. J. Speck	Armour Fertilizer Works.
Nortonville	John Mair	Swift & Co.
Oneida	Emery Conwell	Swift & Co.
Opolis	Jas. Denton	Armour Fertilizer Works.
Opolis	T. T. Embree	Swift & Co.
Osawatomie	Osawatomie Lbr. Co	Armour Fertilizer Works.
Oskaloosa	L. H. Kimmel	Swift & Co
Oswego	Oswego Milling Co	Swift & Co.
Oswego	B. H. Williams	Swift & Co.

Place.	*Dealer.*	*Manufacturer.*
Ottawa	Franklin Co. Hdw. Co	Armour Fertilizer Works.
Ottawa	Williams Wilson Grain Co	Swift & Co.
Paola	Griffith & Co	Armour Fertilizer Works.
Parsons	F. E. Maxwell	Armour Fertilizer Works.
Parsons	Steele Hardware Co	Empire Carbon Works.
Parsons	Harry Neath	Sulzberger & Sons Co.
Parsons	F. H. Briggs	Swift & Co.
Parsons	C. D. Lynd	Swift & Co.
Pendleton	C. F. Henson	Swift & Co.
Phillipsburg	Fred Bridegroom	Swift & Co.
Piedmont	Chas. Reno	Armour Fertilizer Works.
Piqua	Wenzel Sicka	Armour Fertilizer Works.
Pittsburg	Pittsburg Modern Mill Co	Armour Fertilizer Works.
Pittsburg	Pittsburg Elev. Co	Swift & Co.
Pittsburg	J. Luther Taylor	Swift & Co.
Pleasanton	M. V. Bradley	Armour Fertilizer Works.
Pleasanton	Blaker Lumber Co	Swift & Co.
Plevna	Hinshaw & Hinshaw	Armour Fertilizer Works.
Quaker	E. B. Davis	Swift & Co.
Quenemo	J. S. Painter	Armour Fertilizer Works.
Redfield	Redfield Lbr. Co	Armour Fertilizer Works.
Robisnon	Nick Maze	Swift & Co.
Rossville	Wilt Bros	Armour Fertilizer Works.
St. George	St. George Lbr. Co	Armour Fertilizer Works.
St. Paul	Pat Diskin	Swift & Co.
Salina	Western Seed House	Armour Fertilizer Works.
Savonburg	W. H. Roberts	Swift & Co.
Sedgwick	Farmers' State Bank	Swift & Co.
Seneca	Ed M. Collins	Swift & Co.
Sherwin	E. B. Davis	Swift & Co.
Sibley	E. O. Karnes	Armour Fertilizer Works.
South Mound	C. S. Bales	Empire Carbon Works.
South Mound	Denton & Limbocker	Swift & Co.
Star Valley	E. B. Davis	Swift & Co.
Sterling	D. J. Fair Lbr. Co	Armour Fertilizer Works.
Stilwell	A. L. LaDuex	Empire Carbon Works.
Summerfield	Summerfield Elev. Co	Armour Fertilizer Works.
Sycamore	H. B. Miller	Armour Fertilizer Works.
Thayer	L. A. Stall	Armour Fertilizer Works.
Thayer	E. I. Cole	Swift & Co.
Tonganoxie	Zellner Merc. Co	Swift & Co.
Topeka	E. G. Bass	Armour Fertilizer Works.
Topeka	D. O. Coe	Swift & Co.
Topeka	Keeshan Gardens	Swift & Co.
Toronto	J. G. McLaughlin	Armour Fertilizer Works.
Troy	Windsor Bros	Swift & Co.
Vinland	O. T. York	Swift & Co.
Vliets	W. T. Buck	Armour Fertilizer Works.
Wagstaff	Wagstaff Merc. Co	Swift & Co.
WaKeeney	Kelley Bros	Armour Fertilizer Works.
Wallula	H. H. Young & Son	Swift & Co.
Walnut	Robison Bros	Armour Fertilizer Works.
Walnut	J. E. Clark	Swift & Co.
Washington	E. A. Mueller	Armour Fertilizer Works.
Wellsville	C. J. Musick	Armour Fertilizer Works.
Wellsville	M. C. Everitt	Swift & Co.
White Cloud	J. H. Lynds M. & E. Co	Armour Fertilizer Works.
White Water	Jacob J. Regier	Armour Fertilizer Works.
Whiting	W. G. Higby	Swift & Co.
Wichita	Ross Bros	Armour Fertilizer Works.
Williamsburg	Dan Thomas	Swift & Co.
Windom	Deeds & Day	Armour Fertilizer Works.
Winfield	C. E. Harter	Swift & Co.
Yates Center	Yates Center Mills, T. W. Hurst, Prod	Armour Fertilizer Works.
Zenda	D. E. Sloan	Armour Fertilizer Works.