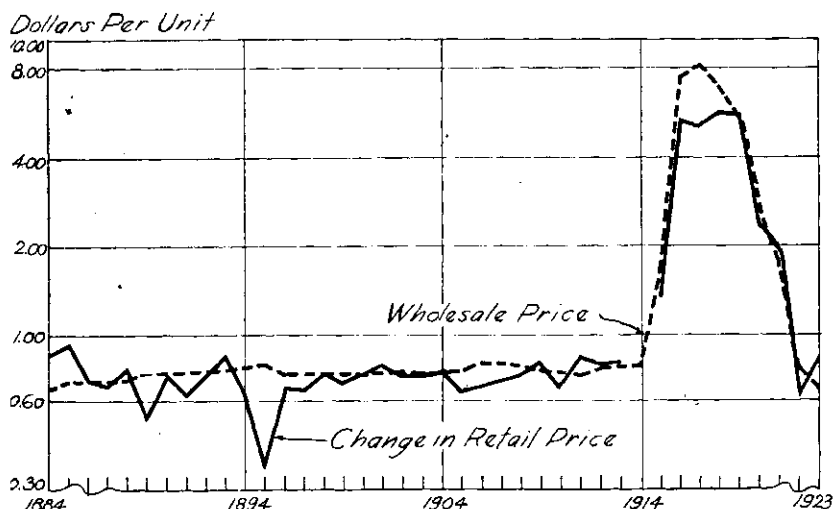


# Retail Prices of Fertilizer Materials and Mixed Fertilizers

E. E. Vial



WHOLESALE PRICE OF POTASH PER UNIT, AND CHANGE IN THE RETAIL PRICE OF COMPLETE FERTILIZER PER UNIT CHANGE IN POTASH CONTENT, 1884 to 1923

Each unit of potash in the mixed fertilizer increased the retail price of the mixed fertilizer amount approximately equal to the wholesale cost of the potash

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# CONTENTS

PAGE

Fertilizer materials.....	1
Ammoniates.....	1
Organic ammoniates.....	1
Cottonseed meal.....	1
Castor pomace.....	1
Ground fish.....	1
Tankage.....	1
Price of nitrogen in organic ammoniates.....	1
Mineral ammoniates.....	1
Nitrate of soda.....	1
In Connecticut.....	1
In Pennsylvania.....	1
In New York.....	1
In Texas.....	1
Sulfate of ammonia.....	1
In Connecticut.....	1
In other States.....	1
Superphosphate.....	1
Retail and wholesale prices.....	1
In Connecticut.....	1
In New York.....	1
In Indiana.....	1
In Pennsylvania.....	1
Relation of retail price to analysis.....	1
In Pennsylvania.....	1
In Indiana.....	1
In Texas.....	1
Potash salts.....	1
In Connecticut.....	1
Muriate of potash.....	1
Sulfate of potash.....	1
Sulfate of potash magnesia.....	1
Kainit.....	1
Relation of analysis of potash salts to cost of distribution.....	1
In Indiana.....	1
In Texas.....	1
In Pennsylvania.....	1
Muriate of potash.....	1
Kainit.....	1
Relation of wholesale and retail prices to analysis.....	1
Bone manures.....	1
In Connecticut.....	1
In Pennsylvania.....	1
Mixed fertilizers.....	1
Phosphate and potash fertilizers.....	1
In Pennsylvania.....	1
Complete fertilizers.....	1
In Pennsylvania.....	1
In New York.....	1
In New Hampshire.....	1
In Indiana.....	1
In Texas.....	1
In Connecticut.....	1
Relation between guaranteed and actual analysis of complete fertilizers.....	1
Relation of the retail price of complete fertilizers to the guaranteed and the actual analysis.....	1
Variability in the retail prices of mixed fertilizers not guaranteed.....	1
Analyses.....	1
Summary.....	1
Sources of data.....	1

## RETAIL PRICES OF FERTILIZER MATERIALS AND MIXED FERTILIZERS

E. E. VIAL

The inflation and deflation of commodity prices which took place during and following the World War brought about many changes in price relationships and maladjustments in our industries. The fertilizer industry, unlike many others, has not been able to adjust itself quickly to the sudden changes that have taken place. The post-war agricultural depression curtailed the demand for fertilizers; in addition, owing to the change in relationship between wholesale and retail prices, the fertilizer manufacturer has received a smaller proportion of the money spent by farmers for fertilizers than during the pre-war period. These have been important factors affecting the industry during the post-war period.

There has been much misunderstanding as to what is contained in fertilizers. Too frequently, farmers judge the value of a fertilizer by its color, its odor, and its physical characteristics. This uncertainty as to the content of fertilizers, and the opportunity for misrepresentation, have led to state legislation to protect the interests of the purchaser. All the important fertilizer States have laws to control the sale of the product. As a result of these laws, a vast amount of data concerning the actual and guaranteed analyses of fertilizers has been published. While chemists have made innumerable chemical analyses of fertilizers, perfected methods of analysis, and carried on important regulatory work, little attention has been given to the study of the relationships between the analysis and the retail price of fertilizers.

Farmers, dealers, and the general public have been bewildered by the innumerable types of fertilizers that have been put on the market. It is probable that during the development of the industry every conceivable combination of nitrogen, phosphoric acid, and potash has been made, for sale as mixed fertilizers. This was, first, a result of the attempts of a few manufacturers to capitalize temporarily upon the ignorance of the purchaser, and secondly, the result of experimentation by thousands of fertilizer dealers, manufacturers, farmers, scientists, and others, with various combinations of ingredients, to determine the best mixed fertilizers under certain conditions. These conditions varied with the crop, the soil, the weather, prices of crops, prices of fertilizer materials, and costs of manufacture and distribution. It is impossible to estimate the amount of time, effort, and money spent by farmers, by federal, state, and local agencies, and by fertilizer manufacturers and dealers, in solving this problem. From these efforts there have gradually developed certain more or less standard mixed goods that are sold in large quantities.

The other aspect of the problem, which has been a subject of discussion among farmers for many years but which did not command the scientific attention that it merits until its importance was magnified by the post-war agricultural depression and the difficulties in the industry, was the relationship between the analysis and the retail price of fertilizers. This study is an attempt to answer some of the perplexing questions in regard to the

relation between wholesale and retail prices, and the relation between the analysis, or content, of fertilizers and the prices paid by farmers.

The fertilizer reports of various States were the principal source of the data used in this study. While there is considerable variation in the fertilizer laws of different States, many require the collection of samples of fertilizer sold in the State by authorized agents and the analysis of these samples by the state chemist. The fertilizer reports of the various States contain primarily the guaranteed and actual analyses of the samples collected by the fertilizer inspectors. The reports for Connecticut, Pennsylvania, Indiana, New Hampshire, New York, and Texas, however, contained the retail prices of the fertilizers that were sampled, as well as the analyses. These data were used in studying the relation of the retail prices of fertilizers to the analysis.

The first part of the present study is concerned with the retail prices of fertilizer materials. An attempt was made to determine how changes in wholesale prices affected retail prices. If the data on retail prices were collected during the period from January to June inclusive, as in Connecticut, the wholesale prices with which they were compared were an average for the twelve months from July 1 of the preceding year to June 30 of the current year. Fertilizer manufacturers, and to some extent dealers, buy materials considerably in advance of the time when they are delivered to farmers. In comparing the wholesale and the retail prices, an attempt was made to compare the wholesale prices that existed during the time when manufacturers and dealers were buying materials, with the retail prices that farmers paid for the same materials when they purchased fertilizer. Estimates were made of the cost of distribution—the difference between the wholesale and the retail price. This is not the cost of distribution as would be determined by cost-accounting methods; for the farmer, however, the difference between the prices at wholesale markets and the price which he pays in his local community represents the cost of distribution.

The second part of the study is devoted to an analysis of the prices of mixed fertilizers. Even though fertilizer materials are purchased by farmers, the bulk of the fertilizer tonnage in the United States is mixed fertilizer. Many different grades or analyses of mixed fertilizers are manufactured, and there is considerable variation in the retail price of these various grades. The degree of relationship between the price and the analysis was determined by correlating the retail price with the analysis. The change in the retail price of the mixed fertilizer per unit change in plant-food content was determined, and was compared with the wholesale price of plant food. Estimates were made of the wholesale cost of plant food in mixed fertilizers, and also of the cost of manufacture and distribution of mixed fertilizers.

## PERTILIZER MATERIALS

### AMMONIATES

#### *Organic ammoniates*

#### *Cottonseed meal*

Cottonseed meal is one of the important sources of organic nitrogen in many tobacco fertilizers used in the Connecticut River Valley. During the seven years 1888 to 1894, the price of cottonseed meal in Connecticut

was relatively constant, averaging \$26.26 per ton (table 1). During the following four years, 1895 to 1898, the price averaged \$21.50 per ton, or only 64 per cent as high as the pre-war (1910-to-1912) price.

TABLE 1. AVERAGE CAR-LOT PRICE AND AVERAGE ANALYSIS OF COTTONSEED MEAL IN CONNECTICUT, AND PRICE OF NITROGEN PER UNIT IN COTTONSEED MEAL, 1888 TO 1923\*

Year	Number of samples	Car-lot price per ton in Connecticut†	Per cent of nitrogen found	Per cent of nitrogen guaranteed	Nitrogen overrun (per cent found minus guarantee)	Retail value of phosphoric acid and potash in one ton of cottonseed meal	Price of nitrogen per unit after deducting value of phosphoric acid and potash
1890-1894	8	\$26.40	6.57			\$ 5.57	\$ 3.20
1900-1904	66	26.68	7.14			5.13	3.02
1910-1912	209	33.63	6.74	6.76	-0.02	4.89	4.27
1922-1923	56	52.94	6.50	6.48	+0.02	6.30	7.18
1888	7	25.14	7.25				
1889	3	26.67	7.01			5.86	2.97
1890	5	24.60	6.62			5.81	2.84
1891	4	25.62	5.70			5.60	3.51
1892	9	26.72	7.06			5.64	2.99
1893	11	28.86	6.10			5.57	3.82
1894	12	26.21	7.36			5.23	2.85
1895	26	20.33	6.99			5.40	2.14
1896	43	22.23	7.06			5.77	2.33
1897	65	21.89	7.41			5.21	2.25
1898	30	21.56	7.44			4.46	2.30
1899	30	22.82	7.14			4.72	2.54
1900	44	25.20	7.26			5.38	2.73
1901	44	26.08	7.25			5.14	2.89
1902	36	27.70	7.05			5.26	3.18
1903	94	26.95	7.06			4.77	3.14
1904	114	27.47	7.07			5.08	3.17
1905	157	27.05	6.93			4.62	3.24
1906	91	31.47	6.61			4.74	4.04
1907	166	30.85	6.82	6.77	+0.05	5.16	3.77
1908	158	31.04	7.04	6.95	+0.09	5.20	3.67
1909	195	32.65	7.04	6.95	+0.09	4.78	3.96
1910	141	37.65	6.80	6.81	-0.01	4.68	4.85
1911	220	32.06	6.83	6.82	+0.01	5.02	3.96
1912	266	31.19	6.58	6.64	-0.06	4.96	3.99
1913	121	33.61	6.86	7.22	-0.36	4.55	4.24
1914	46	33.67	6.53	6.83	-0.30	4.59	4.45
1915	32	32.47	6.81	7.06	-0.25	4.96	4.04
1916	63	37.59	6.03	6.53	-0.50	18.35	3.19
1917	40	43.24	5.86	6.16	-0.30	19.41	4.07
1918	11	54.90	5.54	5.83	-0.29	18.63	6.55
1919	10	64.25	5.70	6.00	-0.30	17.11	8.27
1920	101	79.46	6.48	6.44	+0.04	11.14	10.54
1921	188	45.69	6.52	6.37	+0.15	9.70	5.52
1922	65	50.51	6.54	6.49	+0.05	6.23	6.77
1923	46	55.37	6.46	6.46	0.00	6.38	7.58

\* Analyses of cottonseed meal average about 3 per cent phosphoric acid and 1.9 per cent potash. The value of the phosphoric acid was calculated by using the Connecticut retail price of available phosphoric acid in superphosphate. Retail prices of superphosphate in Connecticut were not available prior to 1896. For the five years 1896 to 1900, the Connecticut retail price of available phosphoric acid in superphosphate averaged 54 cents per unit more than the wholesale price. For the seven years 1889 to 1895, the price used was the wholesale price plus 54 cents.

† The value of the potash was calculated by using the retail price of potash in muriate of potash in Connecticut. Retail prices of muriate in Connecticut were not available for the five years 1916 to 1920. During the pre-war period, 1910 to 1914, the margin between wholesale and retail prices averaged \$5.75 per ton; during the post-war period from 1922 to 1923, it averaged \$15.94. The average for the two periods was \$10.85. The price used for the five years 1916 to 1920 was the wholesale price plus \$10.85. The actual percentage of potash was taken as 50.84, the average for the seven years 1910 to 1914 and 1922 to 1923.

‡ The price per ton is the average of the prices as reported in the Connecticut fertilizer reports. Most of the samples were samples from car-lot shipments. The prices as given are prices paid by car-lot buyers in Connecticut.

The year 1899 marked the beginning of a period of rising cottonseed-meal prices. The index number of the price rose from 68 in 1899 to 100 in 1913 and 1914 (table 2). During the period from 1899 to 1914 the annual increase in the price was about 70 cents per ton, or 2.4 per cent (figure 1).<sup>1</sup> This upward trend was not unusual, as there were similar increases in prices of other agricultural products during the same period.

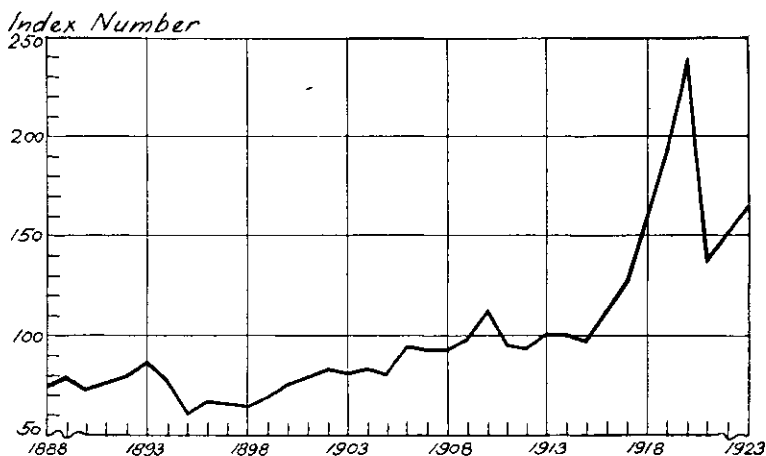


FIGURE 1. INDEX NUMBERS OF THE CONNECTICUT PRICE OF COTTONSEED MEAL, 1888 TO 1923

Prices were low from 1894 to 1898, but rose steadily during the 16-year period 1899 to 1914.

During the war period there were violent fluctuations in commodity prices. The price of cottonseed meal in Connecticut increased 143 per cent from 1915 to 1920, and then declined about 40 per cent from 1920 to 1921. These violent price changes cause unusual gains, disastrous losses, and maladjustments in the industry.

Cottonseed meal is used in fertilizers primarily because of its nitrogen content. In addition to the nitrogen, it contains about 3 per cent of phosphoric acid and 1.9 per cent of potash. During the war period, when potash was exceptionally high in price, the potash content of cottonseed meal was important in affecting its price.

In order to determine the retail price of nitrogen per unit, the retail value of the phosphoric acid and the potash in the cottonseed meal was deducted from the price of the meal and the remainder was then divided by the number of units of nitrogen per ton.

There were fluctuations in the value of both the phosphoric acid and the potash, and also in the nitrogen content, so that the changes in the price per ton of cottonseed meal were not truly representative of the changes in the price per unit of nitrogen (tables 1 and 2). During the sixteen-year period of rising prices, 1899 to 1914, the price of nitrogen in cottonseed

<sup>1</sup> The yearly change was determined by fitting a straight-line trend by the method of least squares; the percentage change is the annual change expressed as a percentage of the average for the entire period. This method is used throughout the bulletin unless otherwise stated.

TABLE 2. INDEX NUMBERS OF AVERAGE CAR-LOT PRICE AND AVERAGE ANALYSIS OF COTTONSEED MEAL IN CONNECTICUT, AND PRICE OF NITROGEN IN COTTONSEED MEAL, 1888 TO 1923  
 (1910-1912 = 100)

Year	Car-lot price per ton in Connecticut	Nitrogen found	Nitrogen guaranteed	Retail value of phosphoric acid and potash in one ton of cottonseed meal	Price of nitrogen per unit after deducting value of phosphoric acid and potash
1890-1894	79	97	.....	114	75
1900-1904	79	106	.....	105	71
1910-1912	100	100	100	100	100
1922-1923	157	96	96	129	168
1888	75	108	.....	.....	.....
1889	79	104	.....	120	70
1890	73	98	.....	119	67
1891	76	85	.....	115	82
1892	79	105	.....	115	70
1893	86	91	.....	114	89
1894	78	109	.....	107	67
1895	60	104	.....	110	50
1896	66	105	.....	118	55
1897	65	110	.....	107	53
1898	64	110	.....	91	54
1899	68	106	.....	97	59
1900	75	108	.....	110	64
1901	78	108	.....	105	68
1902	82	105	.....	108	74
1903	80	105	.....	98	74
1904	82	105	.....	104	74
1905	80	103	.....	94	76
1906	94	98	.....	97	95
1907	92	101	100	106	88
1908	92	104	103	106	86
1909	97	104	103	98	93
1910	112	101	101	96	114
1911	95	101	101	103	93
1912	93	98	98	101	93
1913	100	102	107	93	99
1914	100	97	101	94	104
1915	97	101	104	101	95
1916	112	89	97	375	75
1917	129	87	91	397	95
1918	163	82	86	381	153
1919	191	85	89	350	194
1920	236	96	95	228	247
1921	136	97	94	198	129
1922	150	97	96	127	159
1923	165	96	96	130	178

meal averaged \$3.62 per unit. The price increased at the rate of about 12 cents, or 3.4 per cent, per annum. The rate of increase in the price of nitrogen was even greater than the changes in the price of cottonseed meal would indicate.

For the two years 1922 and 1923, the price of nitrogen in cottonseed meal averaged \$7.18 per unit, or 68 per cent above pre-war prices.

There was some tendency for the average nitrogen content of the samples of cottonseed meal to decline. During the seven years 1913 to 1919, only those samples were reported whose actual analysis did not equal the guaranteed analysis. Thus the average nitrogen content for those years may be somewhat less than if all the samples had been included. During the years when all the samples were reported, there were only slight differences between the average guaranteed analysis and the average actual analysis.

In order to determine the relation between the price of cottonseed meal and the analysis, correlations were made between the actual analysis and the car-lot price. For the years when the data were available, correlations between the price and the guaranteed analysis were made also. During the period from 1895 to 1907, the correlations between the price and the analysis were relatively low, averaging less than 0.23 (table 3 and figure 2). During the period from 1908 to 1915, there was a much higher degree of relationship between price and analysis. For the period from 1913 to

TABLE 3. COEFFICIENTS OF CORRELATION BETWEEN THE PRICE OF COTTONSEED MEAL IN CONNECTICUT AND THE PERCENTAGE OF NITROGEN IN THE MEAL, 1895 TO 1923

Year	Price with actual analysis (r)	Price with guaranteed analysis (r)	Guaranteed analysis with actual analysis (r)	Year	Price with actual analysis (r)	Price with guaranteed analysis (r)	Guaranteed analysis with actual analysis (r)
1895	0.488			1910	0.813	0.896	0.835
1896	0.155			1911	0.565	0.786	0.648
1897	0.068			1912	0.545	0.596	0.557
1898	-0.095			1913	0.854	0.898	0.865
1899	0.129			1914	0.628	0.608	0.943
1900	0.173			1915	0.761	0.774	0.976
1901	0.119			1916	0.359	0.542	0.762
1902	0.505			1917	0.077	0.027	0.737
1903	-0.032			1918	-0.546	-0.677	0.844
1904	-0.355			1919	-0.163	-0.265	0.574
1905	0.143			1920	0.635	0.623	0.902
1906	0.261			1921	0.050	0.050	0.890
1907	0.451	0.593	0.714	1922	0.135	0.081	0.793
1908	0.762	0.869	0.840	1923	0.419	0.450	0.908
1909	0.608	0.804	0.748				

Coefficient of Correlation

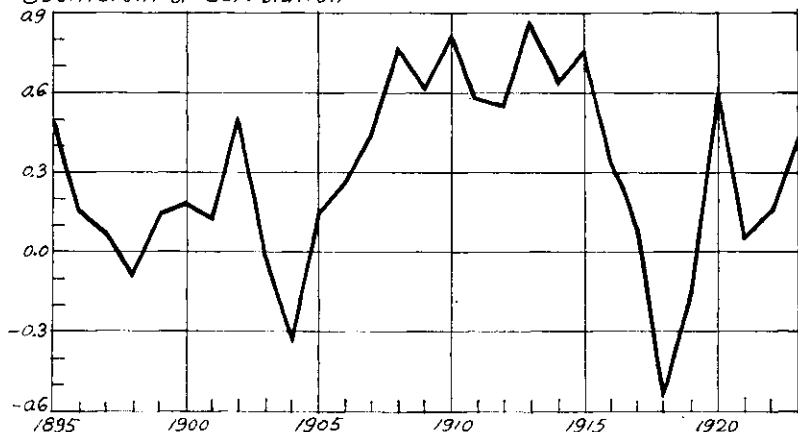


FIGURE 2. COEFFICIENTS OF CORRELATION BETWEEN PRICE AND ACTUAL ANALYSIS OF COTTONSEED MEAL IN CONNECTICUT, 1895 TO 1923

There was a relatively high degree of relationship between price and analysis during the 8-year period 1908 to 1915



1919, only those samples which did not meet the guaranteed analysis were reported, and hence the data and correlations for these years are not strictly comparable with those for the other years. In 1918 and 1919 there were only a few samples reported, and so the correlations for those years are of little significance.

During the period from 1895 to 1907, when the correlations were relatively low, the coefficient of variability of the price averaged 4.11; that is, there was relatively little variation in the price (table 4 and figure 3). What variation there was, was only slightly associated with the analysis.

TABLE 4. COEFFICIENTS OF VARIABILITY OF PRICE AND ANALYSIS OF COTTON-SEED MEAL IN CONNECTICUT, 1895 TO 1923

Year	Coefficients of variability			Year	Coefficients of variability		
	Price	Actual analysis	Guaranteed analysis		Price	Actual analysis	Guaranteed analysis
1910-1912	5.82	6.97	5.91	1910.....	5.38	8.29	8.02
1895.....	9.21	10.86	.....	1911.....	6.25	5.89	5.54
1896.....	2.79	6.30	.....	1912.....	5.84	6.73	4.17
1897.....	5.64	3.07	.....	1913.....	7.01	8.31	7.48
1898.....	2.71	2.92	.....	1914.....	5.97	6.70	6.19
1899.....	3.85	3.07	.....	1915.....	7.98	9.14	8.89
1900.....	4.10	3.88	.....	1916.....	7.22	8.41	6.33
1901.....	2.40	5.18	.....	1917.....	6.65	3.83	2.61
1902.....	5.42	6.91	.....	1918.....	3.70	3.99	2.83
1903.....	3.88	6.93	.....	1919.....	6.05	11.94	6.03
1904.....	2.68	4.95	.....	1920.....	7.91	10.22	9.44
1905.....	2.13	5.37	.....	1921.....	15.07	9.07	8.59
1906.....	3.38	8.15	.....	1922.....	7.27	8.84	6.73
1907.....	5.27	8.42	4.76	1923.....	8.13	7.62	7.82
1908.....	5.78	6.93	8.21				
1909.....	8.22	6.94	6.81				

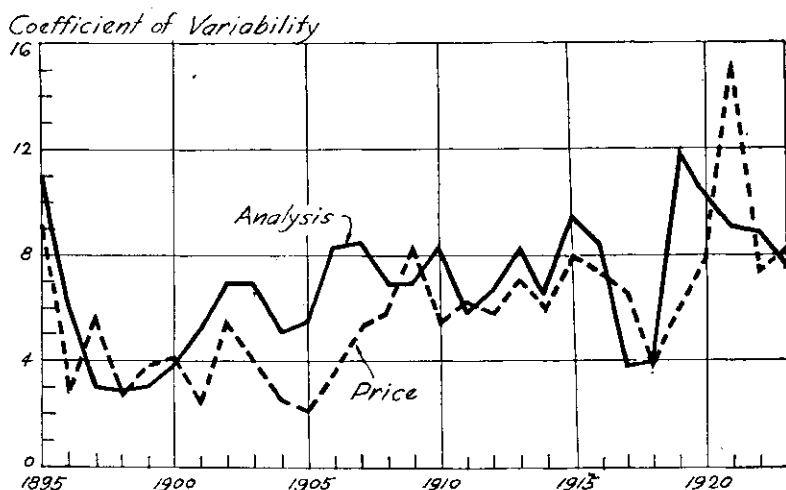


FIGURE 3. COEFFICIENTS OF VARIABILITY OF PRICE AND ANALYSIS OF COTTON-SEED MEAL IN CONNECTICUT, 1895 TO 1923

The variability of the price and of the analysis have been somewhat the same

From 1908 to 1915 the variability in both the price and the analysis was greater than in the preceding period. The variations in the price were associated with variations in the analysis, as is indicated by the correlations between price and analysis for these years.

The prices and samples of cottonseed meal for each year were collected over a period of several months. Prices of cottonseed meal vary from week to week; therefore, a part of the variation in the price was probably due to the time when the meal was purchased, and a part to the analysis. These changes in price during the season may entirely obscure the real relationship between price and analysis. If prices declined during the period in which the samples were collected, and with the lower prices somewhat higher grades were purchased, or if prices rose and lower grades were purchased, the correlations between price and analysis would be negative, indicating a tendency for low prices and high analysis, and high prices and low analysis, to be associated. This is probably the reason why some negative correlations were obtained, as in 1904 and in 1918. These negative correlations indicate a relationship which probably did not exist at any particular time.

Price changes during the season might also greatly magnify the degree of relationship between price and analysis. In order to determine the exact relationship, prices of different analyses should be obtained simultaneously.

The correlations as given in table 3 are, no doubt, somewhat indicative of the relationship between the Connecticut car-lot price of cottonseed meal and the analysis. This is true especially for those seasons in which the price was relatively constant.

For each of the years when there was a fairly high degree of relationship between price and analysis, the difference between the price of low-grade and of high-grade cottonseed meal was less than the average cost of nitrogen in all samples, even when allowance had been made for the retail value of the potash and the phosphoric acid. This means that the average cost of nitrogen tended to be less in the high-grade than in the low-grade product. To obtain nitrogen as cheaply as possible, one should buy cottonseed meal of the higher analyses.

There has been a growing tendency in the fertilizer trade to purchase cottonseed meal, as well as other materials, according to the analysis. In such cases the relationship between price and analysis is high. When the delivered prices of cottonseed meal are in adjustment with the analysis, the cost of nitrogen in the various grades would tend to be the same. Even though purchases were made according to the analysis at the place where the meal was manufactured, the price of the nitrogen in Connecticut would tend to be lower in the higher grades of the meal, since the charges for transportation and handling are a uniform amount per ton.

For the seventeen years 1907 to 1923, data on both the guaranteed and the actual analysis of each sample were available. The correlations between price and guaranteed analysis tended to be somewhat higher than those between price and actual analysis (table 3).

The correlations between actual analysis and guaranteed analysis were high. The relationship was not perfect, however. Many samples might have the same guaranteed analysis but still vary in actual analysis. The guarantee is a minimum guarantee, and there is generally an overrun.

*Castor pomace*

Castor pomace, a residue from the manufacture of castor oil, contains approximately 5 per cent of nitrogen, 1.8 per cent of available phosphoric acid, and 1 per cent of potash. Like cottonseed meal, it is used in fertilizer primarily because of its nitrogen content.

Even though there was considerable variation in the year-to-year changes in the price of castor pomace and of cottonseed meal, the general trends in the prices were much the same. During the period from 1881 to 1898, the price of castor pomace declined at the rate of 39 cents per ton, or 1.8 per cent, per annum (table 5 and figure 4). During the following six-

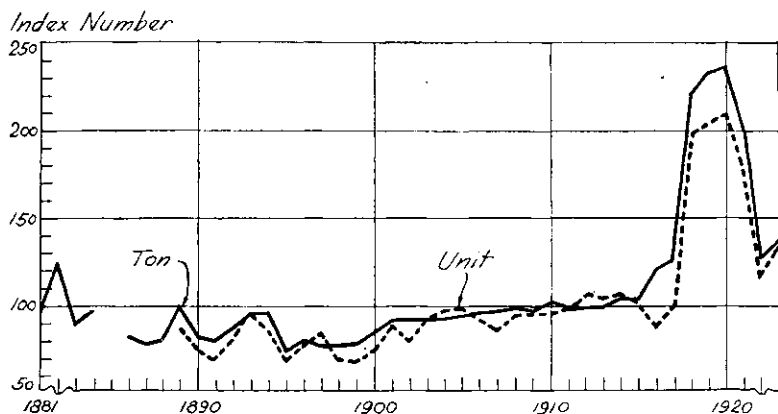


FIGURE 4. INDEX NUMBERS OF THE PRICE OF CASTOR POMACE PER TON, AND THE PRICE OF NITROGEN PER UNIT IN CASTOR POMACE, IN CONNECTICUT, 1881 TO 1923

There were only small changes in the analysis of castor pomace, so that the changes in the price of castor pomace and in the price of nitrogen in castor pomace were much the same.

teen-year period, 1899 to 1914, the price per ton increased at the rate of 31 cents per ton, or 1.3 per cent, per annum. This rate of increase in price (1.3 per cent per annum) was not so great as the corresponding rates for cottonseed meal (2.4) and ground fish (2.4). Cottonseed meal and fish scrap are valuable as protein supplements for feeding livestock, while castor pomace is poisonous to farm animals. The demand for feeding purposes was a factor in causing the greater rise in prices of cottonseed meal and fish scrap.

The price of castor pomace during the inflation period was more than double the pre-war price.

The price of nitrogen per unit was calculated by deducting from the price of castor pomace the retail value of 1.8 units of phosphoric acid and 1 unit of potash, and then dividing the difference by the number of units of nitrogen per ton. Even though there were changes in the nitrogen content of the castor pomace, the index numbers of the price of nitrogen per unit and the index numbers of the price of castor pomace are roughly similar. The largest discrepancy was during the war period, when potash importations were discontinued and potash prices were very high. The

increase in the cost of nitrogen was not so great as the change in the price per ton of castor pomace would indicate.

TABLE 5. AVERAGE RETAIL PRICE AND AVERAGE ANALYSIS OF CASTOR POMACE IN CONNECTICUT, AND PRICE OF NITROGEN PER UNIT IN CASTOR POMACE, 1881 TO 1923

Year	Number of samples	Retail price per ton	Per cent of nitrogen found	Value of phosphoric acid and potash at retail prices*	Price of nitrogen per unit	Index numbers (1910-1914 = 100)			
						Retail price	Nitrogen found	Value of phosphoric acid and potash at retail prices	Price of nitrogen per unit
1881-1884.	3	\$25.48	5.36	.....	.....	101	109	.....	.....
1890-1894.	4	22.02	5.17	\$ 3.22	\$3.65	87	105	118	80
1900-1904.	3	22.60	5.10	2.96	3.87	90	103	108	85
1910-1914.	4	25.17	4.93	2.74	4.56	100	100	100	100
1922-1923.	32	32.56	5.16	3.64	5.60	129	105	133	123
1881.....	3	24.17	5.10	.....	.....	96	103	.....	.....
1882.....	2	31.00	5.34	.....	.....	123	108	.....	.....
1883.....	4	22.25	5.37	.....	.....	88	109	.....	.....
1884.....	2	24.50	5.64	.....	.....	97	114	.....	.....
1885.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1886.....	4	20.50	4.94	.....	.....	81	100	.....	.....
1887.....	3	19.50	5.78	.....	.....	77	117	.....	.....
1888.....	2	20.00	5.77	.....	.....	79	117	.....	.....
1889.....	3	25.00	5.55	3.40	3.89	99	113	124	85
1890.....	5	21.00	5.17	3.37	3.41	83	105	123	75
1891.....	5	19.60	5.34	3.24	3.06	78	108	118	67
1892.....	4	21.75	5.13	3.26	3.60	86	104	119	79
1893.....	4	23.75	4.75	3.21	4.32	94	96	117	95
1894.....	3	24.00	5.44	3.02	3.86	95	110	110	85
1895.....	4	18.12	4.97	3.12	3.02	72	101	114	66
1896.....	4	19.62	4.70	3.34	3.46	78	95	122	76
1897.....	2	19.00	4.26	3.01	3.75	75	86	110	82
1898.....	3	19.00	5.35	2.56	3.07	75	109	93	67
1899.....	5	19.40	5.51	2.71	3.03	77	112	99	66
1900.....	4	21.00	5.39	3.11	3.32	83	109	114	73
1901.....	3	23.00	5.11	2.97	3.92	91	104	108	86
1902.....	2	23.00	5.52	3.04	3.62	91	112	111	79
1903.....	3	23.00	4.86	2.74	4.17	91	99	100	91
1904.....	2	23.00	4.64	2.92	4.33	91	94	107	95
1905.....	4	23.50	4.70	2.65	4.44	93	95	97	97
1906.....	7	23.36	4.97	2.72	4.15	93	101	99	91
1907.....	8	23.75	5.41	2.97	3.84	94	110	108	84
1908.....	12	24.29	5.02	3.00	4.24	97	102	109	93
1909.....	6	24.33	5.05	2.75	4.27	97	102	100	94
1910.....	6	25.67	5.37	2.69	4.28	102	109	98	94
1911.....	3	24.67	4.93	2.89	4.42	98	100	105	97
1912.....	3	25.00	4.69	2.86	4.72	99	95	104	104
1913.....	6	24.83	4.79	2.61	4.64	99	97	95	102
1914.....	3	25.67	4.86	2.63	4.74	102	99	96	104
1915.....	8	25.50	5.05	2.80	4.50	101	102	102	99
1916.....	11	29.64	5.01	9.98	3.92	118	102	364	86
1917.....	8	31.28	4.60	10.51	4.52	124	93	384	99
1918.....	5	54.90	4.92	10.19	9.09	218	100	372	199
1919.....	3	57.37	5.20	9.46	9.21	228	105	345	202
1920.....	3	59.00	5.58	6.32	9.44	234	113	231	207
1921.....	13	50.38	5.61	5.53	7.99	200	114	202	175
1922.....	32	31.46	5.25	3.59	5.31	125	106	131	116
1923.....	31	33.66	5.08	3.69	5.90	134	103	135	129

\* Analyses of castor pomace average about 1.8 per cent phosphoric acid and 1 per cent potash. The value of the phosphoric acid was calculated by using the Connecticut retail price of available phosphoric acid in superphosphate. Retail prices of superphosphate in Connecticut were not available prior to 1896. For the five years 1896 to 1900, the Connecticut retail price of available phosphoric acid in superphosphate averaged 54 cents per unit more than the wholesale price. For the seven years 1889 to 1895, the price used was the wholesale price plus 54 cents.

The value of the potash was calculated by using the retail price of potash in muriate of potash in Connecticut. Retail prices of muriate in Connecticut were not available for the five years 1916 to 1920. During the pre-war period, 1910 to 1914, the margin between wholesale and retail prices averaged \$5.75 per ton; during the post-war period from 1922 to 1923, it averaged \$15.94. The average for the two periods was \$10.85. The price used for the five years 1916 to 1920 was the wholesale price plus \$10.85. The actual percentage of potash was taken as 50.84, the average for the seven years 1910 to 1914 and 1922 to 1923.

*Ground fish*

Tankage and ground fish also are classed as organic ammoniates. The samples of ground fish listed in the Connecticut fertilizer reports averaged more than 8 per cent of nitrogen and about 6 per cent of available phosphoric acid.

Prices of ground fish declined during the period from 1892 to 1898, but during the following sixteen years they increased at the rate of 94 cents per ton, or 2.4 per cent, per annum (tables 6 and 7, and figure 5).

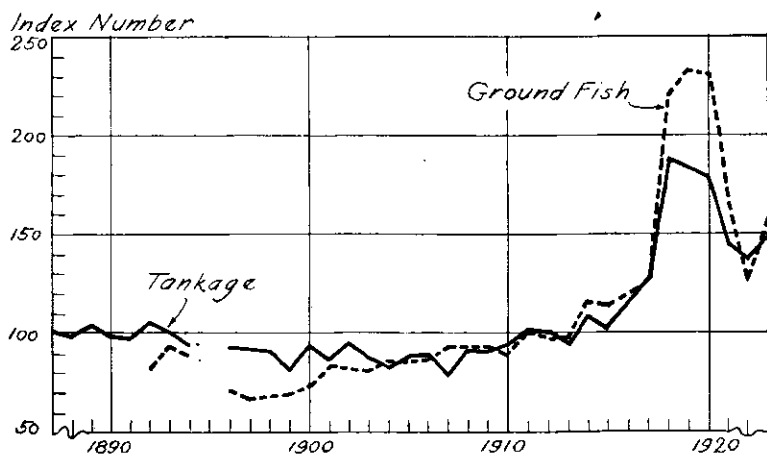


FIGURE 5. INDEX NUMBERS OF THE PRICE OF TANKAGE AND OF GROUND FISH IN CONNECTICUT, 1887 TO 1923

The price of tankage and that of ground fish have moved together

These long-time changes in the price of ground fish were much the same as for the other nitrogen carriers.

In three of the twenty-six years from 1898 to 1923, the average guaranteed nitrogen content was slightly greater than the actual analysis. For the twenty-four years 1898 to 1921, the guaranteed nitrogen content of the ground fish averaged 8.05 per cent while the actual nitrogen content as found by the state chemist averaged 8.47 per cent. During the same years the actual phosphoric-acid content averaged 7.97 per cent while the guaranteed content averaged 6.85 per cent. The overrun for the phosphoric acid was 2.7 times as great as the overrun for the nitrogen. The overrun was greater for the cheaper plant food.

*Tankage*

By-products of the packing industry are a source of plant food, and in the early days of the fertilizer industry they were especially important. The tendency, however, has been to shift more and more to mineral and synthetic plant-food carriers.

Tankage is a by-product of the packing industry, and is important as a nitrogen carrier even though it contains from 10 to 20 per cent of phosphoric acid. During the period from 1889 to 1898, the retail price of

TABLE 6. AVERAGE RETAIL PRICE AND AVERAGE ANALYSIS OF GROUND FISH IN CONNECTICUT, AND PRICE OF NITROGEN PER UNIT IN GROUND FISH, 1881 TO 1923

Year	Number of samples	Retail price per ton	Per cent of nitrogen found	Per cent of nitrogen guaranteed	Per cent of available phosphoric acid found	Per cent of total phosphoric acid found	Per cent of total phosphoric acid guaranteed	Value of available phosphoric acid at retail price*	Price of nitrogen per unit
1883-1885.	5	\$ 41.28	8.18	.....	4.72	7.10	.....	.....	.....
1892-1894.	2	37.67	8.58	.....	5.08	6.96	.....	\$ 6.41	\$ 3.64
1900-1904.	5	34.87	8.44	8.10	6.26	8.75	7.42	7.28	3.27
1910-1914.	8	43.21	8.30	7.94	5.80	7.06	6.11	6.09	4.47
1922-1923.	14	61.72	8.73	8.31	6.26†	7.64	5.75	9.10	6.02
1881.....	2	45.00	7.36	.....	.....	6.14	.....	.....	.....
1882.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1883.....	6	45.33	7.50	.....	4.18	7.05	.....	.....	.....
1884.....	4	40.00	8.51	.....	5.35	7.38	.....	.....	.....
1885.....	4	38.50	8.52	.....	4.64	6.87	.....	.....	.....
1892.....	4	35.00	8.60	.....	4.57	6.92	.....	6.12	3.36
1893.....	1	40.00	8.69	.....	4.88	7.05	.....	6.10	3.90
1894.....	2	38.00	8.44	.....	5.79	6.91	.....	7.01	3.67
1895.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1896.....	6	30.67	8.47	.....	6.21	7.31	.....	8.63	2.60
1897.....	9	29.11	8.49	.....	6.16	7.97	.....	7.45	2.55
1898.....	6	29.33	8.41	7.58	5.35	7.10	6.50	5.14	2.88
1899.....	8	29.75	8.63	7.69	6.34	8.07	7.50	6.59	2.68
1900.....	4	31.50	8.34	8.12	6.84	10.21	8.50	8.55	2.75
1901.....	3	35.67	8.74	8.17	7.28	9.23	7.67	8.52	3.11
1902.....	5	35.40	8.53	8.20	5.19	7.88	7.20	6.28	3.41
1903.....	8	35.12	8.07	7.81	5.83	8.15	6.75	6.06	3.60
1904.....	6	36.67	8.51	8.20	6.18	8.28	7.00	6.98	3.49
1905.....	11	36.82	8.22	8.24	5.65	7.25	6.91	5.65	3.79
1906.....	8	37.00	8.31	8.26	6.47	8.19	6.88	6.66	3.65
1907.....	10	40.25	8.71	8.44	5.68	7.33	7.30	6.53	3.87
1908.....	11	40.36	8.40	8.05	6.62	8.86	7.18	7.94	3.86
1909.....	11	39.93	8.45	7.88	7.14	8.74	8.09	7.50	3.84
1910.....	6	38.50	8.07	8.10	5.63	6.02	5.83	5.74	4.06
1911.....	8	43.75	8.48	7.88	5.68	7.06	6.05	6.42	4.40
1912.....	10	41.76	7.77	7.50	6.30	8.26	6.85	7.06	4.47
1913.....	9	42.06	8.26	8.05	5.38	6.72	5.83	5.33	4.45
1914.....	6	50.00	8.90	8.19	6.00	7.24	5.98	5.88	4.96
1915.....	5	49.20	9.16	8.07	6.51	7.57	5.90	5.73	4.75
1916.....	19	51.41	8.49	8.10	6.57	8.30	6.81	9.53	4.93
1917.....	7	53.86	8.28	8.19	5.03	6.05	5.79	6.64	5.70
1918.....	3	95.00	9.15	8.22	5.80	8.34	6.85	9.98	9.29
1919.....	6	100.83	8.36	7.74	7.45	10.49	8.33	15.27	10.23
1920.....	9	99.64	8.02	8.04	6.37	7.86	6.22	13.25	10.77
1921.....	14	72.48	9.12	8.54	6.86	8.13	6.51	13.24	6.50
1922.....	10	54.75	8.70	8.31	6.26†	7.64	6.05	8.88	5.27
1923.....	18	68.70	8.76	8.31	6.27†	7.65	5.45	9.33	6.78

\* The value of the available phosphoric acid in ground fish was calculated by using the Connecticut retail price of available phosphoric acid in superphosphate. Retail prices of superphosphate in Connecticut were not available prior to 1896. For the five years 1896 to 1900, the Connecticut retail price of available phosphoric acid in superphosphate averaged 54 cents per unit more than the wholesale price. For the three years 1892 to 1894 the price used was the wholesale price plus 54 cents.

† For the two years 1920 and 1921, the available phosphoric acid found averaged 1.38 units less than the total found. The available phosphoric acid for the two years 1922 and 1923 was estimated by deducting 1.38 from the total found.

tankage per ton in Connecticut declined at the rate of 38 cents, or 1.2 per cent, per annum. The price of tankage continued to decline after 1899 although prices of other organic ammoniates had started to increase, and reached a low point, \$25 per ton, in 1907. From 1907 to 1914 there was a rapid increase in the price. (Tables 8 and 9, and figure 5.)

One of the principal sources of tankage is from the slaughter of cattle. There are cycles in cattle prices. Prices reached a peak in 1899. Following this peak there was a marked increase in numbers and in slaughter

TABLE 7. INDEX NUMBERS OF AVERAGE RETAIL PRICE AND AVERAGE ANALYSIS OF GROUND FISH IN CONNECTICUT, AND OF PRICE OF NITROGEN IN GROUND FISH, 1881 TO 1923

(1910-1914 = 100)

Year	Retail price per ton	Nitrogen found	Nitrogen guaranteed	Available phosphoric and found	Total phosphoric acid found	Total phosphoric acid guaranteed	Value of available phosphoric acid at retail price	Price of nitrogen per unit
1883-1885.....	96	99	.....	81	101	.....	.....	.....
1892-1894.....	87	103	.....	88	99	.....	105	81
1900-1904.....	81	102	102	108	124	121	120	73
1910-1914.....	100	100	100	100	100	100	100	100
1922-1923.....	143	105	105	108	108	94	149	135
1881.....	104	89	.....	.....	87	.....	.....	.....
1882.....	.....	.....	.....	.....	.....	.....	.....	.....
1883.....	105	90	.....	72	100	.....	.....	.....
1884.....	93	103	.....	92	105	.....	.....	.....
1885.....	89	103	.....	80	97	.....	.....	.....
1892.....	81	104	.....	79	98	.....	96	76
1893.....	93	105	.....	84	100	.....	95	88
1894.....	88	102	.....	100	98	.....	109	83
1895.....	.....	.....	.....	.....	.....	.....	.....	.....
1896.....	71	102	.....	107	104	.....	134	60
1897.....	67	102	.....	106	113	.....	115	58
1898.....	68	101	95	92	101	106	79	65
1899.....	69	104	97	109	114	123	101	61
1900.....	73	100	102	118	145	139	140	62
1901.....	83	105	103	126	131	126	140	70
1902.....	82	103	103	89	112	118	103	76
1903.....	81	97	98	101	115	110	100	81
1904.....	85	103	103	107	117	115	115	78
1905.....	85	99	104	97	103	113	93	85
1906.....	86	100	104	112	116	113	109	82
1907.....	93	105	106	98	104	119	107	87
1908.....	93	101	101	114	125	118	130	86
1909.....	92	102	99	123	124	132	123	86
1910.....	89	97	102	97	85	95	94	91
1911.....	101	102	99	98	100	99	105	98
1912.....	97	94	94	109	117	112	116	100
1913.....	97	100	101	93	95	95	88	100
1914.....	116	107	103	103	103	98	97	111
1915.....	114	110	102	112	107	97	94	106
1916.....	119	102	102	113	118	111	156	110
1917.....	125	100	103	87	86	95	109	128
1918.....	220	110	104	100	118	112	164	208
1919.....	233	101	97	128	149	136	251	229
1920.....	231	97	101	110	111	102	218	241
1921.....	168	110	108	118	115	107	217	145
1922.....	127	105	105	108	108	99	146	118
1923.....	159	106	105	108	108	89	153	152

of cattle. This probably tended to depress tankage prices even though prices of other ammoniates were increasing.

The changes in the index numbers of the prices of tankage and ground fish were roughly similar (figure 5). The price of ground fish rose higher during the war period, but for the two post-war years 1922 and 1923 the prices of both tankage and ground fish averaged 43 per cent above pre-war prices.

The average analysis of the tankage fluctuated from year to year, but there was no consistent tendency for the analysis to either increase or decrease. During the thirteen years 1911 to 1923, the guaranteed nitrogen content averaged 5.26 per cent as compared with the average actual analysis of 5.42 per cent. The actual phosphoric acid averaged 14.90

TABLE 8. AVERAGE RETAIL PRICE AND AVERAGE ANALYSIS OF TANKAGE IN CONNECTICUT, AND PRICE OF NITROGEN PER UNIT IN TANKAGE, 1887 TO 1923

Year	Number of samples	Retail price per ton	Per cent of nitrogen found	Per cent of nitrogen guaranteed	Per cent of phosphoric acid found	Per cent of phosphoric acid guaranteed	Mechanical analysis (per cent of material finer than $\frac{1}{50}$ inch in diameter)	Value of phosphoric acid at retail price*	Price of nitrogen per unit
1890-1894.	4	\$31.69	5.42	.....	16.85	.....	.....	\$ 7.27	\$ 4.52
1900-1904.	6	28.39	5.59	.....	13.63	.....	50.51	5.22	4.16
1910-1914.	7	32.05	5.57	5.47†	14.23	13.10‡	50.25	4.91	4.87
1922-1923.	5	45.78	6.20	5.49	13.30	14.76	50.14	6.44	6.36
1887.....	5	32.40	7.11	.....	12.25	.....	.....	.....	.....
1888.....	5	31.76	7.76	.....	8.50	.....	.....	.....	.....
1889.....	4	33.40	5.94	.....	14.44	.....	.....	6.77	4.48
1890.....	4	31.25	6.16	.....	14.46	.....	.....	6.73	3.98
1891.....	7	31.14	5.12	.....	18.57	.....	.....	8.21	4.48
1892.....	4	33.75	5.41	.....	17.43	.....	.....	7.70	4.82
1893.....	3	32.33	5.58	.....	15.15	.....	.....	6.25	4.67
1894.....	4	30.00	4.85	.....	18.65	.....	.....	7.44	4.65
1895.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1896.....	6	29.83	5.86	.....	12.39	.....	50.17	5.69	4.12
1897.....	3	29.33	6.18	.....	14.49	.....	55.00	5.78	3.81
1898.....	4	29.25	6.46	.....	10.88	.....	63.50	3.45	3.99
1899.....	4	26.00	6.08	.....	14.46	.....	65.50	4.96	3.46
1900.....	4	30.00	5.50	.....	14.77	.....	59.00	6.09	4.35
1901.....	7	27.57	6.12	.....	8.70	.....	52.14	3.36	3.96
1902.....	3	30.00	5.29	.....	14.69	.....	53.33	5.87	4.56
1903.....	6	28.00	6.14	.....	13.73	.....	47.33	4.71	3.79
1904.....	11	26.36	4.88	.....	16.28	.....	40.73	6.07	4.16
1905.....	8	28.21	5.81	.....	15.18	.....	53.50	5.01	3.99
1906.....	2	28.50	6.98	.....	11.66	.....	48.00	3.97	3.51
1907.....	3	25.00	5.70	.....	14.74	.....	39.00	5.59	3.41
1908.....	7	29.14	6.38	.....	13.05	.....	44.57	5.17	3.76
1909.....	10	29.15	6.12	.....	13.89	.....	35.60	4.81	3.98
1910.....	8	30.25	5.35	.....	14.83	.....	48.62	4.99	4.72
1911.....	9	32.64	5.88	5.82	12.17	.....	44.56	4.54	4.78
1912.....	4	32.50	5.61	5.35	15.02	13.18	52.75	5.56	4.80
1913.....	5	30.30	5.10	5.10	15.67	13.85	54.00	5.12	4.94
1914.....	9	34.56	5.91	5.60	13.44	12.26	51.33	4.35	5.11
1915.....	6	32.99	5.17	4.97	12.79	13.10	51.00	3.71	5.66
1916.....	9	37.20	5.07	5.19	13.61	11.16	46.44	6.51	6.05
1917.....	9	40.56	5.87	5.63	14.63	13.01	40.44	6.38	5.82
1918.....	3	60.00	4.21	4.93	19.28	14.29	42.67	10.94	11.65
1919.....	5	58.80	4.70	4.72	17.48	15.17	46.60	11.83	9.99
1920.....	7	57.07	4.98	5.12	14.56	17.25	45.71	9.98	9.46
1921.....	8	46.00	5.54	4.91	15.73	14.64	43.62	10.02	6.49
1922.....	7	43.57	6.43	5.63	13.03	15.94	48.29	6.15	5.82
1923.....	3	48.00	5.98	5.35	13.58	13.58	52.00	6.72	6.90

\* The value of the phosphoric acid in tankage was calculated by assuming that one-third of the phosphoric acid was available, and by using the Connecticut retail price of available phosphoric acid in superphosphate. Retail prices of superphosphate in Connecticut were not available prior to 1896. For the five years 1896 to 1900, the Connecticut retail price of phosphoric acid in superphosphate averaged 54 cents per unit more than the wholesale price. For the six years 1889 to 1894, the price used was the wholesale price plus 54 cents.

† 1911 to 1914.

‡ 1912 to 1914.

per cent, which was 0.95 unit per ton greater than the guarantee. The phosphoric-acid overrun was about six times as great as the nitrogen overrun.

There was considerable year-to-year variation in the average fineness to which the tankage was ground. In 1907 only 39 per cent of the material would pass through a sieve with holes  $\frac{1}{50}$  inch in diameter, as compared with 65 per cent in 1899. The fineness to which the material is ground affects the readiness with which the plant food becomes available for plant growth.



TABLE 9. INDEX NUMBERS OF AVERAGE RETAIL PRICE AND AVERAGE ANALYSIS OF TANKAGE IN CONNECTICUT, AND OF PRICE OF NITROGEN IN TANKAGE, 1887 TO 1923

(1910-1914 = 100)

Year	Retail price	Nitrogen found	Nitrogen guaranteed	Phosphoric acid found	Phosphoric acid guaranteed	Mechanical analysis	Value of phosphoric acid at retail price	Price of nitrogen per unit
1890-1894.....	99	97	.....	118	.....	.....	148	93
1900-1904.....	89	100	.....	96	.....	101	106	85
1910-1914.....	100	100	100*	100	100†	100	100	100
1922-1923.....	143	111	100	93	113	100	131	131
1887.....	101	128	.....	86	.....	.....	.....	.....
1888.....	99	139	.....	60	.....	.....	.....	.....
1889.....	104	107	.....	101	.....	.....	138	92
1890.....	98	111	.....	102	.....	.....	137	82
1891.....	97	92	.....	130	.....	.....	167	92
1892.....	105	97	.....	122	.....	.....	157	99
1893.....	101	100	.....	106	.....	.....	127	96
1894.....	94	87	.....	131	.....	.....	152	95
1895.....	.....	.....	.....	.....	.....	.....	.....	.....
1896.....	93	105	.....	87	.....	100	116	85
1897.....	92	111	.....	102	.....	109	118	78
1898.....	91	116	.....	76	.....	126	70	82
1899.....	81	109	.....	102	.....	130	101	71
1900.....	94	99	.....	104	.....	117	124	89
1901.....	86	110	.....	61	.....	104	68	81
1902.....	94	95	.....	103	.....	106	120	94
1903.....	87	110	.....	96	.....	94	96	78
1904.....	82	88	.....	114	.....	81	124	85
1905.....	88	104	.....	107	.....	106	102	82
1906.....	89	125	.....	82	.....	96	81	72
1907.....	78	102	.....	104	.....	78	114	70
1908.....	91	115	.....	92	.....	89	105	77
1909.....	91	110	.....	98	.....	71	98	82
1910.....	94	96	.....	104	.....	97	102	97
1911.....	102	106	106	86	.....	89	92	98
1912.....	101	101	98	106	101	105	113	99
1913.....	95	92	93	110	106	107	104	101
1914.....	108	106	102	94	94	102	89	105
1915.....	103	93	91	90	100	101	76	116
1916.....	116	91	95	96	85	92	133	124
1917.....	127	105	103	103	99	80	130	120
1918.....	187	76	90	135	109	85	223	239
1919.....	183	84	86	123	116	93	241	205
1920.....	178	89	94	102	132	91	203	194
1921.....	144	99	90	111	112	87	204	133
1922.....	136	115	103	92	122	96	125	120
1923.....	150	107	98	95	104	103	137	142

\* 1911 to 1914.

† 1912 to 1914.

*Price of nitrogen in organic ammoniates*

In order to determine the relative changes in the prices of nitrogen in the various organic ammoniates in Connecticut, the price of nitrogen per unit in castor pomace, ground fish, and tankage for each year was expressed as a percentage of the price of nitrogen in cottonseed meal (table 10 and figure 6). In only eight of the thirty-five years from 1889 to 1923 was the price of nitrogen in either castor pomace, ground fish, or tankage less than the price of nitrogen in cottonseed meal.

During the period of declining prices from 1889 to 1898, the price of nitrogen in cottonseed meal declined faster than did the price of nitrogen in the other materials. During the sixteen years of rising prices from 1899 to 1914, the general tendency was for the price of nitrogen in cottonseed meal to increase faster than did the price of nitrogen in the other materials. For the five years 1910 to 1914 the price of nitrogen in castor

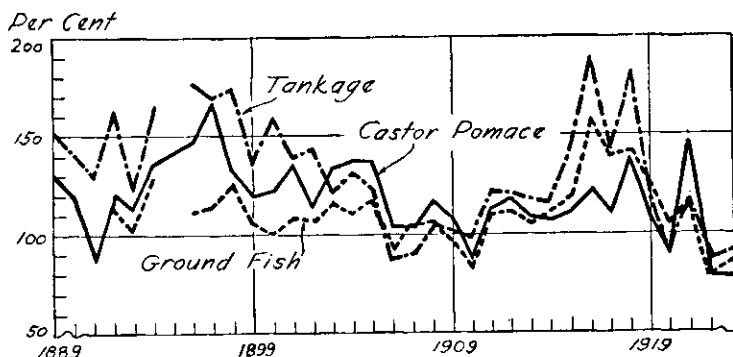


FIGURE 6. PRICES OF NITROGEN IN TANKAGE, IN GROUND FISH, AND IN CASTOR POMACE, IN CONNECTICUT, EXPRESSED AS PERCENTAGES OF THE PRICE OF NITROGEN IN COTTONSEED MEAL IN CONNECTICUT, 1889 TO 1923

During the period 1889 to 1898 the price of nitrogen in cottonseed meal declined faster than did the price of nitrogen in the other organic ammoniates. During the period 1899 to 1914, however, the price of nitrogen in cottonseed meal rose faster than did the price of nitrogen in the other materials

TABLE 10. RETAIL PRICE OF NITROGEN PER UNIT IN COTTONSEED MEAL, CASTOR POMACE, GROUND FISH, AND TANKAGE, IN CONNECTICUT, 1889 TO 1923\*

Year	Price of nitrogen per unit				Index numbers of price of nitrogen (Price of nitrogen in cottonseed meal=100)			
	In cottonseed meal	In castor pomace	In ground fish	In tankage	In cottonseed meal	In castor pomace	In ground fish	In tankage
1889-1894	\$ 3.22	\$3.93	\$ 3.64	\$ 4.71	100	122	113	146
1896-1899	2.36	3.33	2.68	3.84	100	141	114	163
1900-1904	3.02	3.87	3.27	4.16	100	128	108	138
1905-1909	3.74	4.19	3.80	3.73	100	112	102	100
1910-1914	4.30	4.56	4.47	4.87	100	106	104	113
1915-1919	5.22	6.25	6.98	7.83	100	120	134	150
1920-1923	7.60	7.16	7.33	7.17	100	94	96	94
1889	2.97	3.89	.....	4.48	100	131	.....	151
1890	2.84	3.41	.....	3.98	100	120	.....	140
1891	3.51	3.06	.....	4.48	100	87	.....	128
1892	2.99	3.60	3.36	4.82	100	120	112	161
1893	3.82	4.32	3.90	4.67	100	113	102	122
1894	2.85	3.86	3.67	4.65	100	135	129	163
1895	2.14	3.02	.....	.....	100	141	.....	.....
1896	2.33	3.46	2.60	4.12	100	148	112	177
1897	2.25	3.75	2.55	3.81	100	167	113	169
1898	2.30	3.07	2.88	3.99	100	133	125	173
1899	2.54	3.03	2.68	3.46	100	119	106	136
1900	2.73	3.32	2.75	4.35	100	122	101	159
1901	2.89	3.92	3.11	3.96	100	136	108	137
1902	3.18	3.62	3.41	4.56	100	114	107	143
1903	3.14	4.17	3.60	3.79	100	133	115	121
1904	3.17	4.33	3.49	4.16	100	137	110	131
1905	3.24	4.44	3.79	3.99	100	137	117	123
1906	4.04	4.15	3.65	3.51	100	103	90	87
1907	3.77	3.84	3.87	3.41	100	102	103	90
1908	3.67	4.24	3.86	3.76	100	116	105	102
1909	3.96	4.27	3.84	3.98	100	108	97	101
1910	4.85	4.28	4.06	4.72	100	88	84	97
1911	3.96	4.42	4.40	4.78	100	112	111	121
1912	3.99	4.72	4.47	4.80	100	118	112	120
1913	4.24	4.64	4.45	4.94	100	109	105	117
1914	4.45	4.74	4.96	5.11	100	107	111	115
1915	4.04	4.50	4.75	5.66	100	111	118	140
1916	3.19	3.92	4.93	6.05	100	123	155	190
1917	4.07	4.52	5.70	5.82	100	111	140	143
1918	6.55	9.09	9.29	11.65	100	139	142	178
1919	8.27	9.21	10.23	9.99	100	111	124	121
1920	10.54	9.44	10.77	9.46	100	90	102	90
1921	5.52	7.99	6.50	6.49	100	145	118	118
1922	6.77	5.31	5.27	5.82	100	78	78	86
1923	7.58	5.90	6.78	6.90	100	78	89	91

\* The price of nitrogen in cottonseed meal, castor pomace, ground fish, and tankage was calculated from the price per ton and the actual nitrogen content after deductions had been made for the value at retail prices of the phosphoric acid in ground fish and in tankage and of the potash and phosphoric acid

pomace, ground fish, and tankage averaged only 8 per cent more than the price of nitrogen in cottonseed meal, as compared with 40 per cent more during the four years 1896 to 1899. During the war period, the price of nitrogen in cottonseed meal was low as compared with that in the other organic ammoniates. For the two years 1922 and 1923, however, the price of nitrogen in cottonseed meal averaged \$7.18 per unit, as compared with an average of \$6 per unit in the other three organic ammoniates.

The price of nitrogen in tankage was high when compared with the other organic ammoniates in 1899 and 1915, when there were peaks in the price of cattle.

The changes which occurred in the prices of the organic ammoniates followed changes in the general price level, declining from 1881 to 1898, rising from 1899 to 1914, and rising and declining during and following the World War.

Even though prices of organic ammoniates declined abruptly in 1920 and 1921, they remained from 25 to 40 per cent above the pre-war level during the two years 1922 and 1923. Organic ammoniates have been consistently higher than other fertilizer materials during the post-war period. In the earlier years, cottonseed meal and packing-house by-products were used primarily as fertilizers. At the present time, cottonseed meal, tankage, and ground fish are used extensively for feeding purposes. The demand for these products for use as feed has tended to keep the prices at a comparatively high level, so that there has been a decided shift to inorganic and synthetic nitrogen carriers for fertilizing purposes.

#### Mineral ammoniates

##### Nitrate of soda

*In Connecticut.* Nitrate of soda has been the commonest nitrogen carrier purchased by farmers for home mixing or for use in unmixed form. Both the retail price of nitrate of soda in Connecticut, and the wholesale price, are shown in table 11 and figure 7.

Dollars Per Ton

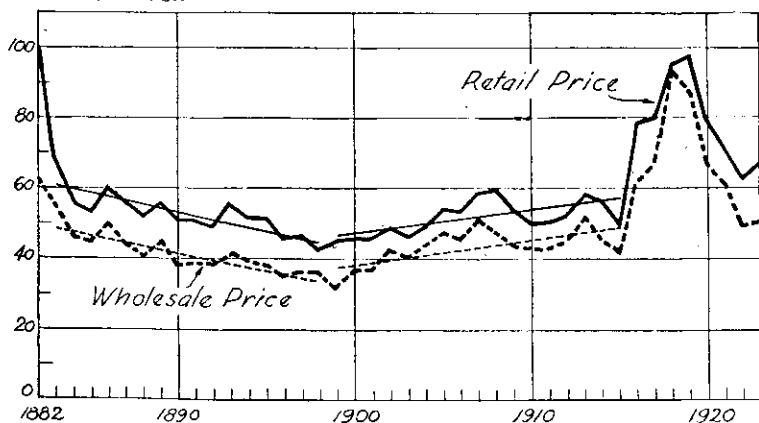


FIGURE 7. WHOLESALE PRICE OF NITRATE OF SODA, AND CONNECTICUT RETAIL PRICE, 1882 TO 1923

The long-time changes in wholesale and retail prices have been similar. The trend in both prices was downward from 1882 to 1898, and upward from 1899 to 1914

During the thirty-two years prior to the World War, the long-time changes or trends in both wholesale and retail prices were much the same. This was true for both the period of generally declining prices, 1882 to 1898, and the period of rising prices, 1899 to 1914. Even though the margin between the wholesale and the retail price varied from year to year, there was not enough change in the margin to cause the trend in retail prices to be greatly different from the trend in wholesale prices.

During the war period the violent price fluctuations caused wide variations in the margin.

The correlation between the wholesale price and the retail price was high during both the period of declining prices ( $r = 0.954$ ) and the period of

TABLE 11. RETAIL AND WHOLESALE PRICES, COST OF DISTRIBUTION, AND ANALYSIS OF NITRATE OF SODA IN CONNECTICUT, 1881 TO 1923

Year	Number of samples	Retail price per ton in Connecticut	Wholesale price per ton at ports	Cost of distribution per ton	Per cent of nitrogen found	Per cent of nitrogen guaranteed	Nitrogen overrun (per cent found minus guarantee)
1883-1885	2	\$ 59.04	\$48.30	\$10.74	15.87	.....	.....
1881-1885	2	72.42	.....	.....	15.54	.....	.....
1890-1894	2	50.97	38.74	12.23	15.99	.....	.....
1900-1904	4	46.75	39.74	7.01	15.72	15.48	0.24
1910-1914	11	53.31	45.28	8.03	15.41	15.00	0.41
1922-1923	16	64.04	49.60	14.44	15.54	15.00	0.54
1881	1	85.00	.....	.....	15.79	.....	.....
1882	1	100.00	61.65	38.35	14.29	.....	.....
1883	2	68.50	54.53	13.97	15.47	.....	.....
1884	4	56.12	46.16	9.96	16.00	.....	.....
1885	1	52.50	44.22	8.28	16.13	.....	.....
1886	3	59.83	48.96	10.87	16.02	.....	.....
1887	3	55.83	43.46	12.37	16.04	.....	.....
1888	2	51.00	40.43	10.57	16.32	.....	.....
1889	3	55.33	44.64	10.69	15.86	.....	.....
1890	1	50.00	37.42	12.58	16.06	.....	.....
1891	3	50.00	38.46	11.54	15.98	.....	.....
1892	4	48.50	37.99	10.51	16.18	.....	.....
1893	1	55.00	41.00	14.00	15.76	.....	.....
1894	3	51.33	38.83	12.50	15.99	.....	.....
1895	5	51.00	38.13	12.87	15.87	.....	.....
1896	7	45.14	34.54	10.60	15.91	.....	.....
1897	12	46.21	36.14	10.07	15.82	.....	.....
1898	12	42.25	35.51	6.74	15.63	.....	.....
1899	7	43.86	31.66	12.20	15.71	.....	.....
1900	3	45.00	36.24	8.76	15.75	15.53	0.22
1901	5	45.20	36.42	8.78	15.71	15.22	0.49
1902	3	48.33	42.26	6.07	15.70	15.37	0.33
1903	4	46.00	40.20	5.80	15.87	15.75	0.12
1904	6	49.25	43.60	5.65	15.56	15.53	0.03
1905	6	53.50	46.40	7.10	15.77	15.13	0.64
1906	10	52.60	44.80	7.80	15.33	15.08	0.25
1907	9	58.44	50.40	8.04	15.54	15.21	0.33
1908	5	59.00	47.60	11.40	15.39	15.32	0.07
1909	12	52.82	43.80	9.02	15.48	15.05	0.43
1910	18	49.45	42.20	7.25	15.27	15.08	0.19
1911	8	50.56	42.40	8.16	15.40	14.98	0.42
1912	11	52.11	45.20	6.91	15.44	15.00	0.44
1913	10	57.98	51.00	6.98	15.46	14.98	0.48
1914	7	56.43	45.60	10.83	15.47	14.97	0.50
1915	8	48.59	41.40	7.19	15.62	14.98	0.64
1916	9	77.94	60.80	17.14	15.44	14.98	0.46
1917	8	79.88	67.20	12.68	15.43	14.98	0.45
1918	4	95.16	93.20	1.96	15.32	14.95	0.37
1919	6	97.50	88.00	9.50	15.43	14.97	0.46
1920	13	78.80	66.60	12.20	15.35	15.02	0.33
1921	22	71.17	60.80	10.37	15.22	14.97	0.25
1922	17	61.79	48.80	12.99	15.59	15.01	0.58
1923	15	66.30	50.40	15.90	15.49	14.99	0.50

TABLE 12. INDEX NUMBERS OF RETAIL AND WHOLESALE PRICES, COST OF DISTRIBUTION, AND ANALYSIS OF NITRATE OF SODA IN CONNECTICUT, 1881 TO 1923  
 (1910-1914 = 100)

Year	Retail price per ton in Connecticut	Wholesale price per ton at ports	Cost of distribution per ton	Nitrogen found	Nitrogen guaranteed	Nitrogen overrun
1883-1885	111	107	134	103	.....	.....
1881-1885	136	.....	.....	101	.....	.....
1890-1894	96	86	152	104	.....	.....
1900-1904	88	88	87	102	103	59
1910-1914	100	100	100	100	100	100
1922-1923	120	110	180	101	100	132
1881	159	.....	.....	102	.....	.....
1882	188	136	478	93	.....	.....
1883	128	120	174	100	.....	.....
1884	105	102	124	104	.....	.....
1885	98	98	103	105	.....	.....
1886	112	108	135	104	.....	.....
1887	105	96	154	104	.....	.....
1888	96	89	132	106	.....	.....
1889	104	99	133	103	.....	.....
1890	94	83	157	104	.....	.....
1891	94	85	144	104	.....	.....
1892	91	84	131	105	.....	.....
1893	103	91	174	102	.....	.....
1894	96	86	156	104	.....	.....
1895	96	84	160	103	.....	.....
1896	85	76	132	103	.....	.....
1897	87	80	125	103	.....	.....
1898	79	78	84	101	.....	.....
1899	82	70	152	102	.....	.....
1900	84	80	109	102	104	54
1901	85	80	109	102	101	120
1902	91	93	76	102	102	80
1903	86	89	72	103	105	29
1904	92	96	70	101	104	7
1905	100	102	88	102	101	156
1906	99	99	97	99	101	61
1907	110	111	100	101	101	80
1908	111	105	142	100	102	17
1909	99	97	112	100	100	109
1910	93	93	90	99	101	46
1911	95	94	102	100	100	102
1912	98	100	86	100	100	107
1913	109	113	87	100	100	117
1914	106	101	135	100	100	122
1915	91	91	90	101	100	156
1916	146	134	213	100	100	112
1917	150	148	158	100	100	110
1918	179	206	24	99	100	90
1919	183	194	118	100	100	112
1920	148	147	152	100	100	80
1921	134	134	129	99	100	61
1922	116	108	162	101	100	141
1923	124	111	198	101	100	122

rising prices ( $r = 0.926$ ) (table 13). High retail prices were associated with high wholesale prices, and low retail prices with low wholesale prices. These correlations were high because the trends in both series were so

TABLE 13. CORRELATIONS BETWEEN THE WHOLESALE PRICE AND THE CONNECTICUT RETAIL PRICE OF NITRATE OF SODA, 1883 TO 1923

	1883-1898	1899-1914	1883-1923
Actual retail price with actual wholesale price	0.954	0.926	0.973
Retail price with wholesale price (first differences)	0.924	0.775	0.892

nearly the same. If the spread, or margin, between the two series of prices had been constant from year to year, the correlation would have been perfect.

Both wholesale and retail prices of nitrate of soda vary from year to year. In order to determine the relationship between these annual or short-time price fluctuations, the changes in the retail price from year to year were correlated with the year-to-year changes in the wholesale price (figures 7 and 8).<sup>2</sup> In thirty-six of the forty years 1884 to 1923, the

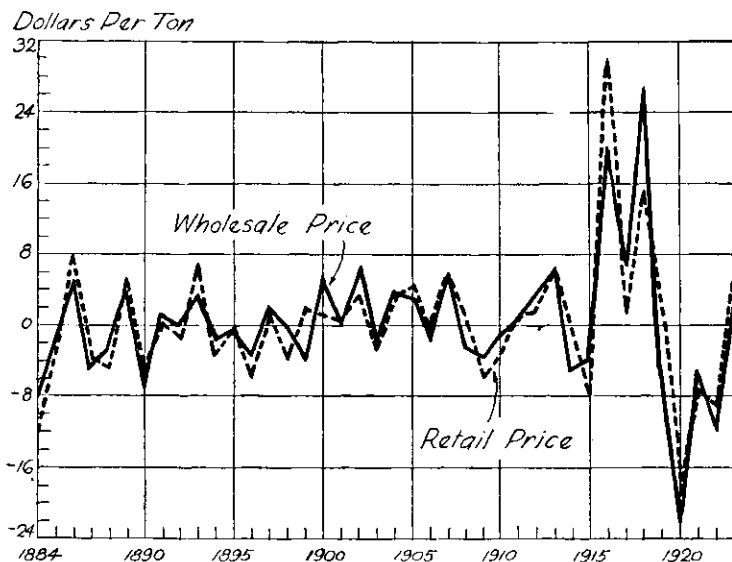


FIGURE 8. CHANGES IN WHOLESALE PRICE OF NITRATE OF SODA FROM YEAR TO YEAR, AND CHANGES IN THE CONNECTICUT RETAIL PRICE FROM YEAR TO YEAR, 1884 TO 1923

When wholesale prices rise, retail prices also rise

changes in the wholesale and retail prices of nitrate of soda were similar—that is, both increased or both decreased. In three of the forty years, the changes in price were opposite—that is, one increased and one decreased; and in one year the retail price remained the same while the wholesale price increased. There was a high degree of relationship between the short-time changes in the wholesale and the retail price during the period of declining prices ( $r = 0.924$ ) and during the period of rising prices ( $r = 0.775$ ), and also for the entire period from 1883 to 1923 ( $r = 0.892$ ) (table 13).

During the period from 1899 to 1914, a change of \$1 per ton in the wholesale price was accompanied by a change of only 67 cents in the retail price (table 14). That is, the change in the retail price was not so great as the change in the wholesale price. If the wholesale price increased \$1

<sup>2</sup> The first differences in the retail prices were correlated with the first differences in the wholesale prices.

per ton, the retail price tended to increase only 67 cents; and if the wholesale price declined \$1 per ton, the retail price tended to decline only 67 cents.

TABLE 14. CHANGE IN THE CONNECTICUT RETAIL PRICE OF NITRATE OF SODA ACCOMPANIED BY A CHANGE OF ONE DOLLAR IN THE WHOLESALE PRICE, 1883 TO 1923

	1883-1898	1884-1898	1899-1914	1883-1923
Change in retail price per ton, per dollar change in wholesale price per ton.....	\$1.22	\$1.12	\$0.67	\$0.90

During the period from 1883 to 1898, however, the changes in the retail price tended to be greater than the changes in the wholesale price (table 14 and figure 8). In the earlier period the data on retail prices were meager, so that some of the year-to-year variations in the retail price were probably due to the small number of quotations. In the period from 1883 to 1914, there was a tendency for retail prices to become more stable as compared with wholesale prices.

For the sixteen years 1883 to 1898, the retail price of nitrate of soda in Connecticut averaged \$52.41 per ton; the wholesale price for these years averaged \$41.28. The margin between the two, or the cost of distribution, averaged \$11.13. During the period of rising prices, the margin averaged \$8.17. This was \$2.96 ± \$2.67 less than the margin during the period of declining prices. The probable error of the difference is so large that the difference may be due to chance fluctuations, and therefore it is not possible to say that the margin during the period of declining prices was significantly greater than that during the period of rising prices.

There was little or no tendency for the margin to either increase or decrease during the period from 1899 to 1914. For the two years 1922 and 1923, however, the retail price averaged 20 per cent higher than for the five years 1910 to 1914; the wholesale price was about 10 per cent higher, and the margin was 80 per cent greater. This would seem to indicate that the cost of distribution was considerably greater than before the war, because of the increase in labor costs and handling charges.

*In Pennsylvania.* Retail prices of nitrate of soda for Pennsylvania are available for the twenty years 1909 to 1928 (table 15). For the pre-war period, 1910 to 1914,<sup>3</sup> the retail prices averaged \$54.88 per ton; the wholesale price for the same years averaged \$44.80. The margin, or cost of distribution, was \$10.08. During the five post-war years 1924 to 1928 the retail price averaged 25 per cent more than the pre-war price, while the wholesale price averaged 11 per cent above the pre-war price. The retail price had increased more than had the wholesale price (figure 9). The cost of distribution was \$18.72, or 86 per cent greater than the pre-war cost. For the two years 1922 and 1923 the margin in Connecticut was 80 per cent greater than the pre-war margin.

<sup>3</sup> 1910 to 1914 except 1912. The data for 1912 were for the spring season only. For each of the other years the data included both the spring and the fall season. Because of this, 1912 was omitted in calculating the average.

TABLE 15. RETAIL AND WHOLESALE PRICES AND COST OF DISTRIBUTION OF NITRATE OF SODA IN PENNSYLVANIA, 1909 TO 1928

Year	Retail price per ton in Pennsylvania*	Wholesale price per ton at ports	Cost of distribution per ton	Index numbers (1910-1914† = 100)		
				Retail price	Wholesale price	Cost of distribution
1910-1914†	\$ 54.88	\$44.80	\$10.08	100	100	100
1924-1928	68.60	49.88	18.72	125	111	186
1909	55.00	43.20	11.80	100	96	117
1910	52.00	42.20	9.80	95	94	97
1911	51.50	42.80	8.70	94	96	86
1912	52.00‡	46.80	5.20	95	104	52
1913	60.00	50.40	9.60	109	112	95
1914	56.00	43.80	12.20	102	98	121
1915	50.00	43.20	6.80	91	96	67
1916	77.50	64.00	13.50	141	143	134
1917	80.00	73.80	6.20	146	165	62
1918	104.00	96.20	7.80	190	215	77
1919	100.00	78.20	21.80	182	175	216
1920	82.00	70.40	11.60	149	157	115
1921	70.00	53.40	16.60	128	119	165
1922	60.00	50.00	10.00	109	112	99
1923	69.75	50.40	19.35	127	112	192
1924	68.00	50.20	17.80	124	112	177
1925	75.00	50.80	24.20	137	113	240
1926	70.00	51.60	18.40	128	115	183
1927	65.00	50.80	14.20	118	113	141
1928	65.00	46.00	19.00	118	103	188

\* Median retail price.

† 1910 to 1914 except 1912.

‡ For the spring season only.

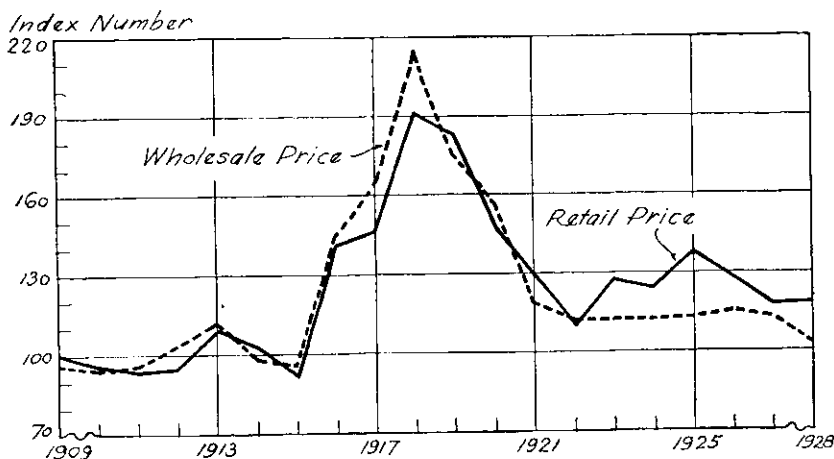


FIGURE 9. INDEX NUMBERS OF THE WHOLESALE PRICE AND THE PENNSYLVANIA RETAIL PRICE OF NITRATE OF SODA, 1909 TO 1928

Both wholesale and retail prices rose sharply during the war period. During the period 1923 to 1928, retail prices were high as compared with wholesale prices, and the margin between retail and wholesale prices was greater than the pre-war margin.

*In New York.* The retail price of nitrate of soda in New York State in 1914 was \$54.25; the wholesale price was \$45.60, and the difference, or cost of distribution, was \$8.65 (table 16). For the three years 1926 to 1928, the cost of distribution averaged \$19.32, or 223 per cent of the cost in 1914.



TABLE 16. RETAIL AND WHOLESALE PRICES, COST OF DISTRIBUTION, AND ANALYSIS OF NITRATE OF SODA IN NEW YORK, 1914 TO 1928

Year	Retail price per ton in New York	Wholesale price per ton at ports	Cost of distribution per ton	Per cent of nitrogen found	Index numbers (1914 = 100)			
					Retail price	Wholesale price	Cost of distribution	Nitrogen found
1914.....	\$ 54.25	\$45.60	\$ 8.65	15.20	100	100	100	100
1915.....	50.25	41.40	8.85	15.25	93	91	102	100
1916.....	77.62	60.80	16.82	15.50	143	133	194	102
1917.....	77.50	67.20	10.30	15.36	143	147	119	101
1918.....	114.50	93.20	21.30	15.38	211	204	246	101
1919.....	116.80	88.00	28.80	15.24	215	193	333	100
1920.....	89.72	66.60	23.12	15.25	165	146	267	100
1921.....	74.55	60.80	13.75	15.14	137	133	159	100
1922.....	67.66	48.80	18.86	15.22	125	107	218	100
1923.....	71.70	50.40	21.30	15.27	132	111	246	100
1924.....	66.28	50.00	16.28	15.23	122	110	188	100
1925.....	.....	50.80	.....	.....	.....	111	.....	.....
1926.....	70.35	52.20	18.15	15.20	130	114	210	100
1927.....	66.10	51.00	15.10	15.22	122	112	175	100
1928.....	71.50	46.80	24.70	15.22	132	103	286	100

There are differences in the year-to-year changes in the price of nitrate of soda in the various States. Some of the differences are probably due to the method of tabulating the data. For New York the average price of all the samples was all that was available. For Pennsylvania the prices of the individual samples were tabulated, and the retail prices given in table 15 are the median prices. In some years, some of the prices were unusually high and probably represented prices for small lots. In such years, the average price and the median price were considerably different, while in other years they were nearly the same. In order to eliminate the fluctuations in the average due to the unusually high prices that were sometimes quoted, the median price was used.

Some of the differences in the retail price probably represent changes which were due to changes in the demand.

While the changes in the retail prices of nitrate of soda varied somewhat in the different States, all the data indicated that the margin between the wholesale and the retail price during the post-war period was approximately double the margin during the pre-war period. That is, retail prices have increased more than wholesale prices have. Since farmers buy at retail prices, index numbers of wholesale prices do not indicate the changes in the prices which farmers have paid.

*In Texas.* During the five seasons 1923-24 to 1927-28 inclusive, the retail price of nitrate of soda in Texas averaged \$71.04 and the margin between the wholesale and the retail price averaged \$20.88 (table 17). The retail price of nitrate of soda averaged higher in Texas than in either New York or Pennsylvania.

The retail price declined at the rate of \$2 per ton per annum during the seven seasons 1922-23 to 1928-29. The wholesale price declined at the rate of 93 cents per annum during the same period. There was a tendency for the spread between the wholesale and the retail price to become smaller.

TABLE 17. RETAIL AND WHOLESALE PRICES AND COST OF DISTRIBUTION OF NITRATE OF SODA IN TEXAS, 1919-20 TO 1928-29

Season	Number of samples	Retail price per ton in Texas	Wholesale price per ton at ports*	Cost of distribution per ton	Number of tons
1919-20	6	\$102.50	\$66.60	\$35.90	.....
1920-21	9	77.61	60.80	16.81	.....
1921-22	14	74.36	48.80	25.56	.....
1922-23	26	76.90	50.40	26.50	.....
1923-24	42	73.28	50.00	23.28	1,558
1924-25	53	74.44	50.80	23.64	2,170
1925-26	35	71.54	52.20	19.34	2,614
1926-27	21	70.20	51.00	19.20	1,095
1927-28	30	65.72	46.80	18.92	2,846
1928-29	21	64.65	43.80	20.85	4,257

\* Wholesale price from July to June inclusive.

### Sulfate of ammonia

*In Connecticut.* At the present time, sulfate of ammonia is the most important single source of nitrogen in mixed fertilizers. During the post-war period the low prices of this product have stimulated its use as a source of nitrogen in the fertilizer industry.

In the pre-war period, when sulfate was less important as a nitrogen carrier, there were relatively few data in the state fertilizer reports on retail prices. This lack of data is no doubt indicative of the fact that sulfate of ammonia was not common in the retail trade.

During the period from 1885 to 1894 the retail price of sulfate in Connecticut averaged \$73.93 per ton, or about \$10 per ton more than the wholesale price (table 18 and figure 10). For the two years 1922 and 1923 the margin averaged \$19.14. This was much the same change that occurred in the margin between retail and wholesale prices of other fertilizer materials.

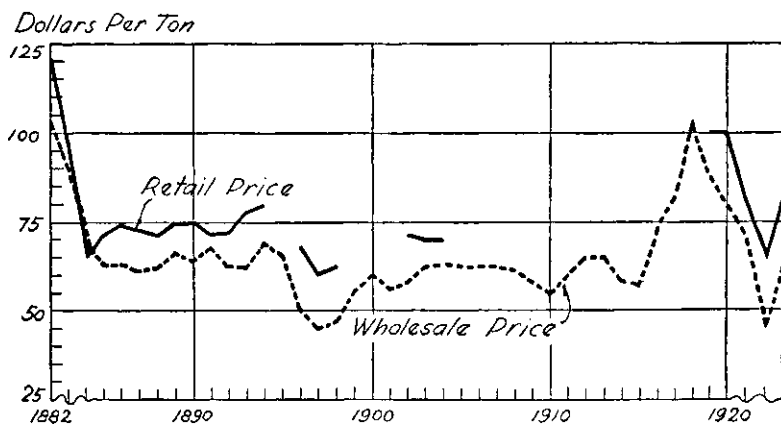


FIGURE 10. WHOLESALE PRICE AND CONNECTICUT RETAIL PRICE OF SULFATE OF AMMONIA, 1882 TO 1923

The wholesale price was high during the two years 1882 and 1883 and during the war period

TABLE 18. RETAIL AND WHOLESALE PRICES AND ANALYSIS OF SULFATE OF AMMONIA IN CONNECTICUT, 1882 TO 1923

Year	Number of samples	Retail price per ton in Connecticut	Wholesale price per ton	Per cent of nitrogen found	Index numbers of wholesale prices (1910-1914=100)
1882-1885	2	\$ 87.54	\$ 80.60	20.56	133
1890-1894	2	75.30	65.02	20.64	108
1900-1904	.....	.....	59.60	.....	99
1910-1914	.....	.....	60.48	.....	100
1922-1923	4	73.24	54.10	20.81	89
1882	1	120.00	102.89	20.56	170
1883	2	95.00	89.09	20.54	147
1884	2	63.75	67.88	20.50	112
1885	2	71.40	62.54	20.66	103
1886	3	73.61	63.13	20.53	104
1887	3	71.83	60.56	20.22	100
1888	4	71.20	61.67	20.08	102
1889	2	74.80	66.07	20.67	109
1890	1	75.00	63.65	20.86	105
1891	4	72.00	68.22	20.66	113
1892	1	72.00	61.67	20.52	102
1893	2	77.50	62.16	20.68	103
1894	1	80.00	69.40	20.50	115
1895	.....	.....	66.07	.....	109
1896	2	67.50	49.50	20.88	82
1897	2	60.00	44.51	20.86	74
1898	2	62.50	46.60	20.94	77
1899	.....	.....	54.60	.....	90
1900	1	75.00	60.20	20.30	100
1901	.....	.....	55.80	.....	92
1902	2	71.00	57.60	20.53	95
1903	1	70.00	61.60	20.80	102
1904	1	70.00	62.80	18.80	104
1905	.....	.....	62.20	.....	103
1906	.....	.....	62.00	.....	103
1907	.....	.....	62.00	.....	103
1908	.....	.....	61.20	.....	101
1909	.....	.....	58.40	.....	97
1910	.....	.....	54.80	.....	91
1911	.....	.....	59.60	.....	99
1912	.....	.....	64.80	.....	107
1913	.....	.....	65.20	.....	108
1914	.....	.....	58.00	.....	96
1915	.....	.....	57.20	.....	95
1916	.....	.....	73.00	.....	121
1917	.....	.....	82.40	.....	136
1918	.....	.....	102.00	.....	169
1919	1	100.00	87.60	20.90	145
1920	1	100.00	79.80	20.92	132
1921	5	78.01	70.80	20.55	117
1922	5	64.69	46.80	20.80	77
1923	4	81.80	61.40	20.82	102

*In other States.* Data on retail prices of sulfate of ammonia in Pennsylvania, New York, and Texas for a few post-war years are given in table 19. During the post-war period the tendency has been for both the

TABLE 19. RETAIL PRICES OF SULFATE OF AMMONIA IN PENNSYLVANIA, NEW YORK, AND TEXAS, 1920 TO 1929

Year	Retail price per ton			Wholesale price per ton†
	Pennsylvania	New York	Texas*	
1920	\$100.00	.....	.....	\$79.80
1921	77.60	.....	\$75.00	70.80
1922	68.84	\$72.25	.....	46.80
1923	.....	90.00	.....	61.40
1924	73.75	78.03	79.17	56.40
1925	76.63	.....	85.63	50.60
1926	74.71	72.00	75.96	54.20
1927	69.20	72.12	75.66	49.40
1928	72.68	71.50	70.55	49.40
1929	.....	.....	67.68	46.80

\* The prices for Texas are for the season. The Texas price for the 1920-21 season is opposite 1921.  
 † The wholesale price for each year is the average for the twelve months ending with June.

wholesale and the retail price to decline. For the five years 1924 to 1928, the wholesale price averaged about \$52 per ton, or 86 per cent of the 1910-to-1914 price.

#### SUPERPHOSPHATE

While there are many materials that are used as sources of nitrogen in the fertilizer trade, and several potash salts used as sources of potash, superphosphate (acid phosphate) is the only important source of phosphoric acid.

#### *Retail and wholesale prices*

##### *In Connecticut*

For the nineteen years 1896 to 1914, the retail price of phosphoric acid in superphosphate averaged \$1.11 per unit (table 20). During this period the price declined at the rate of 1 cent per unit, or 0.8 per cent, per annum. The wholesale price of superphosphate at Baltimore also tended to decline slightly. The trends in both wholesale and retail prices were about the same (figure 11).

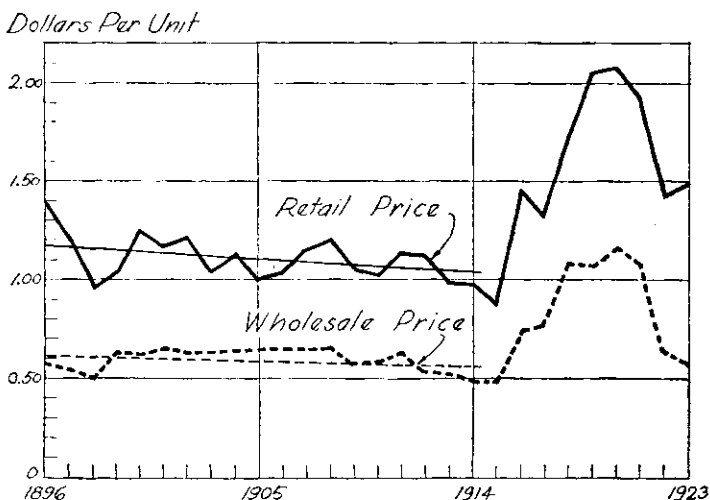


FIGURE 11. WHOLESALE AND RETAIL PRICES OF PHOSPHORIC ACID PER UNIT IN SUPERPHOSPHATE IN CONNECTICUT, 1896 TO 1923

The trends in the wholesale and in the retail prices were similar

During the inflation and deflation period the percentage change in the wholesale price was greater than the change in the retail price. The index number of the wholesale price per unit rose to 211 in 1920, and then declined to 116 in 1922 (table 21). The index number of the retail price rose to 198 in 1920 and declined to 136 in 1922.

For the five years 1910 to 1914, the retail price of phosphoric acid in Connecticut averaged \$1.05 per unit, while the wholesale price at Baltimore averaged 55 cents per unit (table 20). The cost of distribution—that is, the difference between the retail and the wholesale price—was 50 cents per unit.

TABLE 20. RETAIL AND WHOLESALE PRICES, COST OF DISTRIBUTION, AND ANALYSIS OF SUPERPHOSPHATE IN CONNECTICUT, 1896 TO 1923

Year	Number of samples	Retail price in Connecticut		Wholesale price of phosphoric acid per unit at Baltimore	Cost of distribution of phosphoric acid per unit	Per cent of available phosphoric acid found	Per cent of available phosphoric acid guaranteed
		Super-phosphate per ton	Phosphoric acid per unit*				
1896-1900.....	5	\$15.41	\$1.17	\$0.57	\$0.60	14.10	13.19
1910-1914.....	10	15.34	1.05	0.55	0.50	15.44	14.66
1922-1923.....	22	23.16	1.46	0.61	0.85	16.34	15.82
1896.....	3	17.00	1.39	0.57	0.82	13.00	12.19†
1897.....	4	16.00	1.21	0.54	0.67	14.09	13.22†
1898.....	7	12.61	0.96	0.50	0.46	13.99	13.12†
1899.....	7	13.93	1.04	0.62	0.42	14.30	13.41†
1900.....	2	17.50	1.25	0.61	0.64	15.14	14.00
1901.....	6	15.79	1.17	0.64	0.53	14.26	13.50
1902.....	4	17.25	1.21	0.62	0.59	15.10	14.25
1903.....	7	14.07	1.04	0.63	0.41	14.31	13.57
1904.....	11	15.77	1.13	0.64	0.49	15.04	13.91
1905.....	1	14.00	1.00	0.64	0.36	15.89	14.00
1906.....	5	13.80	1.03	0.64	0.39	14.27	13.40
1907.....	7	16.14	1.15	0.64	0.51	13.95	14.00
1908.....	3	16.00	1.20	0.66	0.54	16.04	13.33
1909.....	7	15.31	1.05	0.57	0.48	14.96	14.57
1910.....	4	14.84	1.02	0.58	0.44	15.34	14.50
1911.....	9	16.56	1.13	0.63	0.50	15.72	14.67
1912.....	7	15.89	1.12	0.53	0.59	14.63	14.14
1913.....	12	14.92	0.99	0.52	0.47	15.75	15.12
1914.....	18	14.50	0.98	0.48	0.50	15.75	14.86
1915.....	14	13.23	0.88	0.48	0.40	15.64	15.00
1916.....	12	22.98	1.45	0.72	0.73	16.32	15.83
1917.....	14	20.57	1.32	0.76	0.56	16.67	15.57
1918.....	12	26.58	1.72	1.08	0.64	16.02	15.46
1919.....	13	31.57	2.05	1.07	0.98	15.98	15.38
1920.....	16	32.74	2.08	1.16	0.92	16.24	15.75
1921.....	22	31.29	1.93	1.08	0.85	16.57	16.18
1922.....	26	22.87	1.43	0.64	0.79	16.58	16.00
1923.....	17	23.45	1.50	0.58	0.92	16.09	15.65

\* 1 unit = 20 pounds.

† Estimated. The guaranteed analysis of superphosphate was not given for the four years 1896 to 1899. During the five years 1900 to 1904 the guaranteed analysis averaged 93.8 per cent of the actual. The guaranteed analysis for the four years 1896 to 1899 was estimated by taking 93.8 per cent of the actual analysis.

For the two years 1922 and 1923 the margin between the retail and the wholesale price averaged 70 per cent greater than for the five years 1910 to 1914. For the pre-war period the cost of distribution, or margin, was 48 per cent of the retail price, as compared with 58 per cent for the two post-war years 1922 and 1923. The increase in the margin reflects primarily the increase in transportation and handling charges.

Only a limited amount of data on retail prices of superphosphate was contained in the Connecticut fertilizer reports. The year-to-year changes in the Connecticut retail price of this product were greater than the changes in the wholesale price. Some of the variation in the retail price may be due to sampling variations. For Pennsylvania there were more data available and the average retail price was more constant.

Correlations between the year-to-year changes in wholesale prices and in Connecticut retail prices of superphosphate are given in table 22. During the period from 1896 to 1914 the correlation was relatively low ( $r=0.375$ ). The wholesale price was relatively stable and the changes that did occur were not closely associated with changes in the retail price. For the twenty-eight-year period 1896 to 1923 the correlation was much

TABLE 21. INDEX NUMBERS OF RETAIL AND WHOLESALE PRICES, COST OF DISTRIBUTION, AND ANALYSIS OF SUPERPHOSPHATE IN CONNECTICUT, 1896 TO 1923

Year	Retail price in Connecticut		Wholesale price of phosphoric acid per unit at Baltimore	Cost of distribution of phosphoric acid per unit	Available phosphoric acid found	Available phosphoric acid guaranteed
	Super-phosphate per ton	Phosphoric acid per unit				
1896-1900.....	100	111	104	120	91	90
1910-1914.....	100	100	100	100	100	100
1922-1923.....	151	139	111	170	106	108
1896.....	111	132	104	164	84	83
1897.....	104	115	98	134	91	90
1898.....	82	91	91	92	91	89
1899.....	91	99	113	84	93	91
1900.....	114	119	111	128	98	95
1901.....	103	111	116	106	92	92
1902.....	112	115	113	118	98	97
1903.....	92	99	115	82	93	93
1904.....	103	108	116	98	97	95
1905.....	91	95	116	72	103	95
1906.....	90	98	116	78	92	91
1907.....	105	110	116	102	90	95
1908.....	104	114	120	108	104	91
1909.....	100	100	104	96	97	99
1910.....	97	97	105	88	99	99
1911.....	108	108	115	100	102	100
1912.....	104	107	96	118	95	96
1913.....	97	94	95	94	102	103
1914.....	95	93	87	100	102	101
1915.....	86	84	87	80	101	102
1916.....	150	138	131	146	106	108
1917.....	134	126	138	112	108	106
1918.....	173	164	196	128	104	105
1919.....	206	195	195	196	103	105
1920.....	213	198	211	184	105	107
1921.....	204	184	196	170	107	110
1922.....	149	136	116	158	107	109
1923.....	153	143	105	184	104	107

TABLE 22. CORRELATIONS BETWEEN WHOLESALE PRICES AND CONNECTICUT RETAIL PRICES OF PHOSPHORIC ACID, 1896 TO 1923

	1896-1914	1896-1923
Actual retail and wholesale prices.....	(r) 0.375	(r) 0.758
Retail and wholesale prices (first differences).....	0.285	0.898

higher ( $r = 0.758$ ). There was a rapid rise and decline in both retail and wholesale prices during and following the war. The relatively high correlation for the entire period 1896 to 1923 is due primarily to the unusual changes that occurred during the years 1915 to 1921 (figure 11).

The correlations between the actual wholesale and retail prices were much the same as the correlations between the year-to-year changes in the prices.

#### *In New York*

Data on retail prices of superphosphate for New York were available for the period from 1914 to 1928 (table 23). In 1914 the average retail price in New York was \$14.50 per ton. The analysis averaged 14.65 per cent of available phosphoric acid, and so the retail

price per unit was 99 cents. The wholesale price at Baltimore averaged 48 cents per unit, making the cost of distribution 51 cents per unit. The retail price per unit and the cost of distribution were practically the same as in Connecticut for the same year.

TABLE 23. RETAIL AND WHOLESALE PRICES, COST OF DISTRIBUTION, AND ANALYSIS OF SUPERPHOSPHATE IN NEW YORK, 1914 TO 1928

Year	Retail price of super-phosphate per ton in New York	Per cent of available phosphoric acid found	Retail price of phosphoric acid per unit in New York	Wholesale price of phosphoric acid per unit at Baltimore	Cost of distribution of phosphoric acid per unit
1914.....	\$14.50	14.65	\$0.99	\$0.48	\$0.51
1915.....	14.60	15.23	0.96	0.48	0.48
1916.....	20.20	15.00	1.35	0.72	0.63
1917.....	19.16	15.07	1.27	0.76	0.51
1918.....	25.30	15.00	1.69	1.08	0.61
1919.....	30.50	15.52	1.97	1.07	0.90
1920.....	30.80	16.00	1.92	1.16	0.76
1921.....	29.45	16.19	1.82	1.08	0.74
1922.....	21.30	16.34	1.30	0.64	0.66
1923.....	21.35	16.70	1.28	0.58	0.70
1924.....	19.30	16.53	1.17	0.50	0.67
1925.....	.....	.....	.....	0.54	.....
1926.....	24.47	16.83	1.45	0.61	0.84
1927.....	20.60	17.21	1.20	0.55	0.65
1928.....	23.72	17.44	1.36	0.54	0.82

During the period of inflation the index number of the retail price rose to 199 while the index number of the wholesale price rose to 242 (table 24). Wholesale prices fluctuated more violently than did retail prices.

TABLE 24. INDEX NUMBERS OF RETAIL AND WHOLESALE PRICES, COST OF DISTRIBUTION, AND ANALYSIS OF SUPERPHOSPHATE IN NEW YORK, 1914 TO 1928

(1914 = 100)

Year	Retail price of super-phosphate per ton in New York	Per cent of available phosphoric acid found	Retail price of phosphoric acid per unit in New York	Wholesale price of phosphoric acid per unit at Baltimore	Cost of distribution of phosphoric acid per unit
1914.....	100	100	100	100	100
1915.....	101	104	97	100	94
1916.....	139	102	136	150	124
1917.....	132	103	128	158	100
1918.....	174	102	171	225	120
1919.....	210	106	199	223	176
1920.....	212	109	194	242	149
1921.....	203	111	184	225	145
1922.....	147	112	131	133	129
1923.....	147	114	129	121	137
1924.....	133	113	118	104	131
1925.....	.....	.....	.....	112	.....
1926.....	169	115	146	127	165
1927.....	142	117	121	115	127
1928.....	164	119	137	112	161

For the three years 1926 to 1928, the retail price per unit averaged 35 per cent more than in 1914, the wholesale price was 18 per cent higher, and the cost of distribution was 51 per cent greater (table 24). Retail prices during the post-war period have been relatively higher than whole-

sale prices. The cost of distribution, however, has increased even more than has the retail price. In 1914 the cost of distribution per unit was 52 per cent of the retail price, as compared with 58 per cent for the three years 1926 to 1928.

During the post-war period from 1926 to 1928, the superphosphate in New York averaged 17.16 units of phosphoric acid per ton, which was 17 per cent greater than in 1914. Higher grades of superphosphate are being used. The cost of distribution consists primarily of charges for handling and transportation. These costs tend to be a uniform amount per ton. By using higher grades it is possible to cut down on the average cost of distribution per unit. If there had not been this increase in concentration, the retail price per unit of phosphoric acid would probably be even higher than it has been, since the increase in the cost of distribution would not be spread over so many units.

### *In Indiana*

During the five years 1910 to 1914, the retail price of phosphoric acid in Indiana averaged \$1.16 per unit (table 25), or about 10 per cent more than the Connecticut retail price, \$1.05. The cost of distribution in Indiana was 62 cents per unit, as compared with 50 cents in Connecticut. The cost of distribution was larger, and represented 53 per cent of the retail price in Indiana as compared with 47 per cent in Connecticut.

The relative changes in wholesale and retail prices in Indiana during the inflation period were much the same as in New York and Connecticut.

TABLE 25. RETAIL AND WHOLESALE PRICES, COST OF DISTRIBUTION, AND ANALYSIS OF SUPERPHOSPHATE IN INDIANA, 1906 TO 1928

Year	Retail price of superphosphate per ton in Indiana	Per cent of available phosphoric acid guaranteed	Retail price of phosphoric acid per unit in Indiana	Wholesale price of phosphoric acid per unit in bulk at Baltimore	Cost of distribution of phosphoric acid per unit	Number of tons of superphosphate in Indiana
1906-1909.....	\$16.28	.....	.....	\$0.62	.....	7,988
1910-1914.....	16.22	14.0	\$1.16	0.54	\$0.62	10,325
1924-1928.....	30.19	21.8	1.39	0.56	0.83	43,620
1906.....	14.86	.....	.....	0.64	.....	8,904
1907.....	16.16	.....	.....	0.65	.....	7,044
1908.....	16.73	.....	.....	0.63	.....	7,892
1909.....	17.37	.....	.....	0.58	.....	8,111
1910.....	16.52	13.6	1.21	0.59	0.62	7,572
1911.....	16.74	13.8	1.21	0.60	0.61	9,262
1912.....	16.23	13.9	1.17	0.52	0.65	9,940
1913.....	15.94	14.5	1.10	0.52	0.58	11,974
1914.....	15.67	14.3	1.10	0.48	0.62	12,878
1915.....	16.09	15.2	1.06	0.48	0.58	14,783
1916.....	20.44	15.7	1.30	0.78	0.52	26,526
1917.....	20.18	15.8	1.28	0.82	0.46	42,562
1918.....	26.41	15.8	1.67	1.11	0.56	57,984
1919.....	28.99	16.0	1.81	1.06	0.75	59,001
1920.....	31.91	16.0	1.99	1.22	0.77	68,171
1921.....	23.73	16.5	1.44	0.95	0.49	53,767
1922.....	20.67	16.8	1.23	0.59	0.64	60,740
1923.....	25.78	18.2	1.42	0.57	0.85	49,501
1924.....	28.14	20.8	1.35	0.50	0.85	53,553
1925.....	30.53	23.2	1.32	0.57	0.75	37,127
1926.....	31.99	23.1	1.38	0.61	0.77	48,381
1927.....	28.61	19.6	1.46	0.54	0.92	32,041
1928.....	31.68	22.3	1.42	0.56	0.86	26,997



One of the most notable changes that have occurred in Indiana is the unusual increase in the number of units of phosphoric acid per ton. During the five years 1910 to 1914, the guaranteed analysis averaged 14.0 per cent of available phosphoric acid. During the five years 1924 to 1928, however, the analysis averaged 21.8 per cent, or 56 per cent more than during the pre-war period (table 26). The increase in the use of high-grade superphosphate has been much more marked in Indiana than in either Connecticut, New York, Pennsylvania, or Texas.

TABLE 26. INDEX NUMBERS OF RETAIL AND WHOLESALE PRICES, COST OF DISTRIBUTION, AND ANALYSIS OF SUPERPHOSPHATE IN INDIANA, 1906 TO 1928 (1910-1914 = 100)

Year	Retail price of superphosphate per ton in Indiana	Available phosphoric acid guaranteed	Retail price of phosphoric acid per unit in Indiana	Wholesale price of phosphoric acid per unit in bulk at Baltimore	Cost of distribution of phosphoric acid per unit	Tonnage of superphosphate in Indiana
1906-1909.....	100	.....	.....	115	.....	77
1910-1914.....	100	100	100	100	100	100
1924-1928.....	186	156	120	104	134	422
1906.....	92	.....	.....	119	.....	86
1907.....	100	.....	.....	120	.....	68
1908.....	103	.....	.....	117	.....	76
1909.....	107	.....	.....	107	.....	79
1910.....	102	97	104	109	100	73
1911.....	103	99	104	111	98	90
1912.....	100	99	101	96	105	96
1913.....	98	104	95	96	94	116
1914.....	97	102	95	89	100	125
1915.....	99	109	91	89	94	143
1916.....	126	112	112	144	84	257
1917.....	124	113	110	152	74	412
1918.....	163	113	144	206	90	562
1919.....	179	114	156	196	121	571
1920.....	197	114	172	226	124	660
1921.....	146	118	124	176	79	521
1922.....	127	120	106	109	103	588
1923.....	159	130	122	106	137	479
1924.....	173	149	116	93	137	519
1925.....	188	166	114	106	121	553
1926.....	197	165	119	113	124	469
1927.....	176	140	126	100	148	310
1928.....	195	159	122	104	139	261

During the five years 1924 to 1928 the retail price of superphosphate in Indiana averaged \$30.19 per ton, or 86 per cent more than during the period from 1910 to 1914. The analysis averaged 21.8 per cent of available phosphoric acid. The average retail price of phosphoric acid was \$1.39 per unit, or only 20 per cent above the pre-war price.

Because of the increase in concentration, the cost of distribution of phosphoric acid per unit increased only 34 per cent. For some of the materials the average analysis of which has not changed, the cost of distribution per unit during the post-war period has been nearly double the pre-war cost.

#### *In Pennsylvania*

The average retail price of superphosphate per ton and the retail price of phosphoric acid per unit, in Pennsylvania, are shown in table 27 and figure 12. During the sixteen-year period from 1899 to 1914, the aver-

Dollars Per Unit

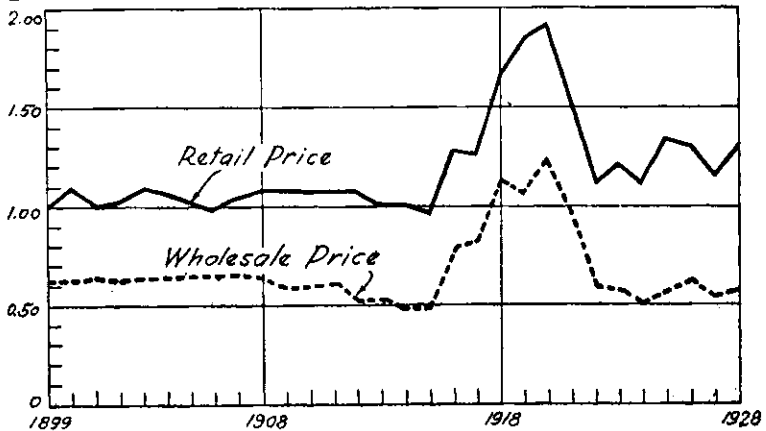


FIGURE 12. WHOLESALE AND RETAIL PRICES OF PHOSPHORIC ACID PER UNIT IN SUPERPHOSPHATE IN PENNSYLVANIA, 1899 TO 1928

Prices were relatively constant during the 16 years prior to the war. The spread between the retail and the wholesale prices during the post-war period was decidedly greater than that during the pre-war period.

TABLE 27. RETAIL AND WHOLESALE PRICES, COST OF DISTRIBUTION, AND ANALYSIS OF SUPERPHOSPHATE IN PENNSYLVANIA, 1899 TO 1928

Year	Retail price of super-phosphate per ton in Pennsylvania	Per cent of available phosphoric acid guaranteed	Retail price of phosphoric acid per unit in Pennsylvania	Wholesale price of phosphoric acid per unit in bulk at Baltimore	Cost of distribution	
					Phosphoric acid per unit	Super-phosphate per ton†
1900-1904.....	\$14.04	13.39	\$1.05	\$0.63	\$0.42	\$ 5.65
1905-1909.....	13.96	13.50	1.04	0.63	0.41	5.51
1910-1914*.....	14.18	13.74	1.03	0.55	0.48	6.66
1924-1928.....	20.08	16.18	1.24	0.56	0.68	11.04
1899.....	13.23	13.26	1.00	0.62	0.38	5.04
1900.....	14.48	13.25	1.09	0.62	0.47	6.23
1901.....	13.60	13.61	1.00	0.63	0.37	5.04
1902.....	13.60	13.36	1.02	0.62	0.40	5.34
1903.....	14.32	13.28	1.08	0.63	0.45	5.98
1904.....	14.20	13.44	1.06	0.64	0.42	5.64
1905.....	13.70	13.33	1.03	0.64	0.39	5.20
1906.....	13.34	13.57	0.98	0.64	0.34	4.61
1907.....	14.04	13.55	1.04	0.65	0.39	5.28
1908.....	14.47	13.56	1.07	0.63	0.44	5.97
1909.....	14.25	13.49	1.06	0.58	0.48	6.48
1910.....	14.34	13.50	1.06	0.59	0.47	6.34
1911.....	14.71	13.73	1.07	0.60	0.47	6.45
1912.....	14.91†	13.90†	1.07	0.52	0.55	7.64
1913.....	13.75	13.80	1.00	0.52	0.48	6.62
1914.....	13.94	13.94	1.00	0.48	0.52	7.25
1915.....	13.95	14.58	0.96	0.48	0.48	7.00
1916.....	18.51	14.59	1.27	0.78	0.49	7.15
1917.....	18.26	14.56	1.25	0.82	0.43	6.26
1918.....	24.19	14.64	1.65	1.11	0.54	7.91
1919.....	27.49	14.97	1.84	1.06	0.78	11.68
1920.....	29.63	15.48	1.91	1.22	0.69	10.68
1921.....	23.76	15.56	1.53	0.95	0.58	9.02
1922.....	17.27	15.55	1.11	0.59	0.52	8.09
1923.....	18.95	15.75	1.20	0.57	0.63	9.92
1924.....	17.46	15.68	1.11	0.50	0.61	9.56
1925.....	21.26	15.95	1.33	0.57	0.76	12.12
1926.....	21.15	16.31	1.30	0.61	0.69	11.25
1927.....	18.98	16.47	1.15	0.54	0.61	10.05
1928.....	21.55	16.51	1.30	0.56	0.74	12.22

\* 1910 to 1914 except 1912.

† For the spring season only.

‡ Calculated by multiplying the cost of distribution per unit by the number of units per ton.

age retail price of phosphoric acid per unit remained practically constant; the highest price, \$1.09 per unit, was in 1900, and the lowest, 98 cents per unit, was in 1906. The wholesale price of phosphoric acid per unit at Baltimore also was relatively constant, especially for the period from 1899 to 1911. From 1911 to 1914, however, the wholesale price declined from 60 to 48 cents per unit.

In 1920 the retail price per unit was 185 per cent of the pre-war price while the wholesale price was 222 per cent of the pre-war price (table 28).<sup>4</sup> The relative increase in the wholesale price was greater than the increase in the retail price.

TABLE 28. INDEX NUMBERS OF RETAIL AND WHOLESALE PRICES, COST OF DISTRIBUTION, AND ANALYSIS OF SUPERPHOSPHATE IN PENNSYLVANIA, 1899 to 1928

(1910-1914 = 100\*)

Year	Retail price of superphosphate per ton in Pennsylvania	Available phosphoric acid guaranteed	Retail price of phosphoric acid per unit in Pennsylvania	Wholesale price of phosphoric acid per unit in bulk at Baltimore	Cost of distribution	
					Phosphoric acid per unit	Superphosphate per ton
1900-1904.....	99	97	102	115	87	85
1905-1909.....	98	98	101	115	85	83
1910-1914*.....	100	100	100	100	100	100
1924-1928.....	142	118	120	102	142	166
1899.....	93	97	97	113	79	76
1900.....	102	96	106	113	98	94
1901.....	96	99	97	115	77	76
1902.....	96	97	99	113	83	80
1903.....	101	97	105	115	94	90
1904.....	100	98	103	116	87	85
1905.....	97	97	100	116	81	78
1906.....	94	99	95	116	71	69
1907.....	99	99	101	118	81	79
1908.....	102	99	104	115	92	90
1909.....	100	98	103	105	100	97
1910.....	101	98	103	107	98	95
1911.....	104	100	104	109	98	97
1912.....	105†	101†	104	95	115	115
1913.....	97	100	97	95	100	99
1914.....	98	101	97	87	108	109
1915.....	98	106	93	87	100	105
1916.....	131	106	123	142	102	107
1917.....	129	106	121	149	90	94
1918.....	171	107	160	202	112	119
1919.....	194	109	179	193	162	175
1920.....	209	113	185	222	144	160
1921.....	168	113	149	173	121	135
1922.....	122	113	108	107	108	121
1923.....	134	115	117	104	131	149
1924.....	123	114	108	91	127	144
1925.....	150	116	129	104	158	182
1926.....	149	119	126	111	144	169
1927.....	134	120	112	98	127	151
1928.....	152	120	126	102	154	183

\* 1910 to 1914 except 1912.

† For the spring season only.

During the five-year period 1924 to 1928, the retail price of superphosphate in Pennsylvania averaged \$20.08 per ton, or 42 per cent higher than the pre-war price. The guaranteed analysis averaged 16.18 per cent avail-

<sup>4</sup> In calculating the index numbers, the average for the four years 1910, 1911, 1913, and 1914 was used as a base. The data for 1912 were for the spring season only; for each of the other years the data were for the spring and fall seasons combined.

able phosphoric acid, or 18 per cent more than the pre-war figure. Thus the retail price per unit of phosphoric acid was only 20 per cent higher than in the pre-war period. The wholesale price at Baltimore during the five years 1924 to 1928 was only 2 per cent above the pre-war price.

The year-to-year variations in the average retail price per unit during the five-year period 1924 to 1928 were greater than during the entire sixteen-year period 1899 to 1914.

For the period from 1910 to 1914<sup>5</sup> the retail price of phosphoric acid in Pennsylvania averaged \$1.03 per unit; the wholesale price was 55 cents. The difference between the retail and the wholesale price, or the cost of distribution, was 48 cents, or 47 per cent of the retail price. In the five years 1924 to 1928 the margin between the retail and the wholesale price was 68 cents, or 42 per cent greater than in the pre-war period. In the post-war period the cost of distribution per unit was 55 per cent of the retail price, as compared with 47 per cent in the pre-war period.

### *Relation of retail price to analysis*

#### *In Pennsylvania*

There are many different analyses, or grades, of superphosphate. The preceding discussion of the prices of superphosphate dealt with the average prices of all grades combined. A more detailed picture is obtained when the prices of the different analyses are compared.

During the period from 1899 to 1928, the guaranteed analyses of superphosphate in Pennsylvania varied from 7 to 20 per cent (table 29). No one analysis predominated throughout the entire period. From 1899 to 1916 the 14-per-cent superphosphate was the most prevalent. From 1917 to 1928, however, the 16-per-cent was the most important. The change has been toward higher analyses.

The average retail price of each grade of superphosphate for the sixteen-year period 1899 to 1914 is given in table 30. There was no consistent relationship between the guaranteed analysis and the price per ton. The retail price of phosphoric acid per unit in each grade is shown in figure 13. The retail price per unit tended to decline as the analysis increased.

The average retail price of phosphoric acid in the 14-per-cent superphosphate (the most important grade from 1899 to 1916) was \$1 per unit; in the 12-per-cent grade it was 19 per cent higher, and in the 10-per-cent grade it was 38 per cent higher. The price per unit in the 16-per-cent grade, however, was only 8 per cent less than in the 14-per-cent superphosphate. That is, there was less difference in the average retail price per unit in the grades that contained more than 14 per cent of phosphoric acid than in the grades that contained less than 14 per cent.

In the five-year period 1924 to 1928, the 16-per-cent superphosphate was the predominant grade. During this period the average retail prices per ton of the 13-, 14-, and 16-per-cent grades were much the same, but the 18- and 20-per-cent grades were distinctly higher in price.

The retail price of phosphoric acid per unit tended to decline as the analysis increased from the lowest to the most popular grade, but for the

<sup>5</sup> 1910 to 1914 except 1912.

TABLE 29. AVERAGE RETAIL PRICE PER TON OF VARIOUS GRADES OF SUPERPHOSPHATE IN PENNSYLVANIA, 1899 TO 1928\*

Year	7 per cent		8 per cent		9 per cent		10 per cent		11 per cent		12 per cent		13 per cent		14 per cent		15 per cent		16 per cent		18 per cent		20 per cent	
	Number of samples	Retail price	Number of samples	Retail price	Number of samples	Retail price	Number of samples	Retail price	Number of samples	Retail price	Number of samples	Retail price	Number of samples	Retail price	Number of samples	Retail price	Number of samples	Retail price	Number of samples	Retail price	Number of samples	Retail price	Number of samples	Retail price
1899					2	\$11.75	12	\$14.00	4	\$15.38	5	\$13.00	12	\$13.42	81	\$13.01			2	\$15.35				
1900	1	\$13.00	1	\$14.50	1	12.50	11	15.27	3	15.67	7	13.43	1	16.00	81	14.47			2	13.50				
1901	1	15.00			2	14.25	3	12.50	5	15.00	7	12.66	2	13.50	121	13.62	4	\$13.00						
1902					3	14.67	9	12.94	4	16.50	21	13.76			131	13.45	3	15.33						
1903					3	12.38	12	14.50	5	15.80	20	14.69	1	16.00	125	14.22								
1904							11	13.43			12	14.33	2	16.00	95	14.13	2	19.50						
1905					2	12.50	9	13.22	2	15.50	17	13.59	2	16.00	100	13.71								
1906					1	12.00	2	14.50	3	16.33	13	13.62	1	16.00	86	13.13	1	13.00	1	16.00				
1907			1	16.40	1	13.00	3	14.67			8	14.34	2	15.50	62	13.93	1	13.00	2	14.00				
1908					1	14.00	4	13.75	1	14.00	8	14.63	1	15.00	69	14.45	1	16.50	1	16.00				
1909					1	13.00	8	14.44	4	16.50	10	13.90			98	14.18			3	14.50				
1910					2	13.00	5	12.75	3	17.33	11	14.41			99	14.30			3	14.69				
1911					3	13.00	2	14.38	1	16.00	13	14.62			121	14.74	1	14.00	6	15.10				
1912†									2	16.00	7	16.43			53	14.71	1	14.00	6	14.74				
1913					1	12.50	3	14.00	3	15.33	6	17.27			93	13.43			10	13.62				
1914					1	12.00	1	12.00	3	16.67	7	14.30			83	13.81			13	14.25				
1915							1	12.00			2	16.00			78	13.82			39	14.20				
1916							7	16.14	4	18.15	9	18.09	1	28.00	89	18.22			86	18.93	1	\$20.50		
1917			3	19.83			12	15.96	2	22.50	12	17.28	4	19.50	86	18.12			113	18.52	2	19.35		
1918			1	23.00			16	21.59	1	28.00	11	23.32	7	24.93	94	23.84			137	24.75				
1919			2	25.00			6	23.58			10	25.93	4	28.06	81	27.09			156	27.96				
1920							1	25.00					8	32.87	38	29.07			158	29.63				
1921													24	24.45	21	24.51			205	23.57			1	\$31.00
1922													37	17.61	13	16.53			215	17.20	2	19.75	3	19.50
1923													18	19.85	2	17.75			150	18.76	3	21.17	2	22.73
1924													35	17.11					228	17.41	3	19.72	3	23.17
1925													34	20.73					224	20.95	8	22.21	18	25.72
1926													24	20.21					235	20.77			41	23.88
1927													25	18.32	1	18.00			209	18.16			53	22.57
1928													29	21.84	2	22.50			220	20.42			63	25.31

\* The following retail prices also were given for grades with fractional guarantees: 1899, one sample 14.5-per-cent, \$11.50; 1900, one sample 11.5-per-cent, \$16.00, and one sample 15.5-per-cent, \$12.50; 1902, one sample 5.5-per-cent, \$15.00; 1910, one sample 6.5-per-cent, \$18.00; 1913, one sample 8.5-per-cent, \$18.60; 1915, one sample 14.4-per-cent, \$12.50; 1917, one sample 12.14-per-cent, \$21.00; 1927, one sample 16.5-per-cent, \$16.25.

† For the spring season only.

RETAIL PRICES OF FERTILIZER MATERIALS AND MIXED FERTILIZERS

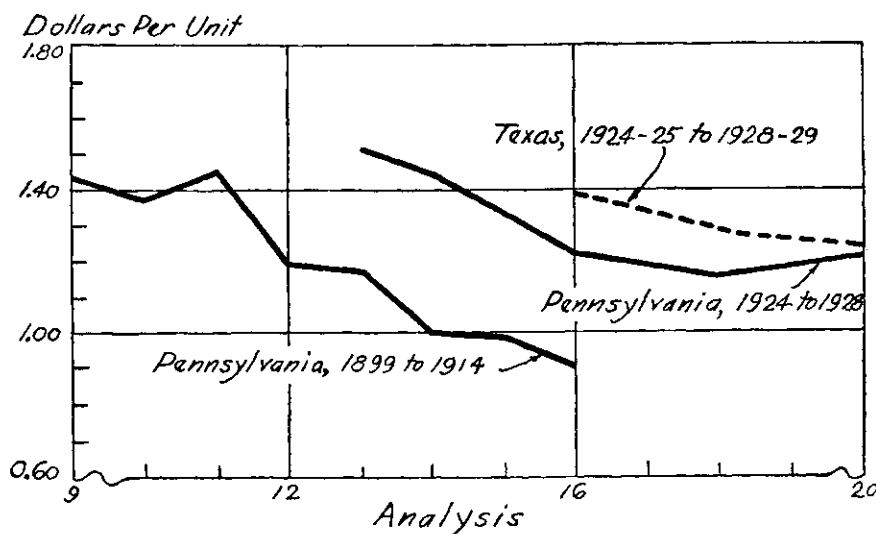


FIGURE 13. RETAIL PRICE OF PHOSPHORIC ACID PER UNIT IN VARIOUS GRADES OF SUPERPHOSPHATE, IN PENNSYLVANIA FROM 1899 TO 1914 AND FROM 1924 TO 1928, AND IN TEXAS FROM 1924-25 TO 1928-29

The retail price per unit tends to decline as the analysis increases

TABLE 30. AVERAGE RETAIL PRICE PER TON OF VARIOUS GRADES OF SUPERPHOSPHATE IN PENNSYLVANIA, 1899 TO 1914 AND 1924 TO 1928

Per cent of available phosphoric acid guaranteed	1899-1914				1924-1928			
	Retail price of superphosphate per ton	Retail price of phosphoric acid per unit	Total number of samples	Number of years price was available	Retail price of superphosphate per ton	Retail price of phosphoric acid per unit	Total number of samples	Number of years price was available
7.....	\$14.00	\$2.00	2	2	.....	.....	.....	.....
8.....	15.45	1.93	2	2	.....	.....	.....	.....
9.....	12.90	1.43	24	14	.....	.....	.....	.....
10.....	13.76	1.38	95	15	.....	.....	.....	.....
11.....	15.86	1.44	43	14	.....	.....	.....	.....
12.....	14.31	1.19	172	16	.....	.....	.....	.....
13.....	15.27	1.17	24	9	\$19.64	\$1.51	147	5
14.....	13.96	1.00	1,498	16	20.25	1.45	3	2
15.....	14.79	0.99	14	8	.....	.....	.....	.....
16.....	14.70	0.92	49	11	19.54	1.22	1,116	5
18.....	.....	.....	.....	.....	20.96	1.16	11	2
20.....	.....	.....	.....	.....	24.13	1.21	178	5

18- and 20-per-cent grades the average retail price per unit was much the same as in the 16-per-cent grade (figure 13).

The average retail price per unit of phosphoric acid in the predominating grade was not the lowest in either the pre-war or the post-war period. During the period from 1924 to 1928 the average price of phosphoric acid in the 14-per-cent superphosphate was \$1.45 per unit; in the 16-per-cent grade it was \$1.22, or 23 cents per unit less. The average price in the 18- and 20-per-cent grades was \$1.16 and \$1.21, respectively. The

difference in price per unit between the 14- and the 16-per-cent grade was much greater than the difference between the 16- and the 18- or 20-per-cent grade. As far as price was concerned, there was more of an incentive to shift from the 14- to the 16-per-cent grade than to shift from the 16- to the 18- or 20-per-cent grade.

#### *In Indiana*

In 1915 the price of phosphoric acid in 20-per-cent superphosphate in Indiana was 92 cents per unit, as compared with \$1.12 in the 14-per-cent grade, which made up more than half of the total tonnage for that year (table 31).

Beginning with 1921, retail prices were given on grades containing more than 40 per cent of available phosphoric acid. For the three years 1926 to 1928 the retail price averaged \$1.21 per unit in these extremely high grades of superphosphate, as compared with \$1.43 per unit in the 20-per-cent grade, which made up the largest tonnage in those years. In the 13- and 16-per-cent grades the retail price per unit averaged \$2.09 and \$1.57 per unit, respectively. The decrease in the retail price of phosphoric acid per unit of increase in the analysis was larger for the grades below 20 per cent than for those with higher analyses (table 31 and figure 14).

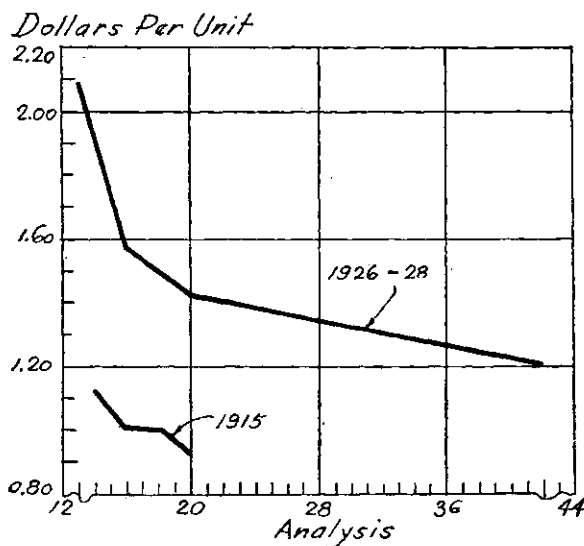


FIGURE 14. RETAIL PRICE OF PHOSPHORIC ACID PER UNIT IN VARIOUS GRADES OF SUPERPHOSPHATE IN INDIANA, 1915 AND 1926 TO 1928

The retail price per unit was lowest for the highest grade

#### *n Texas*

For the five seasons 1924-25 to 1928-29, the average retail price in Texas of phosphoric acid in 16-per-cent superphosphate was \$1.38 per unit; in the 18-per-cent grade it was \$1.28, and in the 20-per-cent grade it

TABLE 31. AVERAGE RETAIL PRICE AND NUMBER OF TONS OF VARIOUS GRADES OF SUPERPHOSPHATE IN INDIANA, 1910 TO 1928

Year	Per cent of available phosphoric acid guaranteed	Retail price		Number of tons	Per cent of available phosphoric acid guaranteed	Retail price		Number of tons	Per cent of available phosphoric acid guaranteed	Retail price		Number of tons	Per cent of available phosphoric acid guaranteed	Retail price		Number of tons
		Super-phosphate per ton	Phosphoric acid per unit			Super-phosphate per ton	Phosphoric acid per unit			Super-phosphate per ton	Phosphoric acid per unit			Super-phosphate per ton	Phosphoric acid per unit	
1910....	14.1	\$16.62	\$1.18	6,499	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1911....	14.1	16.86	1.20	8,505	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1912....	14.2	16.06	1.13	8,794	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1913....	14.0	15.63	1.12	9,250	16.0	\$17.00	\$1.06	2,724	.....	.....	.....	.....	.....	.....	.....	.....
1914....	14.0	15.43	1.10	9,922	16.0	16.72	1.04	2,698	.....	.....	.....	.....	.....	.....	.....	.....
1915....	14.0	15.65	1.12	7,823	16.0	16.16	1.01	5,337	18.0	\$18.00	\$1.00	1,538	20.0	\$18.50	\$0.92	85
1916....	14.0	19.74	1.41	6,160	16.0	20.30	1.27	17,775	18.0	23.46	1.30	2,379	20.0	20.00	1.00	3
1917....	14.0	19.79	1.41	7,041	16.0	20.22	1.26	32,796	17.9	19.61	1.10	2,010	20.0	23.50	1.18	715
1918....	14.0	25.54	1.82	8,032	16.0	26.37	1.65	48,275	18.0	28.00	1.56	521	20.0	33.50	1.68	1,156
1919....	14.0	28.35	2.02	6,991	16.0	28.84	1.80	48,724	19.5	32.64	1.67	3,286	.....	.....	.....	.....
1920....	14.0	32.68	2.51	7,474	16.0	31.43	1.96	54,606	19.5	35.22	1.81	6,091	.....	.....	.....	.....
1921....	.....	.....	.....	951	16.0	23.09	1.44	49,895	19.3	27.54	1.43	3,272	45.4	56.00	1.23	600
1922....	14.0	21.75	1.55	2,407	16.0	19.73	1.23	47,128	19.6	22.80	1.16	10,561	44.0	50.95	1.16	644
1923....	14.0	22.45	1.60	469	16.0	23.44	1.46	35,549	19.6	27.67	1.41	10,326	39.8	46.42	1.17	3,157
1924....	12.9	24.60	1.91	813	16.0	23.73	1.48	28,907	19.8	27.50	1.39	16,601	42.8	47.62	1.11	7,232
1925....	12.5	24.76	1.98	1,032	16.0	25.08	1.57	23,282	20.0	25.86	1.29	20,813	43.7	49.72	1.14	12,000
1926....	13.0	26.70	2.05	1,906	16.0	24.17	1.51	16,744	20.0	28.64	1.43	19,731	43.2	52.72	1.22	10,000
1927....	13.0	29.00	2.23	906	16.0	25.30	1.58	12,666	20.0	28.70	1.44	16,500	41.8	49.00	1.17	1,969
1928....	13.0	25.72	1.98	875	16.0	25.80	1.61	8,053	20.0	28.61	1.43	13,082	40.1	50.26	1.25	4,987



was \$1.24 (table 32). The tonnage of the 18-per-cent superphosphate was greater than for the other two grades combined (table 33). The difference in the retail price per unit between the 16- and the 18-per-cent grade was 2.5 times as great as the difference in the price per unit between the 18- and the 20-per-cent grade.

TABLE 32. AVERAGE RETAIL PRICE OF PHOSPHORIC ACID PER UNIT IN 16-, 18-, AND 20-PER-CENT SUPERPHOSPHATE IN TEXAS, 1916-17 TO 1928-29

Season	Retail price per unit		
	16-per-cent	18-per-cent	20-per-cent
1916-17.....	\$1.31	.....	.....
1917-18.....	1.57	.....	.....
1918-19.....	1.86	.....	.....
1919-20.....	1.86	.....	.....
1920-21.....	1.86	\$1.61	.....
1921-22.....	1.45	1.39	.....
1922-23.....	1.46	1.46	.....
1923-24.....	1.44	1.37	.....
1924-25.....	1.47	1.38	\$1.36
1925-26.....	1.40	1.31	1.24
1926-27.....	1.32	1.26	1.23
1927-28.....	1.35	1.25	1.22
1928-29.....	1.35	1.20	1.17
1924-25 to 1928-29.....	1.38	1.28	1.24

TABLE 33. AVERAGE RETAIL PRICE AND NUMBER OF TONS OF 16-, 18-, AND 20-PER-CENT SUPERPHOSPHATE IN TEXAS, 1916-17 TO 1928-29

Season	Retail price per ton			Number of tons sold		
	16-per-cent	18-per-cent	20-per-cent	16-per-cent	18-per-cent	20-per-cent
1916-17.....	\$20.95	.....	.....	.....	.....	.....
1917-18.....	25.05	.....	.....	.....	.....	.....
1918-19.....	29.72	.....	.....	.....	.....	.....
1919-20.....	29.82	.....	.....	.....	.....	.....
1920-21.....	29.73	\$29.00	.....	.....	.....	.....
1921-22.....	23.19	25.00	.....	.....	.....	.....
1922-23.....	23.36	26.29	.....	.....	.....	.....
1923-24.....	22.99	24.70	.....	26,386	6,180*	.....
1924-25.....	23.51	24.85	\$27.14	19,499	7,467*	.....
1925-26.....	22.47	23.55	24.90	13,493	19,515	3,992
1926-27.....	21.20	22.70	24.69	6,355	12,517	4,053
1927-28.....	21.55	22.44	24.44	4,318	11,353	4,811
1928-29.....	21.66	21.66	23.32	3,920	12,201	5,022

\* Includes 17-, 18-, and 20-per-cent superphosphate.

These data on the prices of the various grades of superphosphate indicate that the users of low-grade material paid decidedly more per unit for phosphoric acid than did those users who purchased superphosphate with analysis as high as or higher than the average. The decrease in cost per unit was greater between the low-grade and the medium-grade goods than between the medium and the high grade.

#### POTASH SALTS

##### *In Connecticut*

##### *Muriate of potash*

Both the retail and the wholesale price of muriate of potash remained relatively constant during the thirty-five years prior to the World War. The general price level in the United States declined during the sixteen-year period 1883 to 1898, but in Connecticut there was no consistent

tendency for the retail price of muriate of potash to either increase or decrease (table 34 and figure 15). The wholesale price increased slightly, at the rate of 21 cents per ton, or 0.6 per cent, per annum.

TABLE 34. RETAIL AND WHOLESALE PRICES, COST OF DISTRIBUTION, AND ANALYSIS OF MURIATE OF POTASH IN CONNECTICUT, 1881 TO 1923

Year	Number of samples	Retail price per ton in Connecticut	Wholesale price per ton at ports	Cost of distribution per ton	Per cent of potash found	Per cent of potash guaranteed	Potash overrun (per cent found minus guarantee)
1882-1885	4	\$ 42.33	\$ 34.63	\$ 7.70	51.76	.....	.....
1890-1894	2	43.80	37.25	6.55	50.74	.....	.....
1900-1904	9	43.77	37.04	6.73	50.56	.....	.....
1910-1914	11	43.29	37.54	5.75	50.84	49.21	1.63
1922-1923	9	50.92	34.98	15.94	50.84	49.12	1.72
1881	6	42.25	.....	.....	51.08	.....	.....
1882	3	45.83	36.25	9.58	52.86	.....	.....
1883	4	43.50	35.07	8.43	53.98	.....	.....
1884	3	37.83	32.98	4.85	49.82	.....	.....
1885	7	42.16	34.21	7.95	50.38	.....	.....
1886	5	43.50	34.43	9.07	48.99	.....	.....
1887	7	43.07	34.53	8.54	51.23	.....	.....
1888	6	41.80	34.76	7.04	51.78	.....	.....
1889	4	42.65	36.76	5.89	50.71	.....	.....
1890	1	42.50	36.73	5.77	51.12	.....	.....
1891	2	42.75	36.64	6.11	51.65	.....	.....
1892	4	43.25	37.32	5.93	50.62	.....	.....
1893	1	48.00	37.19	10.81	49.76	.....	.....
1894	2	42.50	38.36	4.14	50.54	.....	.....
1895	5	43.94	38.90	5.04	50.30	.....	.....
1896	8	43.00	36.26	6.74	51.17	.....	.....
1897	10	42.80	36.38	6.42	51.44	.....	.....
1898	12	42.16	36.80	5.36	50.79	.....	.....
1899	7	42.50	36.49	6.01	50.72	.....	.....
1900	8	42.62	36.46	6.16	49.78	.....	.....
1901	13	44.15	36.95	7.20	51.40	.....	.....
1902	8	43.00	36.94	6.06	50.17	.....	.....
1903	7	44.79	37.01	7.78	51.47	.....	.....
1904	11	44.27	37.84	6.43	49.99	.....	.....
1905	10	44.03	38.43	5.60	51.96	.....	.....
1906	9	44.94	39.30	5.64	51.41	.....	.....
1907	7	45.14	39.27	5.87	50.01	50.00	0.01
1908	7	43.57	38.83	4.74	52.14	50.00	2.14
1909	9	44.10	38.00	6.10	51.13	49.72	1.41
1910	12	43.12	36.60	6.52	50.85	49.04	1.81
1911	10	44.30	35.75	8.55	51.25	49.50	1.75
1912	11	43.04	38.21	4.83	51.03	49.55	1.48
1913	11	42.14	38.55	3.59	50.91	49.14	1.77
1914	12	43.88	38.60	5.28	50.19	48.83	1.36
1915	1	60.00	77.88	.....	49.24	48.00	1.24
1916	.....	.....	363.66	.....	.....	.....	.....
1917	.....	.....	402.52	.....	.....	.....	.....
1918	.....	.....	349.56	.....	.....	.....	.....
1919	.....	.....	282.49	.....	.....	.....	.....
1920	.....	.....	120.42	.....	.....	.....	.....
1921	5	100.60	88.48	12.12	48.92	48.80	0.12
1922	13	51.58	37.78	13.80	50.77	49.57	1.20
1923	6	50.25	32.18	18.07	50.91	48.67	2.24

During the following sixteen-year period, 1899 to 1914, the general price level rose. While there were fluctuations from year to year, there was no consistent tendency for either the wholesale or the retail price of muriate to rise or fall.

In a period of declining prices, a commodity the price of which remains constant becomes relatively expensive. In a period of rising prices, a commodity whose price remains constant becomes relatively cheap. During the sixteen-year period prior to the war, the general trend of agricultural prices was upward. There was a tendency for the amount of potash

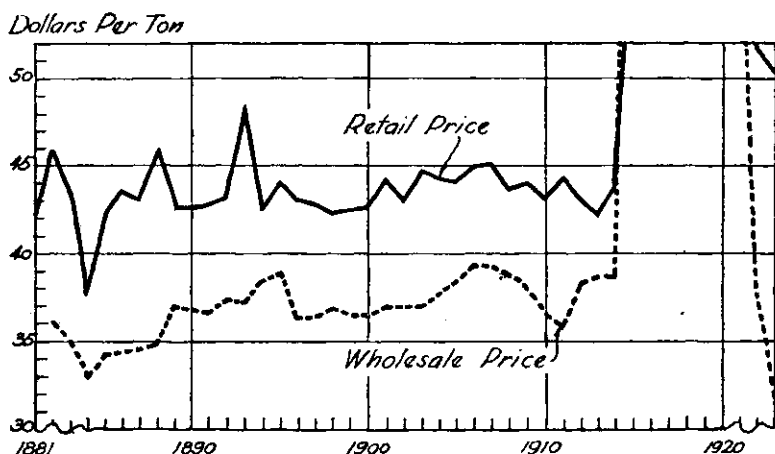


FIGURE 15. WHOLESAL PRICE AND CONNECTICUT RETAIL PRICE OF MURIATE OF POTASH, 1881 TO 1923

Wholesale prices of muriate tended to increase slightly during the 33 years prior to the war. There was very little increase in retail prices

that could be purchased with a pound of cotton, tobacco, or potatoes, to increase. The purchasing power of the price of muriate of potash increased during the period from 1883 to 1898, and decreased during the period from 1899 to 1914.

There was very little similarity in the year-to-year changes in the wholesale and retail prices of muriate of potash, either during the period from 1882 to 1898 ( $r=0.366$ ) or during the period from 1899 to 1914 ( $r=-0.129$ ) (table 36 and figure 16). When account is taken of the

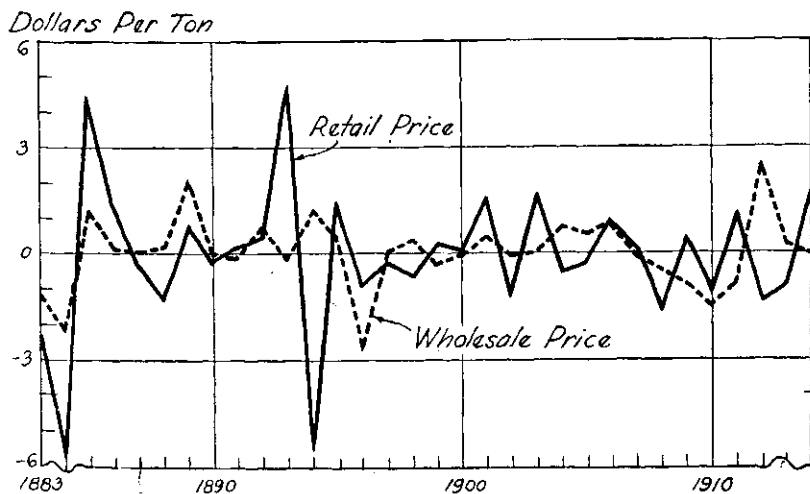


FIGURE 16. YEAR-TO-YEAR CHANGES IN THE WHOLESAL PRICE AND IN THE CONNECTICUT RETAIL PRICE OF MURIATE OF POTASH, 1883 TO 1914

There was little or no tendency for the year-to-year fluctuations in wholesale and in retail prices to be similar

TABLE 35. INDEX NUMBERS OF RETAIL AND WHOLESALE PRICES, COST OF DISTRIBUTION, AND ANALYSIS OF MURIATE OF POTASH IN CONNECTICUT, 1881 TO 1923

(1910-1914 = 100)

Year	Retail price per ton in Connecticut	Wholesale price per ton at ports	Cost of distribution per ton	Potash found	Potash guaranteed	Potash overrun
1882-1885	98	92	134	102	.....	.....
1890-1894	101	99	114	100	.....	.....
1900-1904	101	99	117	99	.....	.....
1910-1914	100	100	100	100	100	100
1922-1923	118	93	277	100	100	106
1881	98	.....	.....	100	.....	.....
1882	106	97	167	104	.....	.....
1883	100	93	147	106	.....	.....
1884	87	88	84	98	.....	.....
1885	97	91	138	99	.....	.....
1886	100	92	158	96	.....	.....
1887	99	92	149	101	.....	.....
1888	97	93	122	102	.....	.....
1889	99	98	102	100	.....	.....
1890	98	98	100	101	.....	.....
1891	99	98	106	102	.....	.....
1892	100	99	103	100	.....	.....
1893	111	99	188	98	.....	.....
1894	98	102	72	99	.....	.....
1895	102	104	88	99	.....	.....
1896	99	97	117	101	.....	.....
1897	99	97	112	101	.....	.....
1898	97	98	93	100	.....	.....
1899	98	97	105	100	.....	.....
1900	98	97	107	98	.....	.....
1901	102	98	125	101	.....	.....
1902	99	98	105	99	.....	.....
1903	103	99	135	101	.....	.....
1904	102	101	112	98	.....	.....
1905	102	102	97	102	.....	.....
1906	104	105	98	101	.....	.....
1907	104	105	102	98	102	1
1908	101	103	82	103	102	131
1909	102	101	106	101	101	87
1910	100	97	113	100	100	111
1911	102	95	149	101	101	107
1912	99	102	84	100	101	91
1913	97	103	62	100	100	109
1914	101	103	92	99	99	83
1915	139	207	.....	97	98	76
1916	.....	969	.....	.....	.....	.....
1917	.....	1,072	.....	.....	.....	.....
1918	.....	931	.....	.....	.....	.....
1919	.....	753	.....	.....	.....	.....
1920	.....	321	.....	.....	.....	.....
1921	232	236	211	96	99	7
1922	119	101	240	100	101	74
1923	116	86	314	100	99	137

TABLE 36. CORRELATIONS BETWEEN THE WHOLESALE PRICE AND THE CONNECTICUT RETAIL PRICE OF MURIATE OF POTASH, 1882 TO 1914

	1882-1898	1899-1914	1882-1914
	(r)	(r)	(r)
Actual retail price with actual wholesale price	0.483	0.314	0.481
Retail price with wholesale price (first differences)	0.366	-0.129	0.245

relatively small number of years, these correlations cannot be said to be significant. The changes in wholesale prices were relatively small, and the changes that did occur were not closely associated with changes in retail prices.

The fluctuations in the retail prices are probably due in part to the small amount of data, and also to the changes in the demand in the retail market.

When the actual retail prices were correlated with the actual wholesale prices the correlations were higher. High retail prices tended to be associated with high wholesale prices (table 36).

For the seventeen years 1882 to 1898, the retail price of muriate of potash in Connecticut averaged \$43.01 per ton (table 37). The wholesale price averaged \$36.09, and the difference, or cost of distribution, \$6.92. During these years the general tendency was for the margin between the wholesale and the retail price to become smaller.

TABLE 37. WHOLESALE PRICE AND CONNECTICUT RETAIL PRICE OF MURIATE OF POTASH, AND RATES OF CHANGE IN WHOLESALE AND RETAIL PRICES, 1882 TO 1914

	1882-1898	1899-1914	1882-1914
Retail price per ton in Connecticut (average).....	\$43.01	\$43.72	\$43.36
Wholesale price per ton (average).....	\$36.09	\$37.70	\$36.87
Cost of distribution per ton (average).....	\$6.92	\$6.02	\$6.49
Average annual change (based on straight-line trend):			
Retail price in Connecticut.....	+\$0.05	\$0.00	.....
Wholesale price.....	+\$0.21	+\$0.09	.....
Cost of distribution.....	-\$0.16	-\$0.09	.....
Annual percentage change (based on straight-line trend):			
Retail price in Connecticut (per cent).....	+ 0.12	0.00	.....
Wholesale price (per cent).....	+ 0.58	+ 0.24	.....
Cost of distribution (per cent).....	- 2.31	- 1.50	.....

For the five years 1910 to 1914, the margin between the wholesale and the Connecticut retail price averaged only \$5.75 (table 34). This was relatively low when compared with the other years. The margin between the retail and the wholesale price averaged \$15.94 for the two years 1922 and 1923. This was 277 per cent of the pre-war average (table 35).

#### *Sulfate of potash*

The changes in the prices of sulfate of potash were somewhat different from those for muriate of potash. During the seven years 1892 to 1898, the retail price of sulfate of potash in Connecticut declined at the rate of \$1.38 per ton per annum while the wholesale price declined at the rate of 56 cents per ton per annum. The retail price declined faster than did the wholesale price (table 38 and figure 17).

During the sixteen years 1899 to 1914 there was a slight upward trend in both retail and wholesale prices, the wholesale price rising the more rapidly. The rising prices of agricultural products resulted in a greater use of fertilizer, and imports of potash into the United States increased rapidly. The general increase in tonnage probably had some effect in reducing the cost of distribution per ton.

The correlation between actual retail and wholesale prices during the period from 1892 to 1914 was relatively low ( $r=0.413$ ) (table 41).

The spread between the retail and the wholesale price of sulfate tended to decline throughout the period from 1892 to 1914. The relationship between the wholesale and the retail price was constantly changing, so that the correlation between the two was low. The relationship between the year-to-year changes in wholesale and retail prices also was low (figure 18).

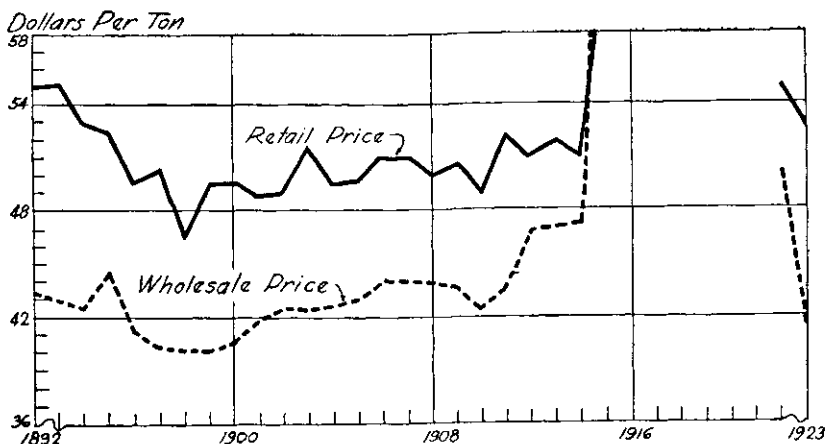


FIGURE 17. WHOLESALE PRICE AND CONNECTICUT RETAIL PRICE OF SULFATE OF POTASH, 1892 TO 1923

Both wholesale and retail prices tended to decline during the period 1892 to 1898, but tended to rise during the period 1899 to 1914

TABLE 38. RETAIL AND WHOLESALE PRICES, COST OF DISTRIBUTION, AND ANALYSIS OF SULFATE OF POTASH IN CONNECTICUT, 1889 TO 1923

Year	Number of samples	Retail price per ton in Connecticut	Wholesale price per ton at ports	Cost of distribution per ton	Per cent of potash found	Per cent of potash guaranteed	Potash overrun (per cent found minus guarantee)
1892-1894	4	\$ 54.40	\$ 42.90	\$11.50	49.58	.....	.....
1900-1904	3	49.68	41.98	7.70	49.15	.....	.....
1910-1914	6	51.04	45.31	5.73	49.40	48.03	1.37
1922-1923	12	53.78	45.60	8.18	49.04	48.08	0.96
1889	1	61.20	.....	.....	52.23	.....	.....
1890	..	.....	47.00	.....	.....	.....	.....
1891	..	.....	43.32	.....	.....	.....	.....
1892	4	55.00	43.30	11.70	49.92	.....	.....
1893	6	55.21	42.95	12.26	49.49	.....	.....
1894	2	53.00	42.45	10.55	49.32	.....	.....
1895	2	52.50	44.41	8.09	48.88	.....	.....
1896	3	49.67	41.25	8.42	49.24	.....	.....
1897	7	50.21	40.34	9.87	49.01	.....	.....
1898	5	46.60	40.25	6.35	48.79	.....	.....
1899	2	49.50	40.14	9.36	49.65	.....	.....
1900	5	49.60	40.56	9.04	48.20	.....	.....
1901	5	48.80	41.77	7.03	50.05	.....	.....
1902	1	49.00	42.49	6.51	48.56	.....	.....
1903	2	51.50	42.42	9.08	49.63	.....	.....
1904	2	49.50	42.64	6.86	49.33	.....	.....
1905	4	49.75	43.04	6.71	49.55	.....	.....
1906	2	51.00	44.00	7.00	49.63	.....	.....
1907	3	51.00	43.99	7.01	49.83	48.67	1.16
1908	2	50.00	43.86	6.14	48.95	48.90	0.05
1909	6	50.65	43.61	7.04	50.52	48.10	2.42
1910	4	49.00	42.47	6.53	48.74	48.00	0.74
1911	5	52.10	43.50	8.60	50.24	48.14	2.10
1912	8	51.12	46.57	4.55	49.80	48.00	1.80
1913	6	51.92	46.80	5.12	48.65	48.00	0.65
1914	6	51.05	47.19	3.86	49.58	48.00	1.58
1915	1	65.00	79.70	.....	49.36	47.00	2.36
1916	..	.....	305.07	.....	.....	.....	.....
1917	..	.....	287.50	.....	.....	.....	.....
1918	1	225.00	338.90	.....	47.76	.....	.....
1919	..	.....	307.88	.....	.....	.....	.....
1920	..	.....	185.28	.....	.....	.....	.....
1921	10	112.30	119.95	.....	49.79	48.23	1.56
1922	14	54.98	49.95	5.03	48.77	48.16	0.61
1923	9	52.59	41.25	11.34	49.31	48.00	1.31

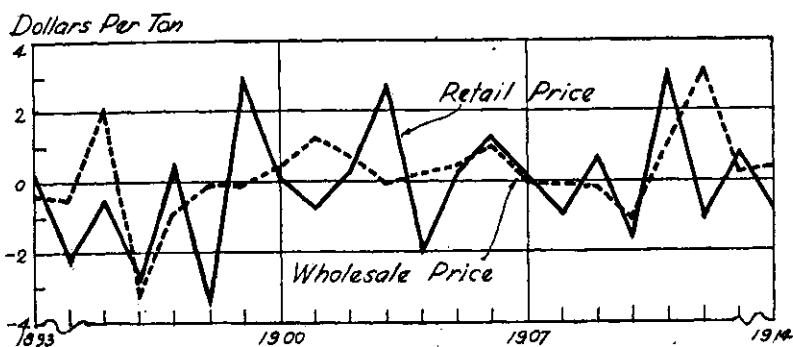


FIGURE 18. YEAR-TO-YEAR CHANGES IN THE WHOLESALE PRICE AND IN THE CONNECTICUT RETAIL PRICE OF SULFATE OF POTASH, 1893 TO 1914

There was little correspondence between the year-to-year changes in wholesale and retail prices of sulfate of potash

TABLE 39. INDEX NUMBERS OF RETAIL AND WHOLESALE PRICES, COST OF DISTRIBUTION, AND ANALYSIS OF SULFATE OF POTASH IN CONNECTICUT, 1889 TO 1923

(1910-1914 = 100)

Year	Retail price per ton in Connecticut	Wholesale price per ton at ports	Cost of distribution per ton	Potash found	Potash guaranteed	Potash overrun
1892-1894.....	107	95	201	100	...	...
1900-1904.....	97	93	134	99	...	...
1910-1914.....	100	100	100	100	100	100
1922-1923.....	105	101	143	99	100	70
1889.....	120	...	...	106	...	...
1890.....	...	104	...	...	...	...
1891.....	...	96	...	...	...	...
1892.....	108	96	204	101	...	...
1893.....	108	95	214	100	...	...
1894.....	104	94	184	100	...	...
1895.....	103	98	141	99	...	...
1896.....	97	91	147	100	...	...
1897.....	98	89	172	99	...	...
1898.....	91	89	111	99	...	...
1899.....	97	89	163	101	...	...
1900.....	97	90	158	98	...	...
1901.....	96	92	123	101	...	...
1902.....	96	94	114	98	...	...
1903.....	101	94	158	100	...	...
1904.....	97	94	120	100	...	...
1905.....	97	95	117	100	...	...
1906.....	100	97	122	100	...	...
1907.....	100	97	122	101	101	85
1908.....	98	97	107	99	102	4
1909.....	99	96	123	102	100	177
1910.....	96	94	114	99	100	54
1911.....	102	96	150	102	100	153
1912.....	100	103	79	101	100	131
1913.....	102	103	89	98	100	47
1914.....	100	104	67	100	100	115
1915.....	127	176	...	100	98	172
1916.....	...	673	...	...	...	...
1917.....	...	635	...	...	...	...
1918.....	441	748	...	97	...	...
1919.....	...	679	...	...	...	...
1920.....	...	409	...	...	...	...
1921.....	220	265	...	101	100	114
1922.....	108	110	88	99	100	45
1923.....	103	91	198	100	100	96

TABLE 40. WHOLESALE PRICE AND CONNECTICUT RETAIL PRICE OF SULFATE OF POTASH, AND RATES OF CHANGE IN WHOLESALE AND RETAIL PRICES, 1892 TO 1914

	1892-1898	1899-1914	1892-1914
Retail price per ton in Connecticut (average).....	\$51.74	\$50.34	\$50.77
Wholesale price per ton (average).....	\$42.13	\$43.44	\$43.04
Cost of distribution per ton (average).....	\$9.61	\$6.90	\$7.73
Average annual change (based on straight-line trend):			
Retail price in Connecticut.....	-\$1.38	+\$0.14	.....
Wholesale price.....	-\$0.56	+\$0.38	.....
Cost of distribution.....	-\$0.82	-\$0.24	.....
Annual percentage change (based on straight-line trend):			
Retail price in Connecticut (per cent).....	- 2.67	+ 0.28	.....
Wholesale price (per cent).....	- 1.33	+ 0.87	.....
Cost of distribution (per cent).....	- 8.53	- 3.48	.....

TABLE 41. CORRELATIONS BETWEEN THE WHOLESALE PRICE AND THE CONNECTICUT RETAIL PRICE OF SULFATE OF POTASH, 1892 TO 1914

	1899-1914	1892-1914
Actual retail price with actual wholesale price.....	(r) 0.337	(r) 0.413
Retail price with wholesale price (first differences).....	0.603	0.254

### Sulfate of potash magnesia

Sulfate of potash magnesia is used as a source of potash in some fertilizers, although it is of only minor importance as compared with muriate and sulfate of potash. Retail prices of sulfate of potash magnesia in

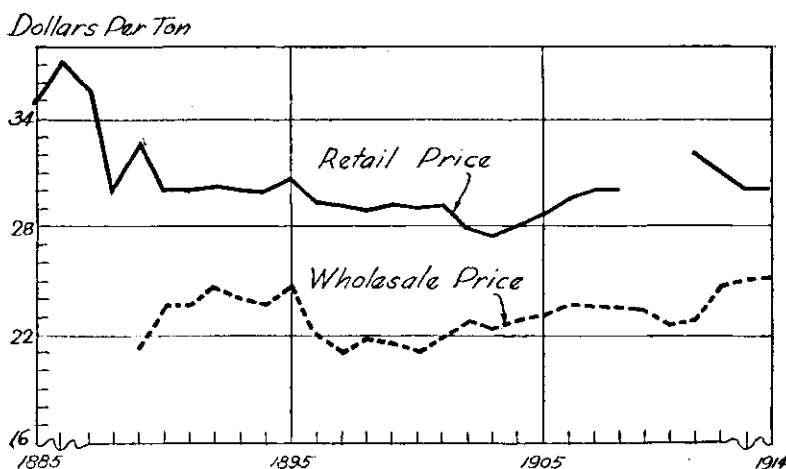


FIGURE 19. WHOLESALE PRICE AND CONNECTICUT RETAIL PRICE OF SULFATE OF POTASH MAGNESIA, 1885 TO 1914

During the period 1898 to 1914 there was a slight upward trend in both retail and wholesale prices



Connecticut were available for most of the period from 1882 to 1923 (tables 42 and 43, and figure 19). The retail price was relatively high in the three-year period 1885 to 1887, but after declining in 1888 it remained relatively constant during the period from 1888 to 1914.

TABLE 42. RETAIL AND WHOLESALE PRICES, COST OF DISTRIBUTION, AND ANALYSIS OF SULFATE OF POTASH MAGNESIA IN CONNECTICUT, 1882 TO 1923

Year	Number of samples	Retail price per ton in Connecticut	Wholesale price per ton at ports	Cost of distribution per ton	Per cent of potash found	Per cent of potash guaranteed	Potash overrun (per cent found minus guarantee)
1890-1894	2	\$30.03	\$ 23.95	\$ 6.08	26.12	.....	.....
1900-1904	4	28.31	22.06	6.25	27.15	.....	.....
1911-1914	1	30.75	24.34	6.41	27.10	26.00	1.10
1922-1923	3	33.12	.....	.....	26.92	24.38	2.54
1882	3	36.86	.....	.....	24.95	.....	.....
1883	.....	.....	.....	.....	.....	.....	.....
1884	.....	.....	.....	.....	.....	.....	.....
1885	1	35.00	.....	.....	26.62	.....	.....
1886	1	37.30	.....	.....	23.61	.....	.....
1887	3	35.67	.....	.....	26.09	.....	.....
1888	1	30.00	.....	.....	27.76	.....	.....
1889	4	32.65	21.23	11.42	25.70	.....	.....
1890	1	30.00	23.59	6.41	25.76	.....	.....
1891	3	30.00	23.70	6.30	25.76	.....	.....
1892	2	30.15	24.70	5.45	26.24	.....	.....
1893	1	30.00	24.06	5.94	25.96	.....	.....
1894	2	30.00	23.70	6.30	26.90	.....	.....
1895	3	30.67	24.73	5.94	27.82	.....	.....
1896	5	29.40	22.05	7.35	26.12	.....	.....
1897	4	29.25	21.03	8.22	25.74	.....	.....
1898	8	28.88	21.80	7.08	24.88	.....	.....
1899	3	29.33	21.36	7.97	27.09	.....	.....
1900	5	29.00	21.00	8.00	27.01	.....	.....
1901	6	29.17	21.83	7.34	27.06	.....	.....
1902	5	27.90	22.58	5.32	27.11	.....	.....
1903	2	27.50	22.25	5.25	26.90	.....	.....
1904	4	28.00	22.66	5.34	27.69	.....	.....
1905	7	28.61	22.98	5.63	26.69	.....	.....
1906	6	29.25	23.59	5.66	24.53	.....	.....
1907	3	30.00	23.56	6.44	26.41	.....	.....
1908	1	30.00	23.39	6.61	28.00	25.00	3.00
1909	.....	.....	23.30	.....	.....	.....	.....
1910	.....	.....	22.51	.....	.....	.....	.....
1911	1	32.00	22.75	9.25	27.35	26.00	1.35
1912	1	31.00	24.65	6.35	25.56	26.00	-0.44
1913	1	30.00	24.95	5.05	26.08	26.00	0.08
1914	1	30.00	25.00	5.00	29.42	26.00	3.42
1915	.....	.....	34.91	.....	.....	.....	.....
1916	.....	.....	103.00	.....	.....	.....	.....
1917	.....	.....	105.00	.....	.....	.....	.....
1918	.....	.....	.....	.....	.....	.....	.....
1919	.....	.....	.....	.....	.....	.....	.....
1920	.....	.....	.....	.....	.....	.....	.....
1921	.....	.....	.....	.....	.....	.....	.....
1922	2	31.50	.....	.....	26.42	23.00	3.42
1923	4	34.73	23.67	11.06	27.42	25.75	1.67

There was an upward trend in the wholesale price for the sixteen-year period prior to the war. The margin between the wholesale and the retail price averaged \$6.41 for the four years 1911 to 1914. This was practically the same as for the five years 1890 to 1894. While there were changes from year to year, there was no marked tendency for the spread between the wholesale and the retail price to increase or decrease during the twenty-five years prior to the war.

In 1923 the cost of distribution was \$11.06, or 73 per cent greater than for the four years 1911 to 1914. For the pre-war years the margin was

TABLE 43. INDEX NUMBERS OF RETAIL AND WHOLESALE PRICES, COST OF DISTRIBUTION, AND ANALYSIS OF SULFATE OF POTASH MAGNESIA IN CONNECTICUT, 1882 TO 1923

(1911-1914 = 100)

Year	Retail price per ton in Connecticut	Wholesale price per ton at ports	Cost of distribution per ton	Potash found	Potash guaranteed	Potash overrun
1890-1894	98	98	95	96		
1900-1904	92	91	98	100		
1911-1914	100	100	100	100	100	100
1922-1923	108			99	94	231
1882	120			92		
1883						
1884						
1885	114			98		
1886	121			87		
1887	116			96		
1888	98			102		
1889	106	87	178	95		
1890	98	97	100	95		
1891	98	97	98	95		
1892	98	101	85	97		
1893	98	99	93	96		
1894	98	97	98	99		
1895	100	102	93	103		
1896	96	91	115	96		
1897	95	86	128	95		
1898	94	90	110	92		
1899	95	88	124	100		
1900	94	86	125	100		
1901	95	90	115	100		
1902	91	93	83	100		
1903	89	91	82	99		
1904	91	93	83	102		
1905	93	94	88	98		
1906	95	97	88	91		
1907	98	97	100	97		
1908	98	96	103	103	96	273
1909		96				
1910		92				
1911	104	93	144	101	100	123
1912	101	101	99	94	100	-40
1913	98	103	79	96	100	7
1914	98	103	78	109	100	311
1915		143				
1916		423				
1917		431				
1918						
1919						
1920						
1921						
1922	102			97	88	311
1923	113	97	173	101	99	152

21 per cent of the retail price, as compared with 32 per cent in 1923. This is much the same change in relationship as existed with the other fertilizer materials.

### Kainit

While imports of kainit were large during the pre-war period, its use was most common in the South, and relatively few retail prices were available for Connecticut (tables 44 and 45). For the four pre-war years the retail price in Connecticut averaged \$15.07 per ton; the wholesale price was \$7.96, and the cost of distribution was \$7.11, or 47 per cent of the retail price.

TABLE 44. RETAIL AND WHOLESALE PRICES, COST OF DISTRIBUTION, AND ANALYSIS OF KAINIT IN CONNECTICUT, 1881 TO 1923

Year	Number of samples	Retail price per ton in Connecticut	Wholesale price per ton at ports	Cost of distribution per ton	Per cent of potash found	Per cent of potash guaranteed	Potash overrun (per cent found minus guarantee)
1900-1904*	2	\$14.12			12.52		
1910-1914†	2	15.07	\$ 7.96	\$ 7.11	13.83	12.00	1.83
1881	2	19.00			12.60		
1882	1	15.00			11.63		
1883	7	15.86			12.26		
1884	1	15.00			12.12		
1885							
1886							
1887	3	12.17			12.50		
1888							
1889	2	12.50			12.89		
1890							
1891							
1892	1	16.00			11.93		
1893							
1894							
1895							
1896							
1897	4	12.50			12.29		
1898	4	14.00			12.20		
1899	1	13.00			12.78		
1900	2	17.50			12.78		
1901	1	13.00			12.74		
1902							
1903	2	12.00			11.62		
1904	2	14.00			12.94		
1905	1	11.75	8.02	3.73	12.49		
1906	1	12.00	7.58	4.42	13.28		
1907			7.58				
1908			7.78				
1909	2	17.00	7.59	9.41	13.04	12.00	1.04
1910	1	14.00	7.47	6.53	13.32	12.00	1.32
1911	3	15.33	7.50	7.83	13.59	12.00	1.59
1912			8.33				
1913	4	15.95	8.45	7.50	13.70	12.00	1.70
1914	1	15.00	8.40	6.60	14.72	12.00	2.72
1915			8.52				
1916			45.00				
1917			45.00				
1918							
1919							
1920							
1921							
1922			7.82				
1923	1	20.00	6.56	13.44	12.57	12.40	0.17

\* 1900 to 1904 except 1902.

† 1910 to 1914 except 1912.

#### *Relation of analysis of potash salts to cost of distribution*

For the years just prior to the war, 1910 to 1914, the cost of distribution for kainit was 47 per cent of the retail price, for sulfate of potash magnesia 21 per cent, for muriate of potash 13 per cent, and for sulfate of potash 11 per cent (table 46).

The cost of distribution was a larger part of the retail price of low-grade materials than of high-grade materials. The same general relationship existed also during the two post-war years 1922 and 1923. For these two years, however, the cost of distribution was a larger part of the retail price than in the pre-war period.

For the years 1910 to 1914, the spread between the retail price in Connecticut and the wholesale price for sulfate of potash was \$5.73; for muriate of potash, \$5.75; for sulfate of potash magnesia, \$6.41; and for

TABLE 45. INDEX NUMBERS OF RETAIL AND WHOLESALE PRICES, COST OF DISTRIBUTION, AND ANALYSIS OF KAINIT IN CONNECTICUT, 1881 TO 1923 (1910-1914†=100)

Year	Retail price per ton in Connecticut	Wholesale price per ton at ports	Cost of distribution per ton	Potash found	Potash guaranteed	Potash overrun
1900-1904*	94			91		
1910-1914†	100	100	100	100	100	100
1881	126			91		
1882	100			84		
1883	105			89		
1884	100			88		
1885						
1886						
1887	81			90		
1888						
1889	83			93		
1890						
1891						
1892	106			86		
1893						
1894						
1895						
1896						
1897	83			89		
1898	93			88		
1899	86			92		
1900	116			92		
1901	86			92		
1902						
1903	80			84		
1904	93			94		
1905	78	101	52	90		
1906	80	95	62	96		
1907		95				
1908		98				
1909	113	95	132	94	100	57
1910	93	94	92	96	100	72
1911	102	94	110	98	100	87
1912		105				
1913	106	106	105	99	100	93
1914	100	106	93	106	100	149
1915		107				
1916		565				
1917		565				
1918						
1919						
1920						
1921						
1922		98				
1923	133	82	189	91	103	9

\* 1900 to 1904 except 1902.

† 1910 to 1914 except 1912.

TABLE 46. RETAIL AND WHOLESALE PRICES AND COST OF DISTRIBUTION OF SULFATE OF POTASH, MURIATE OF POTASH, SULFATE OF POTASH MAGNESIA, AND KAINIT IN CONNECTICUT, 1910 TO 1914 AND 1922 TO 1923

	1910-1914					1922-1923				
	Per cent of potash (K <sub>2</sub> O)	Retail price per ton in Connecticut	Wholesale price per ton at ports	Cost of distribution per ton	Per cent cost of distribution is of retail price	Per cent of potash (K <sub>2</sub> O)	Retail price per ton in Connecticut	Wholesale price per ton at ports	Cost of distribution per ton	Per cent cost of distribution is of retail price
Sulfate of potash	48.03	\$51.04	\$45.31	\$5.73	11	48.08	\$53.78	\$45.60	\$ 8.18	15
Muriate of potash	49.21	43.29	37.54	5.75	13	49.12	50.92	34.98	15.94	31
Sulfate of potash magnesia*	26.00	30.75	24.34	6.41	21	25.75	34.73	23.67	11.06	32
Kainit†	12.00	15.07	7.96	7.11	47	12.40	20.00	6.56	13.44	67

\* 1911 to 1914, and 1923.

† 1910 to 1914 except 1912.

kainit, \$7.11. There was relatively little difference between the cost of distribution for the various salts.

The margin between the wholesale and retail prices fluctuated from year to year. Thus, for a short period it was not possible to determine whether or not there was a real difference between the costs of distribution of the various salts. During the twenty-three-year period 1892 to 1914 the cost of distribution, or the margin between the Connecticut retail price and the wholesale price, of muriate averaged  $\$6.12 \pm 0.99$  (table 47). The cost of distribution for sulfate was  $\$7.73 \pm 1.39$ , and for sulfate of potash magnesia (twenty-one years, no data for 1909 and 1910)  $\$6.45 \pm 0.80$ . The differences between the costs of distribution of the various potash salts were not significant.

TABLE 47. RETAIL AND WHOLESALE PRICES AND COST OF DISTRIBUTION OF SULFATE OF POTASH, MURIATE OF POTASH, AND SULFATE OF POTASH MAGNESIA IN CONNECTICUT, 1892 TO 1914\*

	Retail price per ton in Connecticut	Wholesale price per ton at ports	Cost of distribution per ton
Sulfate of potash.....	\$50.77	\$43.04	\$7.73±1.39
Muriate of potash.....	43.70	37.58	6.12±0.99
Sulfate of potash magnesia*.....	29.53	23.08	6.45±0.80

\* For sulfate of potash magnesia, 1892 to 1914 except 1909 and 1910.

Although the wholesale price and the analysis of sulfate of potash were nearly twice as great as for sulfate of potash magnesia, the differences between the retail and the wholesale price, or the costs of distribution, were not significantly different for the two salts. The cost of distribution tends to be a uniform amount per ton, and not a percentage of the price. The differences in analysis and in wholesale prices of the various salts did not seem to affect the margin between the retail and the wholesale price.

#### *In Indiana*

The Indiana fertilizer reports gave the retail prices and the tonnage of all the potash salts combined, for the period from 1919 to 1928. In 1919 the average guaranteed analysis was only 14.1 per cent of potash (table 48). Most of the tonnage that year was apparently kainit. For the four

TABLE 48. AVERAGE RETAIL PRICE, AVERAGE ANALYSIS AND TONNAGE OF ALL POTASH SALTS IN INDIANA, 1919 TO 1928

Year	Retail price per ton	Per cent of potash guaranteed	Retail price of potash per unit	Number of tons sold
1919.....	\$61.40	14.1	\$4.35	740
1920.....	82.97	27.4	3.03	2,008
1921.....	68.70	41.9	1.64	2,228
1922.....	42.33	43.0	0.98	2,300
1923.....	45.52	47.0	0.97	3,251
1924.....	41.41	47.4	0.87	7,000
1925.....	42.08	48.5	0.87	10,352
1926.....	45.10	49.1	0.92	5,650
1927.....	40.31	48.1	0.84	5,200
1928.....	48.33	48.9	0.99	1,700

years 1925 to 1928 the guaranteed analysis averaged more than 48 per cent of potash. Practically all of the tonnage during those years was muriate. The average retail price of potash declined from \$4.35 per unit in 1919 to 84 cents per unit in 1927. In 1928, however, the retail price was 99 cents per unit, the highest since 1921.

The tonnage of straight potash salts in Indiana reached a peak of 10,352 tons in 1925. In 1928 there were only 1700 tons. The total potash consumption in Indiana, however, has increased, since more potash has been used in mixed fertilizers.

### *In Texas*

Retail prices in Texas of both muriate of potash and kainit were available for the six seasons 1923-24 to 1928-29. During this period the average retail price of potash in muriate was \$1.09 per unit (table 49). The retail price of potash in kainit was \$1.84 per unit, or 69 per cent higher than that of potash in muriate. The retail price per unit was higher in the

TABLE 49. AVERAGE RETAIL PRICE AND TONNAGE OF MURIATE OF POTASH AND KAINIT IN TEXAS, 1920-21 TO 1928-29

Season	Retail price per ton		Retail price of potash per unit		Number of tons sold	
	Muriate of potash	Kainit	In muriate* of potash	In kainit	Muriate of potash	Kainit
1920-21.....		\$28.50		\$2.30	.....	.....
1921-22.....	\$66.00	23.60	\$1.35	1.90	.....	.....
1922-23.....		23.56		1.90	.....	.....
1923-24.....	58.50	25.50	1.19	2.06	169†	628
1924-25.....	54.25	23.61	1.11	1.90	186†	827
1925-26.....	51.57	22.00	1.05	1.77	569	1,030
1926-27.....	51.45	20.31	1.05	1.64	409	1,174
1927-28.....	50.90	22.34	1.04	1.80	440	372
1928-29.....	52.85	23.23	1.08	1.87	579	498
1923-24 to 1928-29.....	53.25	22.83	1.09	1.84	392	755

\* Calculated on the basis of 49 per cent of actual potash in muriate.

† Muriate and sulfate of potash.

lower-grade salt. This difference between the retail price of potash in kainit and in muriate was greater in Texas than in Pennsylvania. Since the cost of distribution tends to be a uniform amount per ton, the retail price per unit in the low-grade salt is much higher than in the high-grade salt, even though the wholesale prices of potash in the two salts were much the same. Retail prices of both muriate and kainit in Texas during the 1928-29 season were the highest since the 1924-25 season.

The retail prices of potash in Indiana seem to be relatively low as compared with the retail prices in other States. Some of the Indiana prices were car-lot prices and thus tended to be somewhat lower than prices on smaller quantities.

### *In Pennsylvania*

#### *Muriate of potash*

Retail prices of muriate of potash in Pennsylvania were available, with the exception of the war years, for the period from 1909 to 1928 (table 50). During the war period, imports of potash were practically discon-

TABLE 50. RETAIL AND WHOLESALE PRICES AND COST OF DISTRIBUTION OF MURIATE OF POTASH IN PENNSYLVANIA, 1909 TO 1928

Year	Retail price per ton in Pennsylvania	Wholesale price per ton at ports*	Cost of distribution per ton	Index numbers (1910-1914† = 100)		
				Retail price in Pennsylvania	Wholesale price at ports	Cost of distribution
1910-1914†	\$ 45.63	\$ 37.44	\$ 8.19	100	100	100
1924-1928	48.65	32.38	16.27	107	86	199
1909	45.00	38.00	7.00	99	101	85
1910	45.00	36.03	8.97	99	96	110
1911	45.00	36.37	8.63	99	97	105
1912	44.00‡	38.29	5.71	96	102	70
1913	47.50	38.47	9.03	104	103	110
1914	45.00	38.88	6.12	99	104	75
1915		140.93			376	
1916		381.26			1,018	
1917		415.89			1,111	
1918		329.14			879	
1919		228.64			611	
1920	147.00	122.19	24.81	322	326	303
1921	98.32	69.75	28.57	215	186	349
1922	49.25	34.93	14.32	108	93	175
1923	48.00	31.72	16.28	105	85	199
1924	48.50	31.10	17.40	106	83	212
1925	50.05	31.11	18.94	110	83	231
1926	48.00	31.41	16.59	105	84	203
1927	45.50	33.04	12.46	100	88	152
1928	51.20	35.22	15.98	112	94	195

\* Average of monthly wholesale prices from October to September inclusive.

† 1910 to 1914 except 1912.

‡ For the spring season only.

tinued and potash prices were extremely high. In this period of scarcity, potash practically disappeared from the retail market and no retail prices were available.

For the four pre-war years 1910, 1911, 1913, and 1914, the average retail price of muriate of potash in Pennsylvania was \$45.63 per ton, and the wholesale price averaged \$37.44. The difference between the retail and the wholesale price, or the cost of distribution, was \$8.19, or 18 per cent of the retail price.

During the five post-war years 1924 to 1928, the retail price averaged \$48.65 per ton, or 7 per cent more than the pre-war price of \$45.63. The wholesale price averaged \$32.38, or 14 per cent less than the pre-war price. Even though the wholesale price was less than before the war, farmers had to pay higher than pre-war prices.

For the five post-war years 1924 to 1928, the difference between the retail price and the wholesale price was \$16.27, or practically double the pre-war difference of \$8.19. The cost of distribution during the post-war period was 33 per cent of the retail price, as compared with only 18 per cent during the pre-war period. The change in the cost of distribution was greater than the change in either the wholesale or the retail price.

The data on retail prices of muriate of potash in Connecticut for the two years 1922 and 1923 indicated that the spread between the retail and the wholesale price was more than double the pre-war amount. Much the same change in relationship between the wholesale and the retail price occurred in Pennsylvania. The prices in Pennsylvania for the five years 1924 to 1928 indicate that this change in relationship between wholesale and retail prices has continued.

## Kainit

For the period from 1910 to 1914 (except 1912), the retail price of kainit in Pennsylvania averaged \$13.75 (table 51). The wholesale price during the same years was \$8 per ton. The cost of distribution was \$5.75, or 42 per cent of the retail price. For the low-grade salt the cost of distribution was a larger part of the retail price than for the high-grade salt.

TABLE 51. RETAIL AND WHOLESALE PRICES AND COST OF DISTRIBUTION OF KAINIT IN PENNSYLVANIA, 1909 TO 1928

Year	Retail price per ton in Pennsylvania	Wholesale price per ton at ports*	Cost of distribution per ton	Index numbers (1910-1914† = 100)		
				Retail price in Pennsylvania	Wholesale price at ports	Cost of distribution per ton
1910-1914†	\$13.75	\$ 8.00	\$ 5.75	100	100	100
1924-1928	19.15	7.48	11.67	139	94	203
1909	13.50	7.59	5.91	98	95	103
1910	14.00	7.45	6.55	102	93	114
1911	14.00	7.70	6.30	102	96	110
1912	14.00‡	8.36	5.64	102	104	98
1913	13.50	8.45	5.05	98	106	88
1914	13.50	8.41	5.09	98	105	89
1915		24.18			302	
1916		45.00			562	
1917		45.00			562	
1918						
1919						
1920						
1921	28.00			204		
1922	20.00	7.18	12.82	145	90	223
1923	19.00	6.51	12.49	138	81	217
1924	17.00	6.51	10.49	124	81	182
1925	21.22	6.79	14.43	154	85	251
1926	20.00	7.25	12.75	145	91	222
1927	17.55	8.14	9.41	128	102	164
1928	20.00	8.71	11.29	145	109	196

\* Average of monthly wholesale prices from October to September inclusive.

† 1910 to 1914 except 1912.

‡ For the spring season only.

During the post-war period from 1924 to 1928, the retail price averaged \$19.15 per ton, or 39 per cent above the pre-war price. The wholesale price was \$7.48, or 6 per cent less than the pre-war figure. The retail price had increased, while the wholesale price had declined.

Such changes as these indicate the folly of assuming that changes in wholesale prices are indicative of corresponding changes in retail prices.

The cost of distribution of kainit during the five-year period 1924 to 1928 was \$11.67, or practically twice the pre-war amount. During the pre-war period the cost of distribution was 42 per cent of the retail price, as compared with 61 per cent for the five years 1924 to 1928.

#### Relation of wholesale and retail prices to analysis

Muriate of potash contains approximately 49 per cent of actual potash ( $K_2O$ ), while during this period kainit contained only 12.4 per cent.

During the pre-war period the wholesale price of bulk kainit was \$8 per ton, or 65 cents per unit. The wholesale price of potash in bagged muriate was 76 cents per unit. The wholesale price of potash per unit in kainit was only 86 per cent of the price of potash in muriate. The rela-



tion between the retail prices per unit in the two salts was reversed: the retail price of potash in kainit was 19 per cent greater than the price of potash in muriate.

The change in the relationship between the wholesale prices of potash in muriate and kainit, and the retail prices of potash in the two salts, is due to the fact that the cost of distribution per ton is not proportional to the analysis or to the wholesale price. The wholesale price of muriate, \$37.44 per ton, was more than four times as great as the wholesale price of kainit, \$8 per ton. The cost of distribution for muriate was \$8.19 per ton, as compared with \$5.75 per ton for kainit. The differences in the cost of distribution may have been due in part to differences in the geographical distribution of the retail prices. There was probably a tendency for the low-grade salt to be used near the seaports.

The cost of distribution tends to be a larger part of the retail price with low-grade than with high-grade goods. For the post-war period the cost of distribution was approximately double the pre-war figure. This means that for low-grade goods a larger part of the retail price has increased; therefore the disparity in the retail price between low-grade and high-grade goods is even greater than before the war. During the post-war years 1924 to 1928 the wholesale price of potash in bagged muriate was 66 cents per unit; in bulk kainit it was 60 cents per unit, or 91 per cent of the price for bagged muriate (table 52). This was much the same relationship as existed prior to the war. The retail price of potash in muriate for the post-war period was 99 cents per unit, as compared with \$1.54 for the potash in kainit. The retail price of potash in kainit was 56 per cent greater than that of the potash in muriate, as compared with a difference of 19 per cent for the pre-war period.

TABLE 52. RETAIL PRICE OF POTASH IN PENNSYLVANIA PER UNIT IN MURIATE AND KAINIT, AND WHOLESALE PRICE OF POTASH IN MURIATE AND KAINIT, 1910 TO 1914\* AND 1924 TO 1928

Period	Wholesale price per unit at ports		Per cent kainit price is of muriate price	Retail price per unit in Pennsylvania		Per cent kainit price is of muriate price	Cost of distribution per unit	
	Muriate	Kainit		Muriate	Kainit		Muriate	Kainit
1910-1914*.....	\$0.76	\$0.65	86	\$0.93	\$1.11	119	\$0.17	\$0.46
1924-1928.....	0.66	0.60	91	0.99	1.54	156	0.33	0.94

\* 1910 to 1914 except 1912.

While the wholesale prices of low- and of high-grade goods may be nearly proportional to the analysis, the retail price per unit in low-grade goods is much higher than in high-grade goods.

The increase of the retail price over the wholesale price is greater for the low-grade than for the high-grade goods. That is, the cost of distribution is more closely related to the tonnage than to the value. When the cost of distribution increases, the disparity in the retail prices between the low- and the high-grade goods becomes even greater, making it more economical to use the higher-grade product. During the period from 1924 to 1928 the tonnage of muriate increased while the tonnage of kainit decreased.

## BONE MANURES

In the early development of the fertilizer industry, bone products were an important source of plant food. At present, however, they are of minor importance. Bone products are valuable for fertilizer because of both their nitrogen and their phosphoric-acid content.

Retail prices and analyses of bone manures were given in the Connecticut and the Pennsylvania fertilizer reports.

*In Connecticut*

During the period from 1881 to 1898, the retail price of bone manures in Connecticut declined at the rate of 12 cents per ton, or 0.4 per cent. per annum (table 53). In the following sixteen years, the price increased

TABLE 53. AVERAGE RETAIL PRICE AND AVERAGE ANALYSIS OF BONE MANURES IN CONNECTICUT, 1881 TO 1923

Year	Number of samples	Retail price per ton	Per cent of nitrogen found	Per cent of nitrogen guaranteed	Per cent of phosphoric acid found	Per cent of phosphoric acid guaranteed	Mechanical analysis (per cent of material finer than $\frac{1}{8}$ inch in diameter)
1881-1885	21	\$34.59	3.55	.....	20.57	.....	37.13
1890-1894	19	32.91	3.61	.....	23.11	.....	45.16
1900-1904	31	29.91	3.28	2.94	23.91	22.06	56.69
1910-1914	23	32.94	2.97	2.72	23.89	21.53	60.44
1922-1923	16	50.80	3.02	2.69	25.46	22.68	59.28
1881	14	31.82	3.59	.....	21.00	.....	32.79
1882	16	34.78	3.33	.....	19.87	.....	36.75
1883	22	36.01	3.45	.....	21.17	.....	36.45
1884	27	35.19	3.56	.....	20.16	.....	36.81
1885	27	35.16	3.84	.....	20.63	.....	42.85
1886	22	36.14	3.66	.....	22.01	.....	44.68
1887	16	34.25	3.59	.....	22.37	.....	55.94
1888	34	32.23	3.57	.....	22.24	.....	47.44
1889	18	34.11	3.38	.....	23.38	.....	44.33
1890	20	32.75	3.62	.....	22.97	.....	46.35
1891	19	33.50	3.70	.....	23.12	.....	40.47
1892	18	33.06	3.55	.....	22.52	.....	47.33
1893	18	31.72	3.60	.....	23.69	.....	42.56
1894	21	33.52	3.56	.....	23.27	.....	49.10
1895	29	32.34	3.58	.....	23.10	.....	50.34
1896	27	31.19	3.30	.....	24.26	.....	52.30
1897	33	31.15	3.42	.....	23.97	.....	50.21
1898	57	29.81	3.07	.....	24.39	.....	55.44
1899	42	29.78	3.16	.....	24.19	.....	54.50
1900	31	29.32	3.21	2.95	23.13	21.49	62.13
1901	24	30.06	3.28	2.99	24.56	22.52	57.92
1902	36	29.75	3.30	2.97	23.89	22.55	56.94
1903	35	30.49	3.54	3.07	23.72	21.78	52.80
1904	28	29.95	3.09	2.71	24.25	21.98	53.68
1905	39	29.76	3.28	2.78	23.76	21.67	54.54
1906	30	30.13	3.24	2.70	23.86	21.89	54.90
1907	36	30.69	3.14	2.78	23.41	22.22	51.43
1908	31	30.55	3.00	2.63	24.54	22.36	58.06
1909	28	31.21	2.87	2.76	24.55	21.79	54.09
1910	21	31.95	3.09	2.74	22.89	20.59	54.19
1911	24	32.62	2.92	2.67	24.18	21.09	63.12
1912	26	33.04	2.96	2.65	24.45	21.74	59.35
1913	24	33.44	3.01	2.77	24.31	22.05	61.92
1914	21	33.67	2.88	2.77	23.61	22.16	63.62
1915	22	33.97	3.06	2.88	24.27	22.30	58.09
1916	18	37.78	3.09	2.76	24.45	22.49	59.44
1917	14	42.14	3.38	2.89	23.49	21.70	53.14
1918	18	51.36	2.94	2.58	25.67	22.90	50.06
1919	14	57.68	3.40	2.93	23.80	21.99	57.64
1920	13	63.19	3.44	2.79	24.13	22.21	56.23
1921	23	56.20	2.94	2.67	25.68	22.11	58.04
1922	19	47.91	3.01	2.67	25.35	22.78	61.84
1923	14	53.69	3.04	2.71	25.56	22.57	56.71

at the rate of 14 cents per ton, or 0.4 per cent, per annum. These changes were small when compared with the changes that occurred in the prices of many of the ammoniates and in the prices of commodities in general.

The retail price of bone manures averaged \$32.94 per ton for the five years 1910 to 1914, or 10 per cent more than for the five years 1900 to 1904. In the same period the price of cottonseed meal in Connecticut practically doubled.

The retail price of bone manures rose rapidly during the war period, and reached a peak of 192 per cent of the pre-war price in 1920 (table 54 and figure 20). For the two years 1922 and 1923 the index number averaged 154.

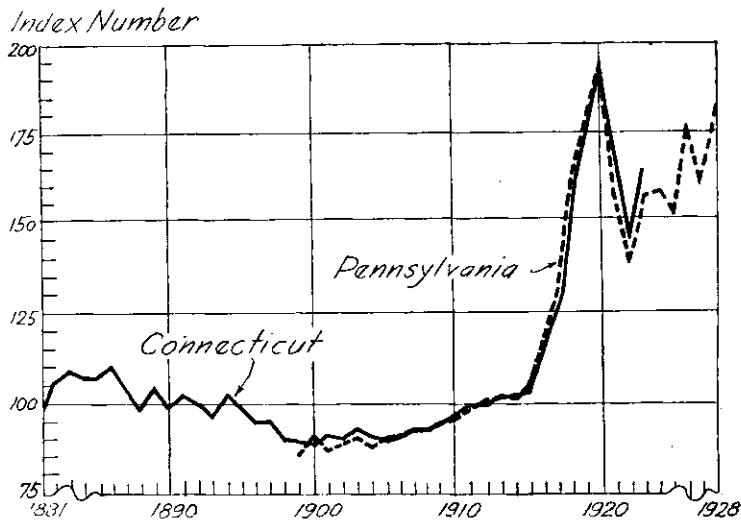


FIGURE 20. INDEX NUMBERS OF THE RETAIL PRICE OF BONE MANURES IN CONNECTICUT AND PENNSYLVANIA, 1881 TO 1928

Price in the two States tend to move together. Prices during the post-war period have been high as compared with pre-war prices

There are cycles in the prices of cattle and hogs. In the period from 1880 to 1923 there were three cycles in the prices of both beef and dairy cattle. The purchasing power of the price averaged about 50 per cent greater in the periods of high prices than in the periods of low prices. Even though there were these violent fluctuations in the price of cattle, the retail price of bone manures in Connecticut remained relatively constant.

The retail price of bone manures is made up primarily of costs of distribution. Bones are collected from packing plants and retail butcher shops, processed, and then sold for fertilizer purposes. The cost of the raw material is only a small part of the retail price. Probably the most important factors affecting the retail price of bone manures are the labor and transportation costs involved in the collection and distribution. This is probably the reason why the decline and rise in retail prices of bone manures during the period from 1882 to 1914 was relatively small as compared with those for other organic-plant-food carriers, and why the retail prices of bone manures have little relation to the cycles in prices of cattle.

TABLE 54. INDEX NUMBERS OF AVERAGE RETAIL PRICE AND AVERAGE ANALYSIS OF BONE MANURES IN CONNECTICUT, 1881 TO 1923  
(1910-1914=100)

Year	Retail price per ton	Nitrogen found	Nitrogen guaranteed	Phosphoric acid found	Phosphoric acid guaranteed	Mechanical analysis
1881-1885	105	120	.....	86	.....	61
1890-1894	100	122	.....	97	.....	75
1900-1904	91	110	108	100	102	94
1910-1914	100	100	100	100	100	100
1922-1923	154	102	99	107	105	98
1881	97	121	.....	88	.....	54
1882	106	112	.....	83	.....	61
1883	109	116	.....	89	.....	60
1884	107	120	.....	84	.....	61
1885	107	129	.....	86	.....	71
1886	110	123	.....	92	.....	74
1887	104	121	.....	94	.....	93
1888	98	120	.....	93	.....	78
1889	104	114	.....	98	.....	73
1890	99	122	.....	96	.....	77
1891	102	125	.....	97	.....	67
1892	100	120	.....	94	.....	78
1893	96	121	.....	99	.....	70
1894	102	120	.....	97	.....	81
1895	98	121	.....	97	.....	83
1896	95	111	.....	102	.....	87
1897	95	115	.....	100	.....	83
1898	90	103	.....	102	.....	92
1899	90	106	.....	101	.....	90
1900	89	108	108	97	100	103
1901	91	110	110	103	105	96
1902	90	111	109	100	105	94
1903	93	119	113	99	101	87
1904	91	104	100	102	102	89
1905	90	110	102	99	101	90
1906	91	109	99	100	102	91
1907	93	106	102	98	103	85
1908	93	101	97	103	104	96
1909	95	97	101	103	101	89
1910	97	104	101	96	96	90
1911	99	98	98	101	98	104
1912	100	100	97	102	101	98
1913	102	101	102	102	102	102
1914	102	97	102	99	103	105
1915	103	103	106	102	104	96
1916	115	104	101	102	104	98
1917	128	114	106	98	101	88
1918	156	99	95	107	106	83
1919	175	114	108	100	102	95
1920	192	116	103	101	103	93
1921	171	99	98	107	103	96
1922	145	101	98	106	106	102
1923	163	102	100	107	105	94

Although the average analysis of the bones fluctuated from year to year, the general tendency was for the nitrogen content to decline and the phosphoric-acid content to increase. For the five years 1881 to 1885 the nitrogen content averaged 3.55 per cent, or about one-fifth more than for the five years 1910 to 1914. The phosphoric-acid content averaged 20.57 per cent for the period from 1881 to 1885, and 23.89 per cent for the period from 1910 to 1914. The increase in the phosphoric-acid content was most rapid during the period from 1881 to 1886.

The mechanical analysis—that is, the percentage of the material that will pass through a sieve with holes 1/50 inch in diameter—was given also. For the five years 1881 to 1885 only 37.13 per cent of the material was finer than 1/50 inch, as compared with 60.44 per cent for the five years 1910 to 1914. The coarser the material, the less rapidly it dissolves in the soil and becomes available for plants.

For the forty-three-year period 1881 to 1923, the coefficient of variability of the nitrogen content of the samples of bone manures averaged 27 (table 55). The variability of the phosphoric-acid content was only about

TABLE 55. COEFFICIENTS OF VARIABILITY OF THE RETAIL PRICE AND THE ANALYSIS OF BONE MANURES IN CONNECTICUT, 1881 TO 1923

Year	Retail price per ton	Nitrogen found	Phosphoric acid found	Mechanical analysis found	Nitrogen guaranteed	Phosphoric acid guaranteed
1881-1885	13.09	24.66	22.43	70.16	.....	.....
1890-1894	10.68	26.06	13.02	41.00	.....	.....
1900-1904	9.10	27.39	13.15	26.52	25.55	12.76
1910-1914	8.62	27.57	14.33	20.62	25.07	13.78
1922-1923	12.58	28.60	6.48	21.42	26.06	8.20
1881	15.32	17.42	22.08	90.83	.....	.....
1882	11.62	24.74	23.85	72.06	.....	.....
1883	13.34	32.27	21.23	61.87	.....	.....
1884	12.18	27.40	23.92	71.39	.....	.....
1885	13.00	21.49	21.07	54.63	.....	.....
1886	11.11	36.28	22.12	37.01	.....	.....
1887	9.03	29.01	18.28	26.94	.....	.....
1888	10.66	26.44	17.60	42.18	.....	.....
1889	7.75	28.31	9.63	37.30	.....	.....
1890	9.84	24.49	11.63	35.30	.....	.....
1891	10.28	24.34	14.06	51.72	.....	.....
1892	9.90	29.11	15.91	34.47	.....	.....
1893	11.16	26.78	13.11	50.11	.....	.....
1894	12.23	25.57	10.41	33.38	.....	.....
1895	12.00	23.36	13.02	34.50	.....	.....
1896	8.73	31.25	13.55	37.00	.....	.....
1897	10.54	26.80	12.57	34.68	.....	.....
1898	8.19	28.51	13.65	27.05	.....	.....
1899	8.57	29.16	12.07	32.48	.....	.....
1900	9.73	23.03	17.65	26.22	28.31	16.84
1901	9.34	30.80	10.78	26.82	30.28	10.16
1902	10.06	29.94	14.56	22.60	27.28	13.65
1903	7.45	23.95	10.87	25.65	20.32	11.92
1904	8.93	29.25	11.87	31.33	21.57	11.24
1905	10.49	32.24	16.75	25.59	22.36	16.45
1906	10.52	29.54	16.15	21.65	26.36	15.01
1907	9.18	30.79	13.17	28.28	23.98	7.18
1908	9.35	30.27	13.00	23.20	28.26	12.09
1909	8.70	29.61	13.64	26.06	18.99	14.87
1910	9.10	26.69	17.16	23.19	25.57	17.23
1911	7.03	29.62	13.11	18.46	24.45	13.55
1912	7.82	28.76	13.45	22.79	26.40	13.13
1913	9.19	29.53	16.02	21.33	24.51	14.53
1914	9.97	23.25	11.89	17.33	24.43	10.45
1915	11.13	28.08	11.22	19.50	25.50	11.49
1916	8.67	27.13	8.35	19.98	25.78	8.46
1917	11.02	27.29	8.22	18.49	24.06	6.72
1918	12.12	24.58	8.13	15.89	23.23	7.69
1919	9.93	18.93	5.15	20.29	25.78	6.16
1920	26.51	18.41	7.22	19.03	25.13	10.12
1921	15.86	27.48	10.41	22.93	23.09	13.91
1922	13.30	26.69	7.49	12.75	24.92	7.67
1923	11.87	30.50	5.48	30.10	27.20	8.73

one-half as great, averaging 14. The mechanical analysis was more variable than the nitrogen or the phosphoric-acid content. The coefficient of variability of the retail price averaged 11. The variations in the prices of the various samples were much less than the variations in the analyses (figure 21).

Since there were such large differences in the analysis and also some variation in the prices of the samples, correlations were made between the retail price and the analysis in order to determine whether or not those samples with relatively high analysis tended to be higher in price than those with low analysis. The coefficients of determination of the retail price by the analysis are shown in table 56 and figure 22. The relationship

## Coefficient of Variability

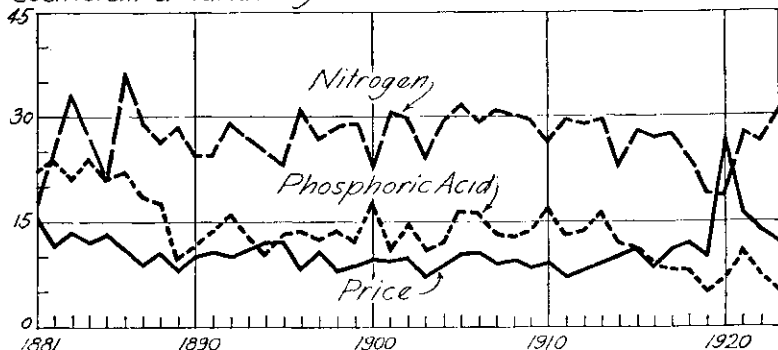


FIGURE 21. COEFFICIENTS OF VARIABILITY OF THE RETAIL PRICE AND THE ANALYSIS OF BONE MANURES IN CONNECTICUT, 1881 TO 1923

During the greater part of the period, the retail price was much less variable than the analysis. The nitrogen content was more variable than the phosphoric-acid content

## Coefficient of Determination

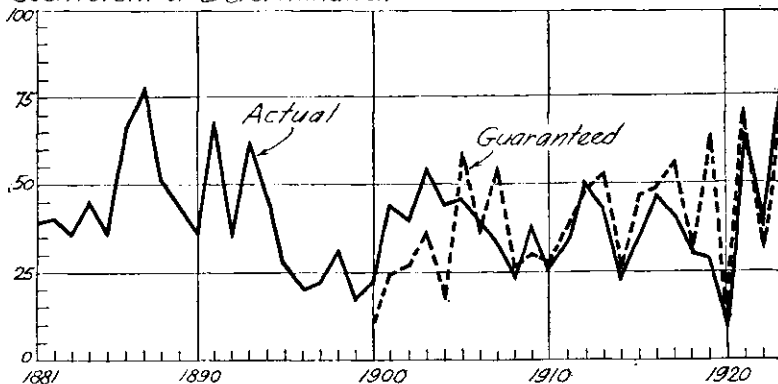


FIGURE 22. COEFFICIENTS OF DETERMINATION OF THE RETAIL PRICE OF BONE MANURES IN CONNECTICUT BY THE GUARANTEED AND THE ACTUAL ANALYSIS, 1881 TO 1923

There are wide variations in the relationship between the price and the analysis of bone manures. Since 1908 the relationship between the price and the guaranteed analysis has been much the same as the relationship between the price and the actual analysis

between the price and the analysis fluctuated violently from year to year. In 1923 approximately 79 per cent of the variability in the retail prices was associated with the variations in the analysis, as compared with only 11 per cent in 1920. Even before the war period there were large year-to-year changes in the relationship between the price and the analysis. For the period as a whole, 1881 to 1923, about 40 per cent of the variation in the retail prices of the bone manures was associated with variations in the analysis. There was a tendency for bone manures with high analysis to sell for higher prices than did those with low analysis. Factors other than the analysis, however, were important in affecting the retail price.

Of the three variables in the analysis, the nitrogen content was the most important in affecting the price. For the period as a whole, about 24 per



The relation between the guaranteed analysis and the price was much the same as for the actual analysis. Such differences as existed were due to the fact that there was not a perfect correlation between the guaranteed and the actual analysis. Several samples might have the same guaranteed analysis but differ considerably in actual analysis. Thus the correlations between the actual and the guaranteed analysis were not perfect (table 57 and figure 24).

Because nitrogen is more expensive than phosphoric acid and has a greater effect on the retail price, manufacturers are more careful to have

### Coefficient of Determination

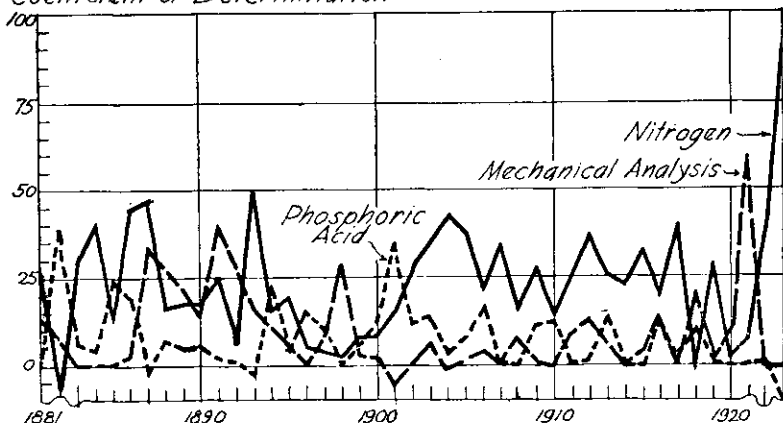


FIGURE 23. COEFFICIENTS OF DETERMINATION OF THE CONNECTICUT RETAIL PRICE OF BONE MANURES BY THE CHEMICAL AND THE MECHANICAL ANALYSIS, 1881 TO 1923

There was no consistent relationship between the various items in the analysis and the retail price. For the period as a whole, the nitrogen content was more closely associated with the price than was either the phosphoric-acid content or the mechanical analysis

### Correlation

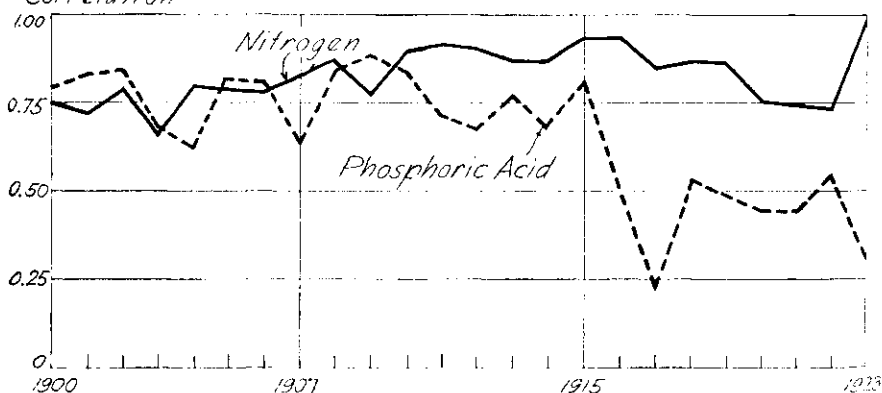


FIGURE 24. CORRELATION BETWEEN GUARANTEED AND ACTUAL NITROGEN CONTENT AND GUARANTEED AND ACTUAL PHOSPHORIC-ACID CONTENT OF BONE MANURES IN CONNECTICUT, 1900 TO 1923

The guaranteed and the actual nitrogen content are more closely correlated than are the guaranteed and the actual phosphoric-acid content



TABLE 57. CORRELATIONS BETWEEN ACTUAL AND GUARANTEED NITROGEN AND PHOSPHORIC-ACID CONTENT OF BONE MANURES IN CONNECTICUT, 1900 TO 1923

Year	Actual nitrogen content with guarantee (r)	Actual phosphoric-acid content with guarantee (r)	Year	Actual nitrogen content with guarantee (r)	Actual phosphoric-acid content with guarantee (r)
1900.....	0.757	0.793	1912.....	0.897	0.680
1901.....	0.721	0.834	1913.....	0.870	0.767
1902.....	0.788	0.839	1914.....	0.869	0.677
1903.....	0.656	0.674	1915.....	0.929	0.801
1904.....	0.803	0.616	1916.....	0.925	0.511
1905.....	0.786	0.816	1917.....	0.843	0.232
1906.....	0.785	0.805	1918.....	0.869	0.528
1907.....	0.818	0.636	1919.....	0.862	0.488
1908.....	0.873	0.836	1920.....	0.752	0.449
1909.....	0.780	0.879	1921.....	0.749	0.447
1910.....	0.889	0.841	1922.....	0.736	0.537
1911.....	0.907	0.718	1923.....	0.965	0.323

the guaranteed nitrogen content indicate more nearly accurately the actual nitrogen content than is the case with the phosphoric acid. The correlation between the actual and the guaranteed nitrogen content was higher than that between the actual and the guaranteed phosphoric-acid content.

The differences in the retail prices of the various grades of bone manures per unit variation in analysis are shown in table 58 and figure 25. In 1881 the bone manures containing 4 per cent of nitrogen tended to sell at retail for about \$9.63 per ton more than did those containing 3 per cent of nitrogen but of equal fineness and phosphoric-acid content. In 1882 this relationship was reversed; the samples containing 4 per cent of nitro-

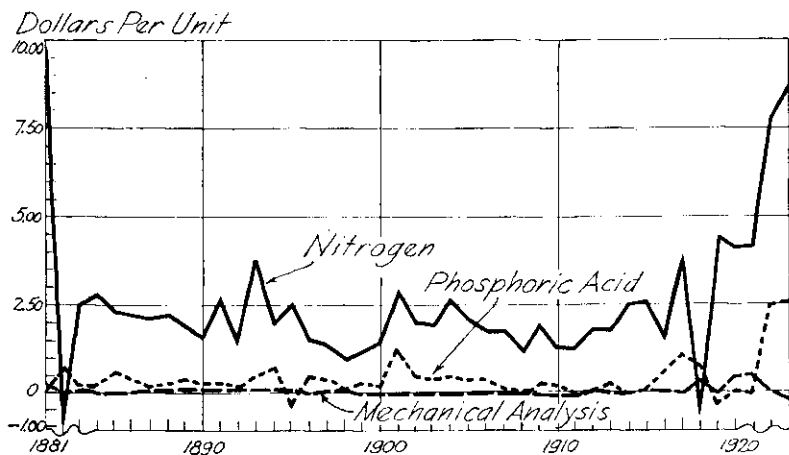


FIGURE 25. INCREASE IN THE RETAIL PRICE PER TON OF BONE MANURES IN CONNECTICUT, PER UNIT INCREASE IN ANALYSIS, 1881 TO 1923

(Net regression coefficients)

A unit variation in the nitrogen content of the bone manures was associated with a much larger change in the retail price than was a corresponding change in the phosphoric-acid content. A percentage change in the mechanical analysis caused very little change in the price

gen tended to sell at retail for 93 cents per ton less than did those containing 3 per cent of nitrogen but otherwise of the same analysis. This was an unusual relationship. In only two of the years (1882 and 1918) of the period from 1881 to 1923 was there an apparent tendency for the bone manures of high nitrogen content to sell for less than those with a low nitrogen content.

The prices of bone manures as reported in the Connecticut fertilizer reports were collected over a period of several months during the fertilizer

TABLE 58. CHANGE IN THE CONNECTICUT RETAIL PRICE OF BONE MANURES PER TON, PER UNIT INCREASE IN THE ANALYSIS, 1881 TO 1923

Year	Change in the retail price of bone manures per ton ( $x_1$ ) per unit increase in			Change in the retail price of bone manures per ton ( $x_1$ ) per unit increase in		
	actual nitrogen content ( $x_2'$ ) eliminating the effect of variations in the actual phosphoric-acid content ( $x_3'$ ) and the mechanical analysis ( $x_4'$ ) $b_{12' \cdot 34'}$	actual phosphoric-acid content ( $x_3'$ ) eliminating the effect of variations in the actual nitrogen content ( $x_2'$ ) and the mechanical analysis ( $x_4'$ ) $b_{13' \cdot 24'}$	mechanical analysis ( $x_4'$ ) eliminating the effect of variations in the actual nitrogen ( $x_2'$ ) and the actual phosphoric-acid content ( $x_3'$ ) $b_{14' \cdot 23'}$	guaranteed nitrogen content ( $x_2$ ) eliminating the effect of variations in the guaranteed phosphoric-acid content ( $x_3$ ) and the actual mechanical analysis ( $x_4'$ ) $b_{12 \cdot 34'}$	guaranteed phosphoric-acid content ( $x_3$ ) eliminating the effect of variations in the guaranteed nitrogen content ( $x_2$ ) and the actual mechanical analysis ( $x_4'$ ) $b_{13 \cdot 24'}$	actual mechanical analysis ( $x_4'$ ) eliminating the effect of variations in the guaranteed nitrogen ( $x_2$ ) and phosphoric-acid content ( $x_3$ ) $b_{14' \cdot 23}$
1881-1885...	\$3.25	\$0.31	\$0.04	.....	.....	.....
1890-1894...	2.33	0.39	0.10	.....	.....	.....
1900-1904...	2.14	0.57	0.00	\$1.43	\$0.20	\$0.03
1910-1914...	1.73	0.13	0.00	1.97	0.11	-0.01
1922-1923...	8.18	2.56	-0.04	6.86	0.36	-0.12
1881.....	9.63	0.00	0.19	.....	.....	.....
1882.....	-0.93	0.55	-0.04	.....	.....	.....
1883.....	2.47	0.25	0.06	.....	.....	.....
1884.....	2.82	0.20	0.00	.....	.....	.....
1885.....	2.28	0.56	0.00	.....	.....	.....
1886.....	2.22	0.44	0.02	.....	.....	.....
1887.....	2.08	0.18	0.11	.....	.....	.....
1888.....	2.15	0.30	0.09	.....	.....	.....
1889.....	1.92	0.40	0.09	.....	.....	.....
1890.....	1.61	0.27	0.07	.....	.....	.....
1891.....	2.63	0.32	0.12	.....	.....	.....
1892.....	1.54	0.17	0.12	.....	.....	.....
1893.....	3.84	0.51	0.10	.....	.....	.....
1894.....	2.03	0.70	0.09	.....	.....	.....
1895.....	2.51	-0.30	0.09	.....	.....	.....
1896.....	1.50	0.54	0.00	.....	.....	.....
1897.....	1.42	0.41	0.05	.....	.....	.....
1898.....	1.02	0.06	0.10	.....	.....	.....
1899.....	1.20	0.28	0.03	.....	.....	.....
1900.....	1.40	0.25	0.02	0.46	0.22	0.02
1901.....	2.76	1.22	-0.03	0.82	0.56	0.04
1902.....	1.98	0.47	-0.02	1.94	0.17	0.05
1903.....	1.91	0.43	0.03	1.93	-0.02	0.06
1904.....	2.65	0.50	0.02	1.98	0.06	0.00
1905.....	2.14	0.39	-0.01	3.78	0.18	-0.02
1906.....	1.79	0.38	0.05	2.57	0.29	0.01
1907.....	1.76	0.11	0.01	3.36	0.51	-0.03
1908.....	1.21	-0.01	0.06	1.80	0.17	0.02
1909.....	1.90	0.33	0.02	1.82	0.32	-0.01
1910.....	1.31	0.25	-0.01	0.62	0.39	-0.01
1911.....	1.27	0.01	-0.05	1.50	0.13	-0.06
1912.....	1.77	0.08	0.06	2.14	0.10	0.03
1913.....	1.75	0.31	-0.05	2.81	0.21	-0.03
1914.....	2.53	0.01	0.04	2.79	-0.30	0.01
1915.....	2.55	0.06	0.07	3.35	0.13	0.08
1916.....	1.72	0.64	0.08	2.41	0.66	0.07
1917.....	3.86	1.12	0.00	4.49	1.20	0.04
1918.....	-0.53	0.81	0.35	2.51	1.38	0.26
1919.....	4.41	-0.32	0.04	7.22	1.59	-0.15
1920.....	4.17	0.07	0.47	2.91	-0.90	0.38
1921.....	4.20	0.02	0.55	7.54	0.74	0.34
1922.....	7.73	2.48	0.06	6.02	0.71	-0.13
1923.....	8.62	2.64	-0.14	7.70	0.02	-0.11

season. As indicated in the discussion of cottonseed-meal prices, variations in prices during the season tend to obscure the usual relationship between price and analysis. The peculiar results obtained for a few of the years may be due to variations in prices during the fertilizer season.

The variation in retail prices of bone manures associated with differences in analysis varied from year to year. The tendency, however, was for the retail prices to be highest for the samples with the highest analysis. For the forty-three-year period 1881 to 1923, a 1-per-cent variation in nitrogen content was associated with a variation of \$1.98 per ton in the retail price, and a 1-per-cent variation in the phosphoric-acid content was associated with a variation of 31 cents per ton in the retail price; variations in the mechanical analysis caused only slight changes in the retail price. Nitrogen is much more expensive than phosphoric acid, and therefore variations in the nitrogen content were associated with much larger variations in the retail price than were variations in the phosphoric-acid content.

### *In Pennsylvania*

For the five years 1910 to 1914, the retail price of bone manures in Connecticut averaged \$32.94. This was \$1.76 higher than the average retail price in Pennsylvania, \$31.18 (table 59). Index numbers of the

TABLE 59. AVERAGE RETAIL PRICE AND AVERAGE ANALYSIS, AND INDEX NUMBERS OF AVERAGE RETAIL PRICE AND ANALYSIS, OF BONE MANURES IN PENNSYLVANIA, 1899 TO 1928

Year	Retail price per ton	Per cent of nitrogen guaranteed	Per cent of total phosphoric acid guaranteed	Number of samples	Number of analyses	Index numbers (1910-1914=100)		
						Retail price per ton	Nitrogen guaranteed	Total phosphoric acid guaranteed
1899-1903.....	\$27.66	2.93	21.46	53	28	89	99	103
1910-1914.....	31.18	2.95	20.87	62	30	100	100	100
1924-1928.....	51.62	2.93	22.26	58	14	166	99	107
1899.....	26.91	2.85	20.68	57	28	86	97	99
1900.....	28.44	2.98	20.91	26	19	91	101	100
1901.....	27.16	2.94	21.94	63	28	87	100	105
1902.....	27.86	2.86	21.38	53	30	89	97	102
1903.....	27.93	3.02	22.37	66	33	90	102	107
1904.....	27.42	2.87	21.95	54	25	88	97	105
1905.....	28.09	2.77	21.64	65	25	90	94	104
1906.....	28.30	3.03	20.80	64	30	91	103	100
1907.....	28.97	2.99	21.24	53	32	93	101	102
1908.....	29.06	2.94	20.93	49	31	93	100	100
1909.....	29.74	2.80	21.03	67	31	95	95	101
1910.....	30.08	2.87	20.48	80	35	96	97	98
1911.....	30.78	2.89	21.06	65	31	99	98	101
1912*.....	31.42	2.93	20.64	36	19	101	99	99
1913.....	31.80	3.07	21.18	66	33	102	104	101
1914.....	31.80	3.00	21.01	64	30	102	102	101
1915.....	33.16	2.95	21.27	59	27	106	100	102
1916.....	36.48	2.84	21.32	51	26	117	96	102
1917.....	40.68	2.90	21.90	56	25	130	98	105
1918.....	49.94	2.81	22.52	54	18	160	95	108
1919.....	55.52	2.84	22.67	63	24	178	96	109
1920.....	60.57	2.82	21.77	44	13	194	96	104
1921.....	48.88	2.79	22.17	65	15	157	95	106
1922.....	43.52	2.92	22.53	51	16	140	99	108
1923.....	49.30	2.86	22.31	31	12	158	97	107
1924.....	49.45	2.90	22.58	49	14	159	98	108
1925.....	47.73	2.89	22.35	76	19	153	98	107
1926.....	55.06	3.01	21.90	54	13	177	102	105
1927.....	50.11	2.86	22.33	57	14	161	97	107
1928.....	55.73	2.99	22.16	55	12	179	101	106

\* For the spring season only.

retail price of bone manures in Pennsylvania and in Connecticut are shown graphically in figure 20 (page 59). Even though the retail prices in Connecticut were higher than those in Pennsylvania, the year-to-year changes in the retail prices were practically the same in both States. For the five years 1924 to 1928 the retail price averaged 166 per cent of the pre-war price. This was high as compared with the price of other fertilizer materials. Costs of distribution during this period were high as compared with the pre-war figure, and, since these costs tend to be such a large part of the retail price, bone manures have been high in price.

In Pennsylvania, as in Connecticut, the retail price was much less variable than the analysis, and the nitrogen content was more variable than the phosphoric-acid content (table 60).

TABLE 60. STANDARD DEVIATIONS AND COEFFICIENTS OF VARIABILITY OF RETAIL PRICE AND ANALYSIS OF BONE MANURES IN PENNSYLVANIA, 1899 TO 1928

Year	Standard deviations			Coefficients of variability		
	Retail price per ton	Per cent of nitrogen guaranteed	Per cent of phosphoric acid guaranteed	Retail price per ton	Nitrogen guaranteed	Phosphoric acid guaranteed
1899-1903.....	\$2.28	0.70	2.70	8.25	24.01	12.64
1910-1914.....	2.32	0.62	3.29	7.43	20.93	15.78
1924-1928.....	5.76	0.66	1.68	11.23	22.50	7.55
1899.....	1.75	0.79	3.19	6.51	27.82	15.41
1900.....	2.23	0.48	2.98	7.83	16.27	14.27
1901.....	1.86	0.75	2.71	6.86	25.56	12.35
1902.....	4.09	0.75	2.24	14.68	26.33	10.50
1903.....	1.49	0.73	2.38	5.35	24.07	10.65
1904.....	1.86	0.69	2.84	6.77	23.90	12.95
1905.....	1.61	0.65	2.99	5.73	23.47	13.82
1906.....	2.35	0.67	3.16	8.31	22.03	15.19
1907.....	1.47	0.60	3.04	5.08	19.95	14.30
1908.....	1.97	0.72	2.75	6.79	24.52	13.16
1909.....	1.80	0.69	3.07	6.07	24.71	14.59
1910.....	1.99	0.63	3.28	6.62	22.05	16.01
1911.....	1.75	0.67	3.06	5.68	23.06	14.52
1912*.....	2.51	0.60	3.22	7.98	20.63	15.62
1913.....	2.79	0.62	3.96	8.78	20.17	18.72
1914.....	2.58	0.56	2.94	8.11	18.76	14.01
1915.....	2.44	0.60	3.04	7.36	20.21	14.31
1916.....	3.38	0.63	3.13	9.27	22.10	14.69
1917.....	2.92	0.72	2.62	7.19	24.78	11.97
1918.....	2.76	0.72	1.73	5.53	25.53	7.67
1919.....	4.90	0.66	2.91	8.83	23.13	12.82
1920.....	5.42	0.65	2.40	8.95	23.23	11.02
1921.....	4.11	0.65	2.38	8.42	23.44	10.73
1922.....	2.88	0.72	1.51	6.63	24.79	6.69
1923.....	3.67	0.55	4.62	7.44	19.13	20.69
1924.....	7.68	0.59	1.42	15.53	20.39	6.28
1925.....	5.81	0.62	1.63	12.17	21.65	7.28
1926.....	6.66	0.59	1.13	12.09	19.69	5.17
1927.....	4.37	0.71	2.22	8.73	24.85	9.95
1928.....	4.26	0.78	2.01	7.64	25.91	9.07

\* For the spring season only.

The correlations between the retail price and the analysis varied greatly from year to year (table 61 and figure 26). In 1925 there was practically no relationship between the analysis and the price. In 1917, however, about 57 per cent of the variations in the retail price were accounted for by the variations in the analysis. As an average for the thirty-year period 1899 to 1928, the analysis accounted for 18 per cent of the variability in the retail price. Factors other than the analysis were important in affecting the retail price of bone manures in Pennsylvania.

## Coefficient of Determination

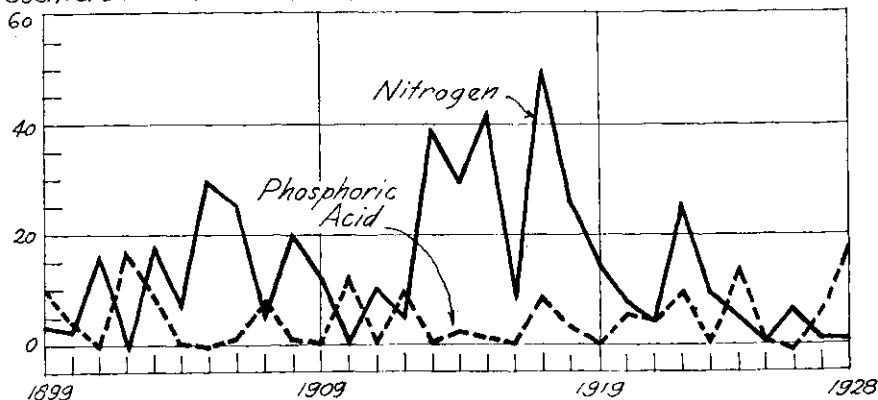


FIGURE 26. COEFFICIENTS OF DETERMINATION OF THE RETAIL PRICE OF BONE MANURES IN PENNSYLVANIA BY THE NITROGEN AND THE PHOSPHORIC-ACID CONTENT, 1899 TO 1928

The nitrogen content of the bone manures was more closely associated with the price than was the phosphoric-acid content, for most of the years

TABLE 61. MULTIPLE CORRELATIONS BETWEEN RETAIL PRICE AND ANALYSIS OF BONE MANURES, AND COEFFICIENTS OF DETERMINATION OF THE RETAIL PRICE BY THE ANALYSIS, PENNSYLVANIA, 1899 TO 1928

Year	Multiple correlation between retail price and guaranteed nitrogen and phosphoric-acid content $R_{1,23}$	Coefficients of determination of retail price by the analysis*			
		Total analysis $R_{1,23}^2 \times 100$	Nitrogen guaranteed $d_{12,2}$	Phosphoric acid guaranteed $d_{13,2}$	Factors other than the analysis $d_{12,1}$
1899-1903	0.382	15.34	7.31	8.03	84.66
1910-1914	0.441	21.03	16.65	4.38	78.97
1924-1928	0.284	9.62	2.68	6.94	90.38
1899	0.363	13.16	2.93	10.23	86.84
1900	0.238	5.69	1.54	4.16	94.31
1901	0.399	15.89	15.95	-0.05	84.11
1902	0.402	16.15	-0.92	17.07	83.85
1903	0.508	25.82	17.06	8.76	74.18
1904	0.273	7.47	7.34	0.13	92.53
1905	0.535	28.66	28.89	-0.23	71.34
1906	0.511	26.13	24.87	1.27	73.87
1907	0.346	11.95	5.45	6.51	88.05
1908	0.456	20.77	19.65	1.12	79.23
1909	0.344	11.84	11.59	0.25	88.16
1910	0.331	10.97	0.34	10.63	89.03
1911	0.318	10.09	10.29	-0.20	89.91
1912†	0.369	13.64	4.65	8.99	86.36
1913	0.626	39.22	38.81	0.41	60.78
1914	0.559	31.21	29.16	2.05	68.79
1915	0.648	42.03	40.92	1.11	57.97
1916	0.286	8.19	8.13	0.06	91.81
1917	0.753	56.67	48.45	8.22	43.33
1918	0.533	28.38	25.06	3.32	71.62
1919	0.374	13.97	13.93	0.04	86.03
1920	0.353	12.48	7.68	4.79	87.52
1921	0.285	8.12	4.01	4.10	91.88
1922	0.580	33.61	24.59	9.02	66.39
1923	0.297	8.81	8.76	0.05	91.19
1924	0.427	18.20	5.49	12.71	81.80
1925	0.093	0.87	-0.08	0.94	99.13
1926	0.226	5.11	6.00	-0.89	94.89
1927	0.260	6.77	1.11	5.66	93.23
1928	0.414	17.14	0.86	16.28	82.86

\* $x_1$  = retail price per ton;  $x_2$  = guaranteed nitrogen content;  $x_3$  = guaranteed total phosphoric-acid content.

† For the spring season only.

‡ Calculated by subtracting ( $R_{1,23}^2 \times 100$ ) from 100.

The relationship between price and analysis was greater in Connecticut than in Pennsylvania. Probably a considerable part of the variation in the retail price in Pennsylvania is due to geographic differences in price. Connecticut is smaller and the geographic differences are less.

The nitrogen content of the bone manures was much more closely related to the retail price than was the phosphoric-acid content. For the thirty years 1899 to 1928, approximately 14 per cent of the variations in the retail price were associated with variations in the nitrogen content as compared with only 5 per cent for the phosphoric-acid content. The relative importance of each factor in the analysis in affecting the retail price varied greatly from year to year. In 1917 the coefficient of determination for the nitrogen was 48.45, as compared with 8.22 for the phosphoric acid. In 1924, however, only 5.49 per cent of the variation in the retail price was associated with variations in the nitrogen content, as compared with 12.71 per cent for the phosphoric acid.

For the period as a whole, there was no consistent tendency for either the nitrogen or the phosphoric acid to increase in importance in affecting the retail price.

The changes in the retail price of bone manures in Pennsylvania per unit change in nitrogen and phosphoric-acid content are shown in table 62 and figure 27. In 1926 a variation of 1 per cent in the nitrogen content

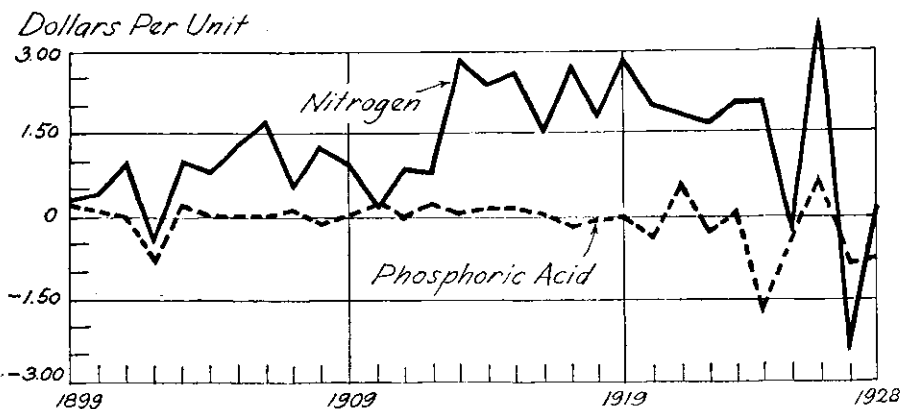


FIGURE 27. INCREASE IN THE RETAIL PRICE PER TON OF BONE MANURES IN PENNSYLVANIA, PER UNIT INCREASE IN ANALYSIS, 1899 TO 1928

(Net regression coefficients)

A unit variation in the nitrogen content caused a much greater change in the price than did a corresponding change in the phosphoric-acid content

was associated with a change of \$3.17 in the retail price. In 1928, however, the price changed only 13 cents for each unit change in the nitrogen content.

In the three years 1902, 1925, and 1927 the retail prices of the samples containing the larger amounts of nitrogen tended to be less than those of the samples with the smaller amounts of nitrogen. While this was an unusual relationship, somewhat similar results were obtained in a few years in Connecticut. These unusual results are probably due to variations in prices and analysis during the period in which the data were col-

TABLE 62. CHANGE IN THE PENNSYLVANIA RETAIL PRICE OF BONE MANURES PER TON, PER UNIT INCREASE IN THE ANALYSIS, 1899 TO 1928

Year	Change in the retail price of bone manures per ton ( $x_1$ ) per unit increase in		Year	Change in the retail price of bone manures per ton ( $x_1$ ) per unit increase in	
	guaranteed nitrogen content ( $x_2$ ) eliminating the effect of variations in the guaranteed phosphoric-acid content ( $x_3$ ) $b_{12:2}$	guaranteed phosphoric-acid content ( $x_3$ ) eliminating the effect of variations in the guaranteed nitrogen content ( $x_2$ ) $b_{13:2}$		guaranteed nitrogen content ( $x_2$ ) eliminating the effect of variations in the guaranteed phosphoric-acid content ( $x_3$ ) $b_{12:2}$	guaranteed phosphoric-acid content ( $x_3$ ) eliminating the effect of variations in the guaranteed nitrogen content ( $x_2$ ) $b_{13:2}$
1899-1903	\$0.43	-\$0.05	1912*	\$0.77	\$0.22
1910-1914	1.40	0.11	1913	2.80	0.03
1924-1928	0.52	-0.85	1914	2.45	0.10
			1915	2.62	0.09
1899	0.27	0.16	1916	1.54	0.03
1900	0.45	0.14	1917	2.68	-0.20
1901	0.99	0.02	1918	1.82	-0.13
1902	-0.50	-0.79	1919	2.78	0.00
1903	0.96	0.23	1920	1.97	-0.38
1904	0.75	0.05	1921	1.91	0.53
1905	1.34	0.03	1922	1.72	-0.33
1906	1.73	0.05	1923	2.01	0.04
1907	0.49	0.11	1924	2.03	-1.68
1908	1.22	-0.09	1925	-0.34	-0.38
1909	0.89	0.03	1926	3.17	0.61
1910	0.11	0.20	1927	-2.39	-0.87
1911	0.85	-0.02	1928	0.13	-0.83

\*For the spring season only.

lected. The Pennsylvania prices for each year are averages for samples collected during the spring and fall fertilizer seasons. If the prices during the season or during the year tended to decline, and with this decline fertilizers of somewhat higher analysis were purchased, or if the prices rose and fertilizers of somewhat lower analysis were purchased, the relationship between all the prices and analyses would indicate that the lower-analysis goods sold for higher prices—a relationship which probably did not exist at any particular time during the year. Price changes during the year might also greatly magnify the actual relationship between price and analysis which existed at any particular time. In years when there were only minor changes in price during the season, however, the data probably do indicate the relationship between price and analysis.

For the thirty-year period 1899 to 1928, there was, on the average, an increase of \$1.24 in the retail price per ton per unit increase in nitrogen content. A unit increase in phosphoric-acid content caused only small changes in the retail price, the average for the thirty-year period being 10 cents. Nitrogen is much more expensive than phosphoric acid, and not all the phosphoric acid in bones is readily soluble. Thus the variations in phosphoric-acid content had relatively little effect on the retail price.

#### MIXED FERTILIZERS

The fertilizer materials discussed in the preceding sections are valuable for fertilizer principally because of one plant food which each contains. Mixed fertilizers, which are for the most part mechanical mixtures of materials that contain plant food, make up the bulk of the fertilizer tonnage in the United States. These mixtures are made in a wide variety, as regards both the proportions and the amounts of plant food which they contain.

In studying the prices of mixed fertilizers, it is important to study not only the changes that have occurred in the prices over a period of years, but also the variation in prices from grade to grade, in order to determine the effect of the analysis upon the price. The following pages present a study of the relationship between the retail price and the analysis of mixed fertilizers.

## PHOSPHATE AND POTASH FERTILIZERS

*In Pennsylvania*

Phosphate and potash fertilizers are mixed fertilizers containing only phosphoric acid and potash. They are manufactured by mixing together various amounts of potash salts and superphosphate. Retail prices of phosphate and potash fertilizers were given in the Pennsylvania fertilizer reports. In order to determine the relationship between price and analysis, correlations were made between the retail price and the guaranteed analysis. In 1928 the correlation between the guaranteed analysis of the various samples and the retail price was 0.914 (table 63). The vari-

TABLE 63. MULTIPLE CORRELATIONS BETWEEN RETAIL PRICE AND ANALYSIS OF PHOSPHATE AND POTASH FERTILIZERS, AND COEFFICIENTS OF DETERMINATION OF THE RETAIL PRICE BY THE ANALYSIS, PENNSYLVANIA, 1899 TO 1928

Year	Multiple correlation between retail price and guaranteed phosphoric-acid and potash content R <sub>1.23</sub>	Coefficients of determination of retail price by the analysis*			
		Total analysis R <sub>1.23</sub> × 100	Phosphoric acid guaranteed d <sub>12.1</sub>	Potash guaranteed d <sub>12.2</sub>	Factors other than the analysis d <sub>12.3</sub> §
1899-1903.....	0.563	33.84	12.33	21.52	66.16
1910-1914†.....	0.926	85.85	15.71	70.14	14.15
1924-1928.....	0.902	81.54	5.76	75.79	18.46
1899.....	0.483	23.33	5.20	18.12	76.67
1900.....	0.317	10.05	5.23	4.82	89.95
1901.....	0.694	48.11	32.79	15.32	51.89
1902.....	0.700	48.94	15.27	33.67	51.06
1903.....	0.623	38.79	3.14	35.65	61.21
1904.....	0.733	53.71	13.80	39.90	46.29
1905.....	0.879	77.20	28.72	48.47	22.80
1906.....	0.837	69.99	14.36	55.63	30.01
1907.....	0.808	65.34	5.49	59.84	34.66
1908.....	0.911	83.08	25.40	57.67	16.92
1909.....	0.836	69.85	20.77	49.08	30.15
1910.....	0.923	85.12	24.78	60.34	14.88
1911.....	0.918	84.32	16.43	67.89	15.68
1912‡.....	0.936	87.65	16.23	71.42	12.35
1913.....	0.956	91.43	15.25	76.18	8.57
1914.....	0.908	82.53	6.39	76.14	17.47
1915.....	0.964	92.84	67.74	25.10	7.16
1916.....	.....	.....	.....	.....	.....
1917.....	.....	.....	.....	.....	.....
1918.....	0.934	87.17	16.37	70.79	12.83
1919.....	0.678	45.93	3.17	42.76	54.07
1920.....	0.973	94.69	3.98	90.72	5.31
1921.....	0.840	70.51	16.17	54.34	29.49
1922.....	0.822	67.64	12.91	54.73	32.36
1923.....	0.673	45.24	10.12	35.12	54.76
1924.....	0.847	71.75	14.45	57.30	28.25
1925.....	0.857	73.38	18.70	54.68	26.62
1926.....	0.904	81.68	- 3.79	85.47	18.32
1927.....	0.986	97.30	- 1.09	98.39	2.70
1928.....	0.914	83.61	0.51	83.10	16.39

\*  $x_1$  = retail price per ton;  $x_2$  = guaranteed phosphoric-acid content;  $x_3$  = guaranteed potash content.

† 1910 to 1914 except 1912.

‡ For the spring season only.

§ Calculated by subtracting ( $R^2_{1.23} \times 100$ ) from 100.



ations in the analysis accounted for 83.61 per cent of the variations in the retail price. Only 16.39 per cent of the variations in the retail price were associated with factors other than the analysis. The relative importance of the analysis and other factors in affecting the retail price varied from year to year. In 1927 the analysis accounted for 97.30 per cent of the factors affecting the variability of the retail price, as compared with only 45.24 per cent in 1923. During the five-year period 1921 to 1925, the degree of relationship between the price and the analysis of the phosphate and potash fertilizers was relatively low. The coefficient of determination averaged 66, as compared with 88 for the three years 1926 to 1928 (table 63 and figure 28).

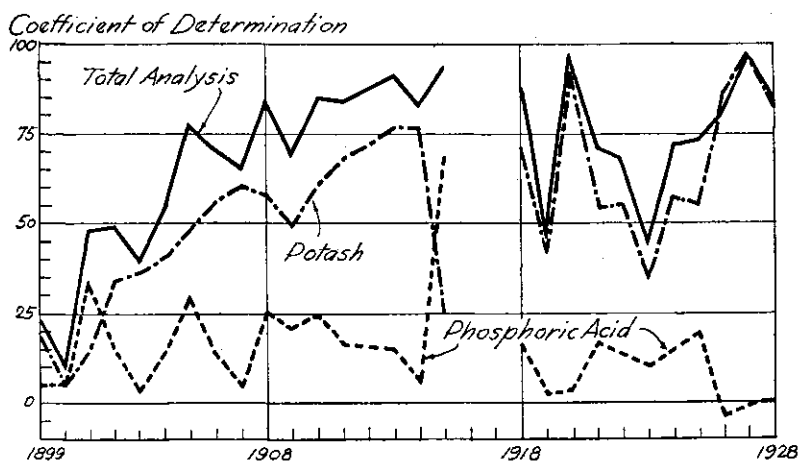


FIGURE 28. COEFFICIENTS OF DETERMINATION OF THE RETAIL PRICE OF PHOSPHATE AND POTASH FERTILIZERS IN PENNSYLVANIA BY THE PHOSPHORIC-ACID AND THE POTASH CONTENT, 1899 TO 1928

The potash content of the phosphate and potash fertilizers is the important factor affecting the retail price.

During the seventeen-year period 1899 to 1915, the general tendency was for the differences in the retail price for the various grades to be more and more closely associated with the analysis. For the two years 1899 and 1900 the variations in the analysis accounted for only 17 per cent of the variability in the retail price, as compared with 88 per cent for the two years 1914 and 1915. The tendency for the highest grades to sell for the highest prices became more and more apparent during this period, and factors other than the analysis became less and less important in affecting the retail price.

In only two of the twenty-eight years was the phosphoric-acid content of these phosphate and potash fertilizers more closely related to the price than the potash content. The increase in the correlations between price and analysis during the period from 1899 to 1914 was due almost entirely to higher correlations between the potash content and the price. For the two years 1899 and 1900 the potash accounted for only 11 per cent of the variations in the price, as compared with 76 per cent for the two years 1913 and 1914.

In the post-war period, the changes in the correlations between price and analysis have been due primarily to changes in the relationship between the potash content and the price.

With the exception of 1915, the variations in the phosphoric-acid content of the phosphate and potash fertilizers had relatively little effect on the retail price. For the seven years 1922 to 1928, the phosphoric acid accounted for about 9 per cent of the variations in the retail price as compared with about 67 per cent for potash. In 1915, however, the coefficient of determination for the phosphoric acid was 67.74, which was more than four times as great as for the five years 1910 to 1914. In 1915 potash was scarce and fertilizers were uniformly low in potash content. In that year variations in the phosphoric-acid content had an important effect on the variations in the retail price.

For the twenty-eight years 1899 to 1915 and 1918 to 1928, the coefficient of variability of the potash content of the phosphate and potash fertilizers averaged about 44, or more than three times the variability of the phosphoric-acid content (table 64 and figure 29). Superphosphate is

TABLE 64. STANDARD DEVIATIONS AND COEFFICIENTS OF VARIABILITY OF RETAIL PRICE AND ANALYSIS OF PHOSPHATE AND POTASH FERTILIZERS IN PENNSYLVANIA, 1899 TO 1928

Year	Standard deviations			Coefficients of variability		
	Retail price per ton	Per cent of phosphoric acid guaranteed	Per cent of potash guaranteed	Retail price per ton	Phosphoric acid guaranteed	Potash guaranteed
1899-1903.....	\$1.56	1.03	1.21	9.28	10.30	51.76
1910-1914*.....	1.90	1.58	2.10	11.50	16.60	52.76
1924-1928.....	1.66	1.19	1.76	6.32	10.73	31.51
1899.....	1.71	0.94	0.89	10.08	9.26	42.40
1900.....	2.38	1.08	1.66	13.60	10.65	69.45
1901.....	0.84	0.96	1.12	5.23	9.61	49.69
1902.....	1.45	0.98	1.13	8.94	9.84	47.95
1903.....	1.42	1.19	1.27	8.57	12.13	49.30
1904.....	1.73	1.15	1.50	10.71	11.71	51.61
1905.....	1.37	1.23	1.55	8.55	12.36	50.65
1906.....	1.62	1.48	1.60	10.19	15.08	49.43
1907.....	1.50	1.42	1.61	9.26	14.59	50.20
1908.....	1.62	1.43	1.65	9.82	14.77	50.54
1909.....	1.85	1.60	1.80	11.18	16.85	50.46
1910.....	1.89	1.60	1.89	11.21	16.82	50.35
1911.....	1.86	1.58	1.97	11.12	16.57	50.83
1912†.....	1.73	1.47	2.13	10.20	15.73	50.32
1913.....	1.89	1.57	2.24	11.46	16.65	51.61
1914.....	1.97	1.58	2.29	12.23	16.37	58.26
1915.....	1.27	1.61	0.35	7.60	15.07	18.49
1916.....						
1917.....						
1918.....	1.93	1.27	0.48	5.85	12.35	30.14
1919.....	2.16	0.96	1.23	6.30	9.62	48.51
1920.....	3.16	1.36	1.07	8.22	13.55	38.45
1921.....	2.08	1.20	1.32	6.56	11.99	41.65
1922.....	1.83	1.34	1.66	7.51	13.27	42.25
1923.....	2.16	1.44	1.75	8.54	13.93	38.00
1924.....	1.56	1.42	1.54	6.34	13.29	30.27
1925.....	1.97	1.46	1.54	7.09	13.52	28.19
1926.....	1.73	1.05	2.03	6.27	9.31	34.55
1927.....	1.80	1.02	1.94	7.21	9.02	33.61
1928.....	1.25	0.98	1.75	4.71	8.51	30.94

\* 1910 to 1914 except 1912.

† For the spring season only.

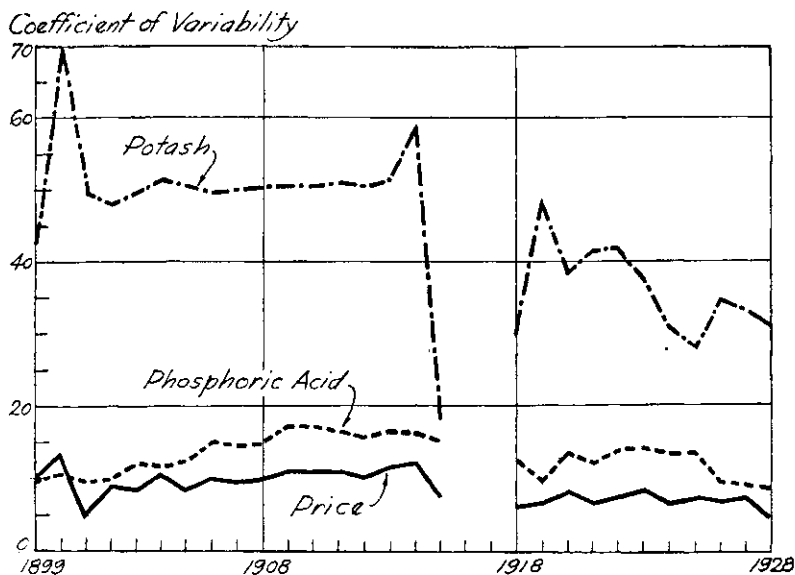


FIGURE 29. COEFFICIENTS OF VARIABILITY OF THE RETAIL PRICE AND THE ANALYSIS OF PHOSPHATE AND POTASH FERTILIZERS IN PENNSYLVANIA, 1899 TO 1928

The retail price was relatively constant, while the potash content was highly variable

used as a basis of many mixed fertilizers, and there was relatively little variation in the amount of phosphoric acid in the various grades.

During the thirty-year period 1899 to 1928, the wholesale price of potash per unit was greater than the wholesale price of phosphoric acid. The higher wholesale price of potash and the much greater variation in the percentage of potash in the fertilizers are the factors that account for the importance of potash in affecting the retail price.

For the five years 1924 to 1928 the coefficient of variability of the potash content averaged 31.51, as compared with 52.76 for the four years 1910 to 1914 except 1912 (table 64). There was also a decline in the variability of the phosphoric-acid content. Many of the analyses, and especially those containing relatively small amounts of plant food, have been eliminated. For the two years 1927 and 1928 there were fewer than ten different analyses of phosphate and potash fertilizers, or only about one-third as many as during the period from 1910 to 1914. The plant-food content for the two years 1927 and 1928 averaged more than 17 units per ton, or 27 per cent higher than for the four years 1910 to 1914 except 1912.

During the twenty-eight years for which the data are available, the coefficient of variability of the retail price of phosphate and potash fertilizers in Pennsylvania averaged 8.73. This was about two-thirds as great as the variability of the phosphoric-acid content, and about one-fifth as great as the variability of the potash content. The prices tended to be more nearly alike than the analyses. Manufacturing costs and

transportation and handling charges are a relatively large part of the retail price. These items do not tend to vary with the analysis. Thus the retail price is relatively constant.

In 1927 each unit change in the phosphoric-acid content of the phosphate and potash fertilizers was associated with a change of 79 cents in the retail price (table 65 and figure 30). In the same year the wholesale

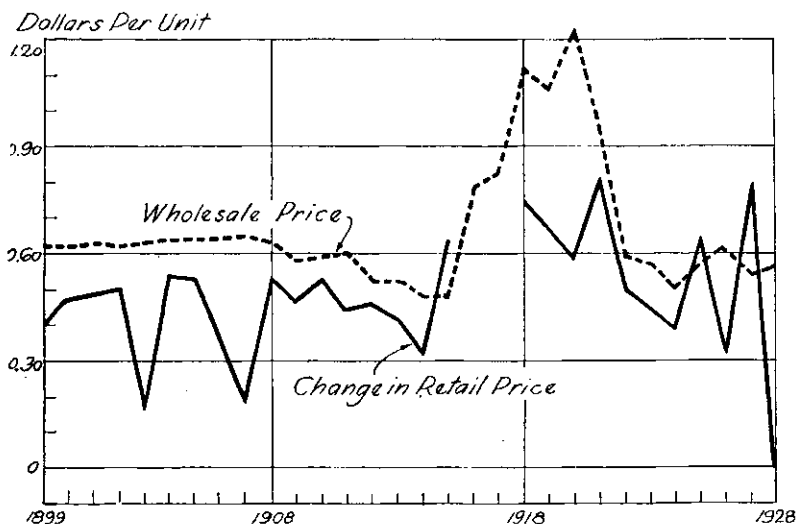


FIGURE 30. WHOLESALE PRICE OF PHOSPHORIC ACID PER UNIT IN SUPERPHOSPHATE AT BALTIMORE, AND CHANGE IN THE RETAIL PRICE PER TON OF PHOSPHATE AND POTASH FERTILIZERS IN PENNSYLVANIA PER UNIT CHANGE IN PHOSPHORIC-ACID CONTENT, 1899 TO 1928

(Change in retail price = net regression coefficient)

The change in the retail price of phosphate and potash fertilizers per unit change in phosphoric-acid content has tended to be less than the wholesale price

price of phosphoric acid at Baltimore was 54 cents per unit. The change in the retail price of the fertilizer per unit change in the phosphoric-acid content was greater than the wholesale price. In 1926 the change in the retail price per unit change in the phosphoric-acid content was 33 cents and the wholesale price was 61 cents. For the seven years 1922 to 1928 the average change in the retail price per unit change in phosphoric-acid content was 44 cents, which was 12 cents less than the average wholesale price for the same period. In 1928 the disparity between the wholesale price and the change in the retail price per unit change in phosphoric-acid content was 57 cents. This was unusually large as compared with the other years. For the six years 1922 to 1927, the wholesale price averaged 56 cents while the change in the retail price per unit change in phosphoric-acid content averaged 51 cents. In only three years during the entire period from 1899 to 1928 was the change in the retail price of phosphate and potash fertilizers per unit change in phosphoric-acid content greater than the wholesale price of phosphoric acid.

TABLE 65. CHANGE IN THE PENNSYLVANIA RETAIL PRICE OF PHOSPHATE AND POTASH FERTILIZERS PER UNIT INCREASE IN PHOSPHORIC-ACID CONTENT, AND WHOLESALE PRICE OF PHOSPHORIC ACID, 1899 TO 1928

Year	Change in retail price per ton of phosphate and potash fertilizers (x <sub>1</sub> ) in Pennsylvania per unit increase in guaranteed phosphoric-acid content (x <sub>2</sub> ) eliminating the effect of variations in the guaranteed potash content (x <sub>3</sub> ) b12.3	Wholesale price of phosphoric acid per unit at Baltimore	Difference between change in retail price, and wholesale price	Index numbers (1910-1914* = 100)	
				Change in retail price per ton per unit increase in phosphoric-acid content b12.3	Wholesale price of phosphoric-acid
1899-1903.....	\$0.40	\$0.62	-\$0.22	93	113
1910-1914*.....	0.43	0.55	-0.12	100	100
1924-1928.....	0.43	0.56	-0.13	100	102
1899.....	0.40	0.62	-0.22	93	113
1900.....	0.47	0.62	-0.15	109	113
1901.....	0.48	0.63	-0.15	112	115
1902.....	0.50	0.62	-0.12	116	113
1903.....	0.16	0.63	-0.47	37	115
1904.....	0.54	0.64	-0.10	126	116
1905.....	0.53	0.64	-0.11	123	116
1906.....	0.36	0.64	-0.28	84	116
1907.....	0.19	0.65	-0.46	44	118
1908.....	0.53	0.63	-0.10	123	115
1909.....	0.47	0.58	-0.11	109	105
1910.....	0.53	0.59	-0.06	123	107
1911.....	0.44	0.60	-0.16	102	109
1912.....	0.46†	0.52	-0.06	107	95
1913.....	0.42	0.52	-0.10	98	95
1914.....	0.33	0.48	-0.15	77	87
1915.....	0.63	0.48	+0.15	147	87
1916.....	-----	0.78	-----	-----	142
1917.....	-----	0.82	-----	-----	149
1918.....	0.75	1.11	-0.36	174	202
1919.....	0.66	1.06	-0.40	153	193
1920.....	0.59	1.22	-0.63	137	222
1921.....	0.80	0.95	-0.15	186	173
1922.....	0.50	0.59	-0.09	116	107
1923.....	0.44	0.57	-0.13	102	104
1924.....	0.39	0.50	-0.11	91	91
1925.....	0.64	0.57	+0.07	149	104
1926.....	0.33	0.61	-0.28	77	111
1927.....	0.79	0.54	+0.25	184	98
1928.....	-0.01	0.56	-0.57	- 2	102

\* 1910 to 1914 except 1912.

† For the spring season only.

The difference in price between a low and a high phosphoric-acid analysis was less than the cost of the additional phosphoric acid at wholesale prices. This indicates that there was a wider gross margin on the grades containing relatively small amounts of phosphoric acid. It is not possible to state who gets the wider margin. The manufacturers' prices to dealers probably vary with the analysis. Since retail prices are relatively more stable than wholesale prices, it may be that the retailer gets the wider margin on the lower grades and the narrower margin on the higher grades.

In 1928 the change in the retail price of the phosphate and potash fertilizers per unit change in potash content was 65 cents (table 66 and figure 31). The wholesale price of potash in muriate was 72 cents. The change in the retail price per unit change in potash content was 7 cents less than the wholesale price.

For the sixteen years 1899 to 1914, the wholesale price of potash in bagged muriate averaged 77 cents per unit; the average change in the retail price of these mixed fertilizers per unit change in potash content for the same years was 66 cents. In the two years 1900 and 1901 the disparity

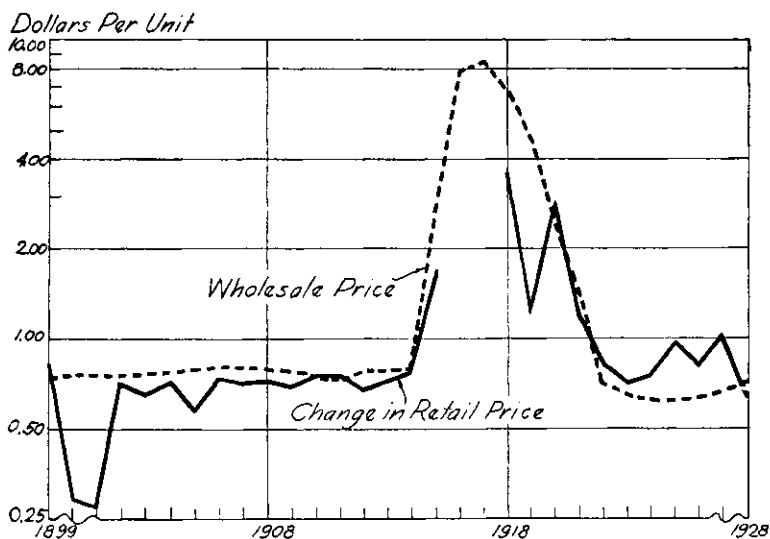


FIGURE 31. WHOLESALE PRICE OF POTASH PER UNIT IN BAGGED MURIATE, AND CHANGE IN THE RETAIL PRICE PER TON OF PHOSPHATE AND POTASH FERTILIZERS IN PENNSYLVANIA PER UNIT CHANGE IN POTASH CONTENT, 1899 TO 1928

(Change in retail price = net regression coefficient)

The change in the retail price of phosphate and potash fertilizers per unit change in potash content tended to be less than the wholesale price during the pre-war period, but more than the wholesale price during the post-war period

between the wholesale price and the change in the retail price per unit change in potash content was relatively great. If these two years are omitted, the average is 77 cents for the wholesale price and 71 cents for the change in the retail price. The change in the retail price per unit change in potash content was much the same as the wholesale price of potash in bagged muriate.

During the eleven years 1904 to 1914 the wholesale price of potash in 20-per-cent manure salts in bulk was 66 cents per unit, or 12 cents less than the price per unit in bagged muriate. The average change in the retail price of phosphate and potash fertilizers per unit change in potash content for this period was 71 cents. This was less than the wholesale price of potash in bagged muriate, but more than the wholesale price in bulk 20-per-cent manure salts. Either the manure salts or the muriate could be used as sources of potash; it is probable that both were used.

This indicates that the change in the retail price of phosphate and potash fertilizers per unit change in potash content tended to equal the wholesale price of potash. The difference between the retail price of a 10-per-cent potash fertilizer and that of a 5-per-cent potash fertilizer tended to equal the cost at wholesale prices of the 5 units of potash.

For the seven years 1922 to 1928, the change in the retail price of the phosphate and potash fertilizers per unit change in potash content averaged 82 cents, while the wholesale price of potash in bagged muriate averaged 67 cents per unit. During this period the change in the retail price per

TABLE 66. CHANGE IN THE PENNSYLVANIA RETAIL PRICE OF PHOSPHATE AND POTASH FERTILIZERS PER UNIT INCREASE IN POTASH CONTENT, AND WHOLESALE PRICE OF POTASH IN BAGGED MURIATE, 1899 TO 1928

Year	Change in retail price per ton of phosphate and potash fertilizers ( $x_1$ ) in Pennsylvania per unit increase in guaranteed potash content ( $x_2$ ) eliminating the effect of variations in the guaranteed phosphoric-acid content ( $x_3$ ) bis.2	Wholesale price of potash per unit in bagged muriate at ports	Difference between change in retail price, and wholesale price	Index numbers (1910-1914* = 100)	
				Change in retail price per ton per unit increase in potash content bis.2	Wholesale price of potash
1899-1903.....	\$0.54	\$0.75	-\$0.21	72	99
1910-1914*.....	0.75	0.76	-0.02	100	100
1924-1928.....	0.84	0.66	0.18	112	87
1899.....	0.80	0.74	0.06	107	97
1900.....	0.29	0.75	-0.46	39	99
1901.....	0.27	0.75	-0.48	36	99
1902.....	0.70	0.75	-0.05	93	99
1903.....	0.66	0.76	-0.10	88	100
1904.....	0.72	0.77	-0.05	96	101
1905.....	0.58	0.79	-0.21	77	104
1906.....	0.73	0.80	-0.07	97	105
1907.....	0.71	0.80	-0.09	95	105
1908.....	0.72	0.79	-0.07	96	104
1909.....	0.69	0.78	-0.09	92	103
1910.....	0.75	0.74	0.01	100	97
1911.....	0.76	0.74	0.02	101	97
1912.....	0.68†	0.78	-0.10	91	103
1913.....	0.72	0.79	-0.07	96	104
1914.....	0.76	0.79	-0.03	101	104
1915.....	1.69	2.88	-1.19	225	379
1916.....	.....	7.78	.....	.....	1,024
1917.....	.....	8.49	.....	.....	1,117
1918.....	3.59	6.72	-3.13	479	884
1919.....	1.22	4.67	-3.45	163	614
1920.....	2.85	2.49	0.36	380	328
1921.....	1.21	1.42	-0.21	161	187
1922.....	0.82	0.71	0.11	109	93
1923.....	0.71	0.65	0.06	95	86
1924.....	0.75	0.63	0.12	100	83
1925.....	0.98	0.63	0.35	131	83
1926.....	0.82	0.64	0.18	109	84
1927.....	1.01	0.67	0.34	135	88
1928.....	0.65	0.72	-0.07	87	95

\* 1910 to 1914 except 1912.

† For the spring season only.

unit change in potash content was greater than the wholesale price of potash. This was the situation in six of the seven years.

This relationship is somewhat different from that which existed prior to the war. During the post-war period the margin has tended to be greater on high-potash brands than on low-potash brands. In the pre-war period the margin tended to be the same on both high- and low-potash brands. It seems probable that competition between dealers and manufacturers will tend to reduce the difference between the wholesale price of potash and the change in the retail price per unit change in potash content, until it more nearly equals the wholesale price of potash. In 1928 the difference was negative, and was smaller than for any other year since 1924.

During the period from 1899 to 1914 the retail price of phosphate and potash fertilizers remained relatively constant. The highest price, in 1900, was about 10 per cent higher than the lowest price, in 1906 (table 67). Constant retail prices of fertilizer and the rising prices for agricultural products stimulated fertilizer consumption.

TABLE 67. AVERAGE RETAIL PRICE AND AVERAGE ANALYSIS OF PHOSPHATE AND POTASH FERTILIZERS IN PENNSYLVANIA, 1899 TO 1928

Year	Retail price per ton in Pennsylvania	Per cent of phosphoric acid guaranteed	Per cent of potash guaranteed	Total units of plant food per ton	Retail price per unit	Number of samples	Number of analyses
1899-1903.....	\$16.66	9.99	2.34	12.32	\$1.35	153	21
1910-1914*	16.54	9.54	3.97	13.51	1.23	410	29
1924-1928.....	26.28	11.10	5.57	16.67	1.58	157	11
1899.....	16.94	10.11	2.11	12.22	1.39	82	22
1900.....	17.48	10.11	2.39	12.50	1.40	110	20
1901.....	16.15	9.95	2.26	12.21	1.32	155	18
1902.....	16.18	9.96	2.35	12.31	1.31	192	22
1903.....	16.56	9.80	2.57	12.37	1.34	226	25
1904.....	16.18	9.81	2.90	12.71	1.27	220	26
1905.....	16.01	9.98	3.06	13.04	1.23	229	26
1906.....	15.90	9.84	3.24	13.08	1.22	236	25
1907.....	16.18	9.76	3.21	12.97	1.25	188	28
1908.....	16.55	9.67	3.27	12.94	1.28	220	31
1909.....	16.53	9.48	3.57	13.05	1.27	323	31
1910.....	16.81	9.52	3.75	13.27	1.27	384	30
1911.....	16.72	9.54	3.87	13.41	1.25	433	31
1912†	17.00	9.37	4.22	13.59	1.25	232	26
1913.....	16.49	9.45	4.34	13.79	1.20	456	28
1914.....	16.13	9.64	3.93	13.57	1.19	368	28
1915.....	16.75	10.69	1.87	12.56	1.33	193	16
1916.....							
1917.....							
1918.....	32.96	10.26	1.58	11.84	2.78	34	6
1919.....	34.21	9.93	2.53	12.46	2.74	132	12
1920.....	38.41	10.05	2.79	12.84	2.99	155	12
1921.....	31.76	10.00	3.18	13.18	2.41	178	14
1922.....	24.37	10.08	3.92	14.00	1.74	183	15
1923.....	25.26	10.36	4.60	14.96	1.69	107	14
1924.....	24.60	10.71	5.08	15.79	1.56	144	13
1925.....	27.80	10.81	5.45	16.26	1.71	171	14
1926.....	27.63	11.22	5.88	17.10	1.62	186	11
1927.....	24.91	11.28	5.78	17.06	1.46	144	8
1928.....	26.46	11.46	5.66	17.12	1.55	142	9

\* 1910 to 1914 except 1912.

† For the spring season only.

In the war period, when potash was extremely high-priced, the phosphate and potash fertilizers were discontinued. In 1918, however, they were again on the market. Retail prices in 1919 and 1920 were more than double the pre-war prices. For the five years 1924 to 1928 the retail price averaged \$26.28 per ton, or 59 per cent more than the pre-war average (tables 67 and 68).

These changes in the retail prices are not indicative of the actual changes in the average retail price of plant food per unit, because of the changes in the average analysis. During the fifteen years prior to the war there was a slight decline in the phosphoric-acid content of the phosphate and potash fertilizers, while the potash content practically doubled (tables 67 and 68, and figure 32). The potash content of all fertilizers was unusually low during the war period, when importations of potash were practically discontinued. In the period from 1918 to 1928, the percentage of potash recovered rapidly from the low point following the war. For the five years 1924 to 1928 the phosphate and potash fertilizers averaged 5.57 units of potash per ton, or 40 per cent more than for the years just prior to the war, while the phosphoric-acid content averaged 16 per cent higher than the pre-war figure and the total plant food averaged 23 per cent higher.

The retail price of plant food in phosphate and potash fertilizers in Pennsylvania averaged \$1.35 per unit for the five years 1899 to 1903



TABLE 68. INDEX NUMBERS OF AVERAGE RETAIL PRICE AND AVERAGE ANALYSIS OF PHOSPHATE AND POTASH FERTILIZERS IN PENNSYLVANIA, 1899 TO 1928 (1910-1914\* = 100)

Year	Retail price per ton	Phosphoric acid guaranteed	Potash guaranteed	Total units of plant food	Retail price per unit	Number of samples	Number of analyses
1899-1903...	101	105	59	91	110	37	72
1910-1914*...	100	100	100	100	100	100	100
1924-1928...	159	116	140	123	128	38	38
1899.....	102	106	53	90	113	20	76
1900.....	106	106	60	93	114	27	69
1901.....	98	104	57	90	107	38	62
1902.....	98	104	59	91	107	47	76
1903.....	100	103	65	92	109	55	86
1904.....	98	103	73	94	103	54	90
1905.....	97	105	77	97	100	56	90
1906.....	96	103	82	97	99	58	86
1907.....	98	102	81	96	102	46	97
1908.....	100	101	82	96	104	54	107
1909.....	100	99	90	97	103	79	107
1910.....	102	100	94	98	103	94	103
1911.....	101	100	97	99	102	106	107
1912†.....	103	98	106	101	102	57	90
1913.....	100	99	109	102	98	111	97
1914.....	98	101	99	100	97	90	97
1915.....	101	112	47	93	108	47	55
1916.....							
1917.....							
1918.....	199	108	40	88	226	8	21
1919.....	207	104	64	92	223	32	41
1920.....	232	105	70	95	243	38	41
1921.....	192	105	80	98	196	43	48
1922.....	147	106	99	104	141	45	52
1923.....	153	109	116	111	137	26	48
1924.....	149	112	128	117	127	35	45
1925.....	168	113	137	120	139	42	48
1926.....	167	118	148	127	132	45	38
1927.....	151	118	146	126	119	35	28
1928.....	160	120	143	127	126	35	31

\* 1910 to 1914 except 1912.

† For the spring season only.

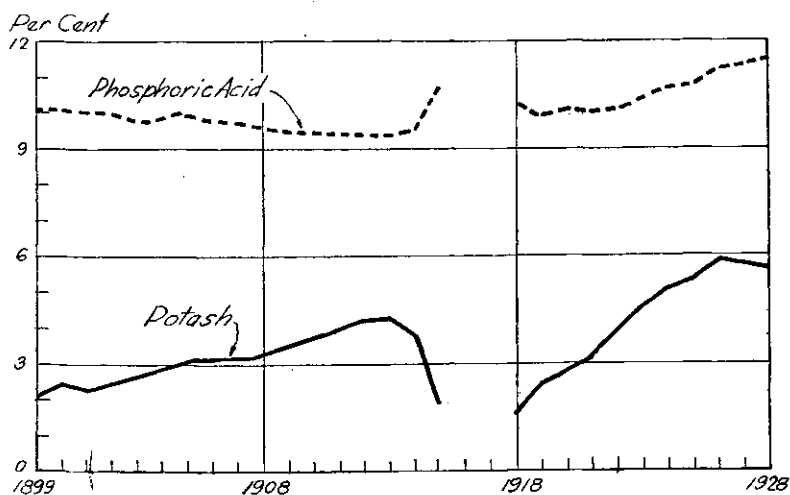


FIGURE 32. AVERAGE GUARANTEED ANALYSIS OF PHOSPHATE AND POTASH FERTILIZERS IN PENNSYLVANIA, 1899 TO 1928

Except for the war period, the potash content has tended to increase

(table 67). This was 10 per cent more than for the pre-war period 1910 to 1914. For the post-war period 1924 to 1928, however, the retail price of the plant food averaged \$1.58 per unit, or 28 per cent more than the pre-war average.

The potash made up 19 per cent of the total plant food for the five years 1899 to 1903, 29 per cent for the four years 1910 to 1914 (except 1912), and 33 per cent for the five years 1924 to 1928. Thus, even the average retail prices of plant food per unit for the different years are not exactly comparable, since the proportions of potash and phosphoric acid changed from year to year.

Superphosphate and muriate of potash are the important sources of phosphoric acid and potash in mixed fertilizers. The wholesale cost of the plant food in the average analysis of phosphate and potash fertilizers for each year was calculated from the wholesale prices of superphosphate and muriate of potash.

For the period 1910 to 1914 (except 1912) the cost of materials averaged \$8.26 (table 69); the retail price averaged \$16.54; the difference between the retail price and the cost of materials was \$8.28, or 50 per cent of the retail price. Much the same relationship between the cost of mate-

TABLE 69. RETAIL PRICE OF PHOSPHATE AND POTASH FERTILIZERS IN PENNSYLVANIA, ESTIMATED VALUE OF PLANT FOOD IN AVERAGE ANALYSIS AT WHOLESALE PRICES, AND COST OF MANUFACTURE AND DISTRIBUTION, 1899 TO 1928

Year	Retail price per ton in Pennsylvania	Value of phosphoric acid and potash at wholesale prices	Cost of manufacture and distribution	Index numbers (1910-1914* = 100)		
				Retail price per ton	Value of materials	Cost of manufacture and distribution
1899-1903.....	\$16.66	\$ 7.98	\$ 8.68	101	97	105
1910-1914*.....	16.54	8.26	8.28	100	100	100
1924-1928.....	26.28	9.84	16.44	159	119	199
1899.....	16.94	7.83	9.11	102	95	110
1900.....	17.48	8.06	9.42	106	98	114
1901.....	16.15	7.97	8.18	98	96	99
1902.....	16.18	7.94	8.24	98	96	100
1903.....	16.56	8.12	8.44	100	98	102
1904.....	16.18	8.51	7.67	98	103	93
1905.....	16.01	8.81	7.20	97	107	87
1906.....	15.90	8.89	7.01	96	108	85
1907.....	16.18	8.91	7.27	98	108	88
1908.....	16.55	8.67	7.88	100	105	95
1909.....	16.53	8.28	8.25	100	100	100
1910.....	16.81	8.40	8.41	102	102	102
1911.....	16.72	8.58	8.14	101	104	98
1912†.....	17.00	8.16	8.84	103	99	107
1913.....	16.49	8.34	8.15	100	101	98
1914.....	16.13	7.73	8.40	98	94	101
1915.....	16.75	10.52	6.23	101	127	75
1916.....	.....	.....	.....	.....	.....	.....
1917.....	.....	.....	.....	.....	.....	.....
1918.....	32.96	22.01	10.95	199	266	132
1919.....	34.21	22.35	11.86	207	271	143
1920.....	38.41	19.21	19.20	232	233	232
1921.....	31.76	14.02	17.74	192	170	214
1922.....	24.37	8.73	15.64	147	106	189
1923.....	25.26	8.90	16.36	153	108	198
1924.....	24.60	8.56	16.04	149	104	194
1925.....	27.80	9.59	18.21	168	116	220
1926.....	27.63	10.60	17.03	167	128	206
1927.....	24.91	9.96	14.95	151	121	181
1928.....	26.46	10.50	15.96	160	127	193

\* 1910 to 1914 except 1912.

† For the spring season only.

rials and the retail price existed during the entire sixteen years 1899 to 1914. For the five years 1924 to 1928, however, the cost of materials averaged \$9.84, or about 19 per cent more than the pre-war cost; the retail price averaged \$26.28, or 59 per cent greater than the pre-war price; the margin between the cost of materials and the retail price averaged \$16.44, or nearly twice as much as for the pre-war period. During the later period the margin between the cost of materials and the retail price was 63 per cent of the retail price, as compared with 50 per cent for the pre-war period.

The spread between the wholesale and retail prices of fertilizer materials during the post-war period was approximately twice as great as during the pre-war period. Much the same change has occurred in the difference between the cost of materials and the retail price of phosphate and potash fertilizers. During the post-war period the manufacturer of fertilizer materials received a smaller proportion of the money which the farmer spent for fertilizer than he received during the pre-war period.

#### COMPLETE FERTILIZERS

While some mixed fertilizers contain only two plant foods, the greater proportion contain three—nitrogen, phosphoric acid, and potash. In studying the relationship between the analysis and the retail price of complete fertilizers, three factors are to be considered, instead of only two as in the case of the phosphate and potash fertilizers.

#### *In Pennsylvania*

The relation between the plant-food content and the Pennsylvania retail price of complete fertilizers varied from year to year (table 70 and figure 33). In 1928 there was a smaller degree of relationship between price and

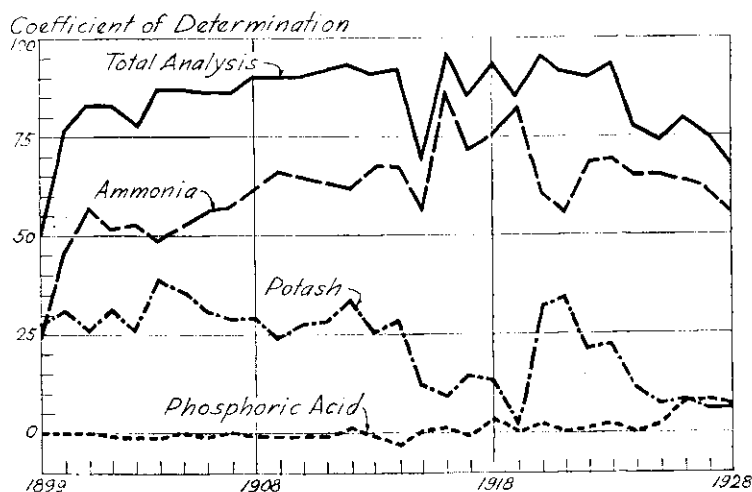


FIGURE 33. COEFFICIENTS OF DETERMINATION OF THE RETAIL PRICE OF COMPLETE FERTILIZERS IN PENNSYLVANIA BY THE AMMONIA, PHOSPHORIC ACID, AND POTASH CONTENT, 1899 TO 1928

The ammonia content of the fertilizer was the most important ingredient affecting the retail price

TABLE 70. MULTIPLE CORRELATIONS BETWEEN THE RETAIL PRICE AND THE ANALYSIS OF COMPLETE FERTILIZERS, AND COEFFICIENTS OF DETERMINATION OF THE RETAIL PRICE BY THE ANALYSIS, PENNSYLVANIA, 1899 TO 1928

Year	Multiple correlation between retail price and guaranteed ammonia, phosphoric acid, and potash content $R_{1-234}$	Coefficients of determination of retail price by the analysis*				
		Total analysis $R_{1-234}^2 \times 100$	Ammonia guaranteed $d_{12-24}$	Phosphoric acid guaranteed $d_{13-24}$	Potash guaranteed $d_{14-23}$	Factors other than the analysis $d_{12}^{\S}$
1899-1903.....	0.858	74.25	46.34	-0.27	28.18	25.75
1910-1914†.....	0.954	91.08	65.45	-1.47	27.10	8.92
1924-1928.....	0.863	74.54	62.37	4.73	7.44	25.46
1899.....	0.709	50.30	23.59	-0.15	26.86	49.70
1900.....	0.879	77.19	46.22	0.42	30.55	22.81
1901.....	0.914	83.48	57.16	0.00	26.33	16.52
1902.....	0.909	82.58	52.12	-0.78	31.23	17.42
1903.....	0.881	77.69	52.59	-0.86	25.95	22.31
1904.....	0.935	87.45	49.41	-0.53	38.57	12.55
1905.....	0.933	86.99	51.59	-0.48	35.88	13.01
1906.....	0.930	86.41	55.93	-0.98	31.46	13.59
1907.....	0.929	86.26	57.26	0.18	28.81	13.74
1908.....	0.949	90.02	61.95	-0.98	29.06	9.98
1909.....	0.946	89.52	65.89	-0.71	24.34	10.48
1910.....	0.950	90.18	64.25	-1.26	27.19	9.82
1911.....	0.953	90.82	63.10	-0.54	28.26	9.18
1912‡.....	0.966	93.29	62.14	1.41	32.56	6.71
1913.....	0.956	91.45	67.43	-1.40	25.42	8.55
1914.....	0.959	91.87	67.02	-2.69	27.54	8.13
1915.....	0.829	68.67	56.49	0.25	11.94	31.33
1916.....	0.978	95.62	85.68	1.27	8.66	4.38
1917.....	0.924	85.36	71.71	-0.70	14.36	14.64
1918.....	0.965	93.03	76.44	3.25	13.35	6.97
1919.....	0.920	84.67	82.85	-0.02	1.83	15.33
1920.....	0.976	95.19	61.22	1.93	32.05	4.81
1921.....	0.952	90.70	56.46	0.03	34.22	9.30
1922.....	0.948	89.96	68.07	0.82	21.07	10.04
1923.....	0.963	92.81	69.38	1.90	21.53	7.19
1924.....	0.875	76.65	65.48	0.39	10.78	23.35
1925.....	0.858	73.66	64.69	2.27	6.71	26.34
1926.....	0.888	78.86	64.26	6.57	8.03	21.14
1927.....	0.868	75.30	61.45	7.65	6.20	24.70
1928.....	0.826	68.24	55.95	6.79	5.50	31.76

\*  $x_1$  = retail price per ton;  $x_2$  = per cent of ammonia guaranteed;  $x_3$  = per cent of phosphoric acid guaranteed;  $x_4$  = per cent of potash guaranteed.

† 1910 to 1914 except 1912.

‡ For the spring season only.

§ Calculated by subtracting  $(R_{1-234}^2 \times 100)$  from 100.

analysis than for any other year since 1899. The multiple correlation between price and analysis in 1928 ( $R_{1-234} = 0.826$ ) indicates that the variations in the analysis accounted for 68.24 per cent of the factors affecting the variation in the prices of the different grades of complete fertilizers. All factors other than the analysis accounted for 31.76 per cent of the variability. In 1920 the analysis accounted for 95.19 per cent of the variability, as compared with only 68.24 per cent in 1928. The relationship between price and analysis declined, while factors other than the analysis increased in importance.<sup>6</sup>

During the pre-war period 1899 to 1914, the situation was reversed. Variations in the retail price tended to become more and more closely associated with variations in the analysis. In 1899 the analysis accounted for only 50.30 per cent of the variability in the retail price; this was the lowest for the thirty-year period 1899 to 1928. In 1900 the analysis

<sup>6</sup> The decline in the correlation may be due to the fact that the type of relationship has changed.

accounted for 77.19 per cent of the variations in the retail price. The degree of relationship increased, and for the seven years 1908 to 1914 the variations in the analysis accounted for 89 per cent or more of the variations in the retail price.

From 1915 to 1920, a period of inflation, the prices of fertilizer materials rose rapidly, and there was greater variability in the relationship between the analysis and the retail price than during the pre-war period.

For the five years 1924 to 1928 the coefficient of determination averaged 74.54, as compared with the pre-war average of 91.08. The decline in the relationship between price and analysis was probably due in part to the increased cost of distribution.

Variations in the retail price were more closely associated with variations in the ammonia content than with variations in either the phosphoric acid or the potash content. In twenty-seven of the thirty years from 1899 to 1928, variations in the ammonia content accounted for more than 50 per cent of the variations in the retail price. The ammonia content was more important than all other factors.

For the three years 1899 to 1901 the ammonia content accounted for about 42 per cent of the variability in the retail price, as compared with 65.45 per cent for the four years 1910 to 1914 except 1912. During the period from 1899 to 1914, there was an upward trend in the degree of relationship between the ammonia content and the price. The increase in the degree of relationship between the total analysis and the retail price was due primarily to the higher correlations between the ammonia content and the price.

For the four years 1916 to 1919, the coefficient of determination of the retail price by the ammonia content averaged about 79 as compared with the total determination of about 90 for all three plant foods combined. During this four-year period the ammonia content was more closely associated with the retail price than at any other time in the thirty-year period 1899 to 1928. The decline in the relationship between analysis and price during the period from 1922 to 1928 was due in part to the decline in the correlations between the ammonia content and the price. For the five years 1924 to 1928 the ammonia content accounted for 62.37 per cent of the variability of the retail price, which was only slightly less than the pre-war average of 65.45.

In the sixteen-year period 1899 to 1914, the variations in the potash content accounted for about 29 per cent of the variability of the retail price of complete fertilizers in Pennsylvania. During the period from 1904 to 1914 the importance of the potash in affecting the retail price tended to decline. In the five years 1915 to 1919, potash was high-priced, and complete fertilizers were uniformly low in potash content. For these years the coefficient of determination of the retail price by the potash content averaged only about 10, as compared with 27.10 for the four years 1910 to 1914 except 1912.

When importations of potash were resumed in 1920, potash recovered its pre-war importance in affecting the retail price of complete fertilizers. For the period from 1921 to 1928, however, the coefficient of determination for potash declined from 34.22 to 5.50. The decline in the relationship between total analysis and price during this period was due primarily to the decline in the relationship between the potash content and the price.

For the four years 1925 to 1928 the coefficient of determination for potash averaged about 7, or only one-fourth of the pre-war average of 27.10.

For the twenty-seven-year period 1899 to 1925 there was practically no relationship between the variations in the phosphoric-acid content of the fertilizers and the retail price. For the three years 1926 to 1928, however, about 7 per cent of the variability in the retail price was due to variations in the phosphoric-acid content. During this period the potash and the phosphoric-acid content of the fertilizers were of nearly equal importance in affecting the retail price.

In 1928 a change of 1 per cent in the ammonia content of complete fertilizers caused a change of \$4.28 in the Pennsylvania retail price (table 71). That is, of two fertilizers each containing the same amount of

TABLE 71. CHANGE IN THE PENNSYLVANIA RETAIL PRICE OF COMPLETE FERTILIZERS PER UNIT INCREASE IN AMMONIA CONTENT, AND WHOLESALE PRICE OF AMMONIA IN DRIED BLOOD, TANKAGE, NITRATE OF SODA, AND SULFATE OF AMMONIA, 1899 TO 1928

Year	Change in retail price per ton of complete fertilizers ( $x_1$ ) in Pennsylvania per unit increase in guaranteed ammonia content ( $x_2$ ) eliminating the effect of variations in the guaranteed phosphoric-acid ( $x_3$ ) and potash ( $x_4$ ) content b12.31	Wholesale price of ammonia per unit				Difference between change in retail price per unit increase in ammonia content, and wholesale price of ammonia*			
		In dried blood	In tankage	In nitrate of soda	In sulfate of ammonia	In dried blood	In tankage	In nitrate of soda	In sulfate of ammonia
1899-1903.	\$2.65	\$2.25	\$1.94	\$2.00	\$2.34	+\$0.40	+\$0.71	+\$0.64	+\$0.31
1910-1914†	3.53	3.04	2.78	2.36	2.37	+ 0.49	+ 0.74	+ 1.17	+ 1.16
1924-1928.	4.29	4.02	3.46	2.62	2.05	+ 0.27	+ 0.82	+ 1.66	+ 2.24
1899.....	1.78	1.84	1.59§	1.71	2.30	- 0.06	+ 0.19	+ 0.07	- 0.52
1900.....	2.82	2.18	1.88§	1.94	2.34	+ 0.64	+ 0.94	+ 0.88	+ 0.48
1901.....	3.04	2.32	2.00§	1.96	2.22	+ 0.72	+ 1.04	+ 1.08	+ 0.82
1902.....	2.68	2.32	2.00§	2.23	2.36	+ 0.36	+ 0.68	+ 0.45	+ 0.32
1903.....	2.91	2.57	2.22§	2.17	2.48	+ 0.34	+ 0.69	+ 0.74	+ 0.43
1904.....	2.74	2.54	2.19§	2.31	2.50	+ 0.20	+ 0.55	+ 0.43	+ 0.24
1905.....	2.86	2.61	2.24	2.46	2.50	+ 0.25	+ 0.62	+ 0.40	+ 0.36
1906.....	3.03	2.68	2.33	2.39	2.48	+ 0.35	+ 0.70	+ 0.64	+ 0.55
1907.....	3.28	2.75	2.57	2.67	2.48	+ 0.53	+ 0.71	+ 0.61	+ 0.80
1908.....	3.45	2.55	2.19	2.45	2.41	+ 0.90	+ 1.26	+ 1.00	+ 1.04
1909.....	3.65	2.71	2.33	2.27	2.30	+ 0.94	+ 1.32	+ 1.38	+ 1.35
1910.....	3.50	2.97	2.70	2.22	2.21	+ 0.53	+ 0.80	+ 1.28	+ 1.29
1911.....	3.48	3.21	2.80	2.25	2.45	+ 0.27	+ 0.68	+ 1.23	+ 1.03
1912.....	3.28‡	2.79	2.67	2.46	2.62	+ 0.49	+ 0.61	+ 0.82	+ 0.66
1913.....	3.69	2.78	2.70	2.65	2.56	+ 0.91	+ 0.99	+ 1.04	+ 1.15
1914.....	3.44	3.19	2.94	2.31	2.25	+ 0.25	+ 0.50	+ 1.13	+ 1.19
1915.....	3.28	2.84	2.69	2.27	2.45	+ 0.44	+ 0.59	+ 1.01	+ 0.83
1916.....	3.92	3.07	2.93	3.37	2.96	+ 0.85	+ 0.99	+ 0.55	+ 0.96
1917.....	3.45	4.90	4.65	3.88	3.61	- 1.45	- 1.20	- 0.43	- 0.16
1918.....	6.79	6.72	6.46	5.06	4.03	+ 0.07	+ 0.33	+ 1.73	+ 2.76
1919.....	8.00	6.19	5.78	4.12	3.28	+ 1.81	+ 2.22	+ 3.88	+ 4.12
1920.....	5.75	7.86	7.45	3.71	3.44	- 2.11	- 1.70	- 2.04	- 2.31
1921.....	4.75	3.77	3.05	2.81	2.30	+ 0.98	+ 1.70	+ 1.94	+ 2.45
1922.....	3.66	3.90	3.48	2.63	2.02	- 0.24	+ 0.18	+ 1.03	+ 1.64
1923.....	3.56	4.30	3.96	2.65	2.50	- 0.74	- 0.40	+ 0.91	+ 1.06
1924.....	4.18	3.38	3.04	2.64	2.13	+ 0.80	+ 1.14	+ 1.54	+ 2.05
1925.....	4.59	3.66	3.25	2.67	2.07	+ 0.93	+ 1.34	+ 1.92	+ 2.52
1926.....	4.48	3.94	3.54	2.72	2.13	+ 0.54	+ 0.94	+ 1.76	+ 2.35
1927.....	3.91	4.21	3.57	2.67	1.95	- 0.30	+ 0.34	+ 1.24	+ 1.96
1928.....	4.28	4.91	3.92	2.42	1.98	- 0.63	+ 0.36	+ 1.86	+ 2.30

\* The difference is equal to b12.31 minus the wholesale price.

† 1910 to 1914 except 1912.

‡ For the spring season only.

§ Estimated. For the four years 1905, 1906, 1908, and 1909, the price of ammonia in tankage averaged 86.2 per cent of the price of ammonia in dried blood. The prices of ammonia in tankage for the six years 1899 to 1904 are 86.2 per cent of the price of ammonia in dried blood.

phosphoric acid and of potash but differing by 1 per cent in ammonia content, the retail price of the one with the higher ammonia content tended to be \$4.28 per ton more than that of the other. A change of 1 per cent in the phosphoric-acid content caused a change of 72 cents in the retail price (table 73, page 91), while a corresponding change in the potash content caused a change of 63 cents in the retail price (table 74, page 93). A unit change in the ammonia content of the fertilizer caused a change in the retail price about six times as great as that caused by a unit change in the phosphoric-acid content, and nearly seven times as great as that caused by a corresponding change in the potash content. Ammonia is the most expensive plant food in complete fertilizers. This is one of the reasons why it is so important in affecting the retail price.

Many different materials are used as sources of ammonia in fertilizers. The price of ammonia per unit in these materials varies. In 1928 the wholesale price of ammonia in dried blood averaged \$4.91 per unit (table 71 and figure 34). The change in the retail price of the complete fer-

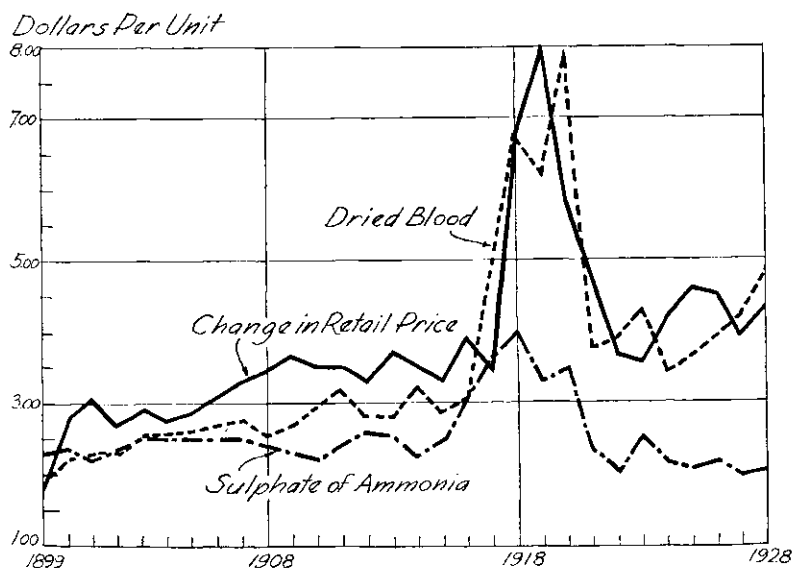


FIGURE 34. WHOLESALE PRICE OF AMMONIA PER UNIT IN DRIED BLOOD AND IN SULFATE OF AMMONIA, AND CHANGE IN THE RETAIL PRICE PER TON OF COMPLETE FERTILIZERS IN PENNSYLVANIA PER UNIT CHANGE IN AMMONIA CONTENT, 1899 TO 1928

(Change in retail price = net regression coefficient)

The change in the retail price of complete fertilizers per unit change in ammonia content has tended to be greater than the wholesale price of ammonia

tilizer per unit change in ammonia content was 63 cents less than the wholesale price of ammonia in dried blood. In 1928 the wholesale price of ammonia in tankage averaged \$3.92 per unit, of ammonia in nitrate of soda \$2.42, and of ammonia in sulfate of ammonia \$1.98. The change in the retail price of the complete fertilizer per unit change in

ammonia content was less than the wholesale price of ammonia in dried blood, but greater than the wholesale price of ammonia in tankage, nitrate of soda, or sulfate of ammonia.

For the sixteen years 1899 to 1914, the average change in the retail price of complete fertilizers per unit change in ammonia content was \$3.10. This was 18 per cent higher than the wholesale price of ammonia in blood, 29 per cent higher than the price of ammonia in sulfate of ammonia, and 36 per cent higher than the wholesale price of ammonia in nitrate of soda. The increase in the retail price of the complete fertilizers per unit increase in ammonia content was greater than the wholesale price of ammonia in various fertilizer materials. There was a wider margin on those analyses which contained a relatively high percentage of ammonia.

During this period there was an upward trend in the wholesale price

TABLE 72. INDEX NUMBERS OF THE CHANGE IN THE PENNSYLVANIA RETAIL PRICE OF COMPLETE FERTILIZERS PER UNIT INCREASE IN AMMONIA CONTENT, AND OF THE WHOLESALE PRICE OF AMMONIA IN DRIED BLOOD, TANKAGE, NITRATE OF SODA, AND SULFATE OF AMMONIA, 1899 TO 1928

(1910-1914\* = 100)

Year	Change in retail price per ton of complete fertilizers ( $x_1$ ) in Pennsylvania per unit increase in guaranteed ammonia content ( $x_2$ ) eliminating the effect of variations in the guaranteed phosphoric-acid ( $x_3$ ) and potash ( $x_4$ ) content <small>See p. 24</small>	Wholesale price of ammonia per unit			
		In dried blood	In tankage	In nitrate of soda	In sulfate of ammonia
1899-1903.....	75	74	70	85	99
1910-1914*.....	100	100	100	100	100
1924-1928.....	122	132	124	111	86
1899.....	50	61	57	72	97
1900.....	80	72	68	82	99
1901.....	86	76	72	83	94
1902.....	76	76	72	94	100
1903.....	82	85	80	92	105
1904.....	78	84	79	98	105
1905.....	81	86	81	104	105
1906.....	86	88	84	101	105
1907.....	93	90	92	113	105
1908.....	98	84	79	104	102
1909.....	103	89	84	96	97
1910.....	99	98	97	94	93
1911.....	99	106	101	95	103
1912.....	93†	92	96	104	111
1913.....	105	91	97	112	108
1914.....	97	105	106	98	95
1915.....	93	93	97	96	103
1916.....	111	101	105	143	125
1917.....	98	161	167	164	152
1918.....	192	221	232	214	170
1919.....	227	204	208	175	138
1920.....	163	259	268	157	145
1921.....	135	124	110	119	97
1922.....	104	128	125	111	85
1923.....	101	141	142	112	105
1924.....	118	111	109	112	90
1925.....	130	120	117	113	87
1926.....	127	130	127	115	90
1927.....	111	138	128	113	82
1928.....	121	162	141	103	84

\* 1910 to 1914 except 1912.

† For the spring season only.



of organic ammoniates and in the change in the retail price of the complete fertilizers per unit change in ammonia content. The wholesale price of ammonia in the mineral ammoniates remained relatively constant. The major part of the ammonia in the complete fertilizers was probably from organic materials.

For the post-war period 1922 to 1928, the average change in the retail price of complete fertilizers per unit change in ammonia content was \$4.09. This was 1 per cent higher than the price of ammonia in blood, 16 per cent higher than the price of ammonia in tankage, and 56 and 94 per cent higher, respectively, than the wholesale price of ammonia in nitrate of soda and in sulfate of ammonia. Since the change in the retail price of the complete fertilizers per unit change in ammonia content was greater than the wholesale price of ammonia in various ammonia carriers, there was apparently a wider margin on the analyses containing relatively high percentages of ammonia. This was much the same relationship as existed prior to the war. In the seven years 1922 to 1928, the spread between the change in the retail price of complete fertilizers per unit change in ammonia content, and the wholesale price of ammonia in mineral ammoniates, was 50 per cent greater than the pre-war average, while for organic ammoniates the spread was only about one-half as great. During this post-war period the mineral-ammoniate content of fertilizers increased while the organic-ammoniate content decreased. Practically no dried blood is used in fertilizers at the present time. With the present relatively low prices of mineral ammoniates, it seems probable that the change in the retail price of complete fertilizers per unit change in ammonia content will tend to decrease. There has been some tendency in this direction since 1925.

In 1928 the change in the retail price of complete fertilizers in Pennsylvania per unit change in phosphoric-acid content was 72 cents; in other words, each unit increase in the phosphoric-acid content tended to increase the retail price by 72 cents (table 73 and figure 35). The average wholesale price of phosphoric acid at Baltimore for the twelve-months period from October, 1927, to September, 1928, was 56 cents. Thus the change in the retail price of the fertilizers per unit change in the phosphoric-acid content was greater than the wholesale price of the phosphoric acid. In 1925, however, the change in the retail price of complete fertilizers per unit change in the phosphoric-acid content was 39 cents, or 18 cents less than the wholesale price of phosphoric acid.

For the sixteen-year period 1899 to 1914 the wholesale price of phosphoric acid at Baltimore averaged 60 cents per unit. During the same period the average change in the retail price of complete fertilizers per unit change in the phosphoric-acid content was 22 cents. The change in the retail price of complete fertilizers per unit change in phosphoric-acid content was less than the wholesale price of phosphoric acid. This indicates that, in general, there was a wider margin on those analyses which contained a relatively small percentage of phosphoric acid. The disparity between the wholesale price of phosphoric acid and the change in the retail price of complete fertilizers per unit change in phosphoric-acid content tended to decrease during this period. For the five years 1899 to 1903,

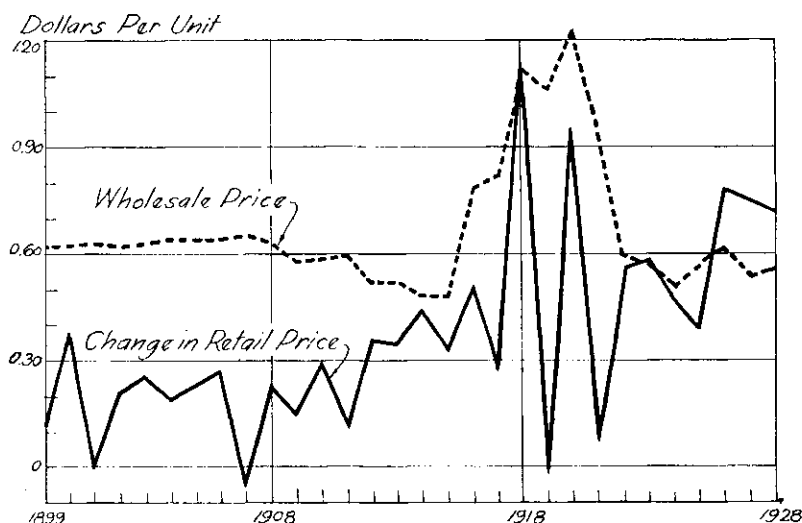


FIGURE 35. WHOLESALE PRICE OF PHOSPHORIC ACID PER UNIT IN SUPERPHOSPHATE AT BALTIMORE, AND CHANGE IN THE RETAIL PRICE PER TON OF COMPLETE FERTILIZERS IN PENNSYLVANIA PER UNIT CHANGE IN PHOSPHORIC-ACID CONTENT, 1899 TO 1928

(Change in retail price = net regression coefficient)

The change in the retail price of complete fertilizers per unit change in phosphoric-acid content has tended to be less than the wholesale price of phosphoric acid

the difference between the wholesale price and the changes in the retail price per unit change in phosphoric-acid content was 43 cents, as compared with 25 cents for the four years 1910 to 1914 except 1912.

During the four-year period 1918 to 1921, the amount by which the retail price of complete fertilizers changed per unit change in phosphoric-acid content fluctuated violently, varying from an increase of \$1.13 in 1918 to a decrease of 1 cent in 1919.

For the seven years 1922 to 1928, the wholesale price of phosphoric acid averaged 56 cents per unit; for the same period, the change in the retail price of complete fertilizers per unit change in phosphoric-acid content averaged 61 cents. During this period the tendency was for the changes in the retail price due to variations in the phosphoric-acid content to be approximately equal to the wholesale price, instead of less than the wholesale price as was the case during the pre-war period.

The increase in the retail price of complete fertilizers for each additional unit of phosphoric acid is now apparently equal to the wholesale price of the phosphoric acid. It has taken twenty-five years to bring about this normal relationship. This means that for farmers who use complete fertilizers it is much cheaper to get additional phosphoric acid by purchasing mixed goods of higher analysis than by buying additional material in unmixed form. During the thirty years 1899 to 1928, the additional cost of the higher-analysis goods tended to be less than the wholesale cost of the additional units of phosphoric acid.

TABLE 73. CHANGE IN THE PENNSYLVANIA RETAIL PRICE OF COMPLETE FERTILIZERS PER UNIT INCREASE IN PHOSPHORIC-ACID CONTENT, AND WHOLESALE PRICE OF PHOSPHORIC ACID, 1899 TO 1928

Year	Change in retail price per ton of complete fertilizers ( $x_1$ ) in Pennsylvania per unit increase in guaranteed phosphoric-acid content ( $x_2$ ) eliminating the effect of variations in the guaranteed ammonia ( $x_3$ ) and potash ( $x_4$ ) content b13.21	Wholesale price of phosphoric acid per unit in super-phosphate at Baltimore	Difference between change in retail price, and wholesale price	Index numbers (1910-1914* = 100)	
				Change in retail price per ton per unit increase in phosphoric-acid content b13.24	Wholesale price of phosphoric acid in super-phosphate
1899-1903.....	\$0.19	\$0.62	-\$0.43	63	113
1910-1914*.....	0.30	0.55	- 0.25	100	100
1924-1928.....	0.62	0.56	+ 0.07	207	102
1899.....	0.11	0.62	- 0.51	37	113
1900.....	0.38	0.62	- 0.24	127	113
1901.....	0.00	0.63	- 0.63	0	115
1902.....	0.21	0.62	- 0.41	70	113
1903.....	0.26	0.63	- 0.37	87	115
1904.....	0.19	0.64	- 0.45	63	116
1905.....	0.23	0.64	- 0.41	77	116
1906.....	0.27	0.64	- 0.37	90	116
1907.....	- 0.05	0.65	- 0.70	-17	118
1908.....	0.23	0.63	- 0.40	77	115
1909.....	0.15	0.58	- 0.43	50	105
1910.....	0.29	0.59	- 0.30	97	107
1911.....	0.12	0.60	- 0.48	40	109
1912.....	0.36†	0.52	- 0.16	120	95
1913.....	0.35	0.52	- 0.17	117	95
1914.....	0.44	0.48	- 0.04	147	87
1915.....	0.33	0.48	- 0.15	110	87
1916.....	0.51	0.78	- 0.27	170	142
1917.....	0.27	0.82	- 0.55	90	149
1918.....	1.13	1.11	+ 0.02	377	202
1919.....	- 0.01	1.06	- 1.07	-3	193
1920.....	0.95	1.22	- 0.27	317	222
1921.....	0.08	0.95	- 0.87	27	173
1922.....	0.56	0.59	- 0.03	187	107
1923.....	0.58	0.57	+ 0.01	193	104
1924.....	0.47	0.50	- 0.03	157	91
1925.....	0.39	0.57	- 0.18	130	104
1926.....	0.78	0.61	+ 0.17	260	111
1927.....	0.75	0.54	+ 0.21	250	98
1928.....	0.72	0.56	+ 0.16	240	102

\* 1910 to 1914 except 1912.

† For the spring season only.

In 1928 the change in the retail price of complete fertilizers per unit change in potash content was 63 cents (table 74 and figure 36). The wholesale price of potash in bagged muriate was 72 cents, or 9 cents higher than the change in the retail price of complete fertilizers per unit variation in potash content.

During the sixteen-year period 1899 to 1914, the change in the retail price of complete fertilizers per unit change in potash content fluctuated around the wholesale price of potash in bagged muriate, so that for the entire period the wholesale price averaged 77 cents per unit, the same as the change in the retail price of the mixed fertilizer per unit variation in potash content. Apparently the normal relationship between the wholesale price of potash and the increase in the retail price of commercial fertilizers for each additional unit of potash has existed for many years.

The index number of the wholesale price of potash rose to 1117 in 1917. During the period of extremely high potash prices the change in

## Coefficient of Variability

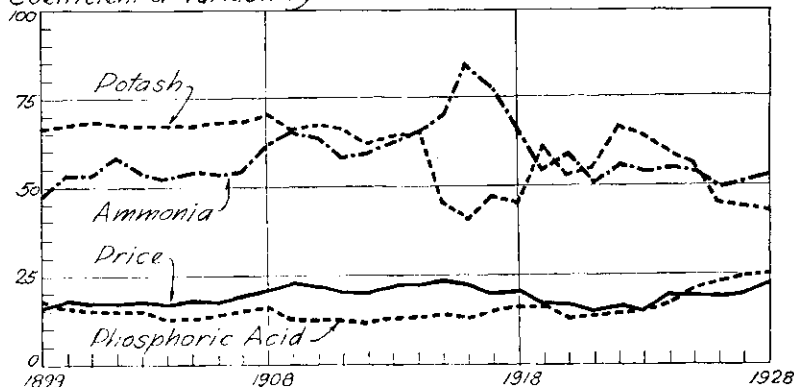


FIGURE 37. COEFFICIENTS OF VARIABILITY OF THE RETAIL PRICE AND THE ANALYSIS OF COMPLETE FERTILIZERS IN PENNSYLVANIA, 1899 TO 1928

The variability of the price and of the phosphoric-acid content are low as compared with the variability of the ammonia and the potash content

TABLE 75. STANDARD DEVIATIONS AND COEFFICIENTS OF VARIABILITY OF THE RETAIL PRICE AND THE ANALYSIS OF COMPLETE FERTILIZERS IN PENNSYLVANIA, 1899 TO 1928

Year	Standard deviations				Coefficients of variability			
	Retail price per ton	Percent of ammonia guaranteed	Per cent of phosphoric acid guaranteed	Per cent of potash guaranteed	Retail price per ton	Ammonia guaranteed	Phosphoric acid guaranteed	Potash guaranteed
1899-1903....	\$4.03	0.90	1.25	2.05	17.12	53.09	15.50	67.28
1910-1914*....	5.08	1.07	1.00	2.86	21.39	62.32	12.89	65.23
1924-1928....	6.46	1.15	2.04	2.49	19.64	52.35	22.06	49.47
1899.....	3.64	0.81	1.40	1.80	15.75	47.24	16.66	66.18
1900.....	4.41	0.93	1.27	2.11	17.88	53.03	15.98	67.43
1901.....	4.02	0.90	1.23	2.02	17.15	53.43	15.33	68.37
1902.....	4.02	0.96	1.19	2.10	17.40	57.62	15.00	67.34
1903.....	4.07	0.90	1.16	2.23	17.44	54.12	14.52	67.07
1904.....	3.84	0.84	1.01	2.28	16.53	51.57	12.76	66.77
1905.....	4.10	0.89	1.00	2.34	17.78	53.62	12.60	66.64
1906.....	4.08	0.89	1.13	2.49	17.58	53.11	14.26	68.18
1907.....	4.53	0.92	1.22	2.63	19.11	53.89	15.37	68.26
1908.....	5.20	1.07	1.23	2.67	21.49	60.93	15.76	69.60
1909.....	5.47	1.12	1.02	2.73	22.59	65.14	13.12	66.46
1910.....	5.17	1.09	1.00	2.75	21.65	63.56	12.86	66.53
1911.....	4.68	0.97	0.96	2.74	19.54	58.22	12.36	65.62
1912†.....	4.83	1.05	0.94	3.08	19.64	59.23	12.16	61.95
1913.....	5.31	1.09	1.00	2.97	22.43	62.47	12.93	63.93
1914.....	5.14	1.13	1.04	2.98	21.95	65.03	13.40	64.83
1915.....	5.69	1.24	1.14	1.10	23.48	69.98	13.75	45.46
1916.....	6.06	1.40	1.09	0.45	22.80	83.59	13.03	40.76
1917.....	5.61	1.35	1.25	0.55	19.69	78.11	14.87	47.27
1918.....	7.84	0.99	1.30	0.52	20.43	64.75	15.83	44.64
1919.....	6.61	0.75	1.34	1.01	16.94	54.42	16.02	61.70
1920.....	7.63	0.92	1.07	1.33	16.88	59.04	13.08	53.07
1921.....	5.44	0.77	1.15	1.43	14.93	50.99	13.89	54.83
1922.....	4.63	0.98	1.20	2.40	15.63	56.29	14.48	66.23
1923.....	4.48	0.98	1.27	2.65	14.51	53.79	15.26	64.02
1924.....	5.67	1.06	1.48	2.63	18.60	55.20	17.33	59.40
1925.....	6.35	1.09	1.80	2.57	18.84	53.72	20.54	55.96
1926.....	6.36	1.10	2.13	2.46	18.56	49.09	22.53	45.33
1927.....	6.26	1.22	2.37	2.43	19.60	50.89	24.84	43.85
1928.....	7.68	1.28	2.42	2.34	22.58	52.84	25.06	42.70

\* 1910 to 1914 except 1912.

† For the spring season only.

other plant foods. Superphosphate is used as a basis of most complete fertilizers. To the superphosphate are added varying amounts of ammonia and potash.

The ammonia content of the fertilizers was most variable during the war period, while the potash content was more or less uniformly low. For the seven years 1922 to 1928 the outstanding changes were a decrease in the coefficients of variability of the potash content from 66.23 to 42.79, a decrease in the coefficient of variability of the ammonia content from 56.29 to 52.84 and an increase in the variability of the phosphoric-acid content from 14.48 to 25.06. These changes in the variability of the analyses have been somewhat similar to the changes in the relationship between the retail price and the analysis. The coefficient of determination of the retail price by the potash and the ammonia content has declined. The coefficient of determination of the retail price by the phosphoric-acid content, however, has increased. The variability of the analysis and the wholesale price of the plant foods are the important factors affecting the degree of relationship between price and analysis.

For the pre-war period 1899 to 1914, the coefficient of variability of the retail price averaged about 19, which was greater than the variability of the phosphoric-acid content but decidedly less than the variability of the ammonia and the potash content. For the five years 1924 to 1928 the coefficient of variability of the price averaged about 20, which was less than the variability of the content of any of the plant foods. The prices of the various grades of complete fertilizer were more nearly alike than the analyses. The retail price includes the cost of manufacture and distribution, which tends to be a fixed amount per ton. Thus a large part of the retail price does not vary, and retail prices of the different grades vary little as compared with the analyses.

During the entire sixteen-year period 1899 to 1914, the average retail price of complete fertilizers in Pennsylvania remained relatively constant (tables 76 and 77). The highest price, \$24.66 per ton in 1900, was only 7 per cent greater than the lowest price, \$23.07 in 1905. As compared with the changes that occurred in the prices of farm crops and commodities in general during this period, the fluctuations in the retail price of complete fertilizers were small. The changes that occurred in the fertilizer tonnage in Pennsylvania during the period were due primarily to changes in the demand for fertilizer rather than to changes in the price.

During the war and inflation periods the prices of fertilizer rose rapidly. In 1920 the average price per ton, \$45.18, was 90 per cent higher than the pre-war price. By 1922 the price had declined to \$29.63, or 25 per cent above the pre-war price.

In the seven-year period 1922 to 1928 there was an upward trend in the retail price, and for the five years 1924 to 1928 the price averaged 39 per cent greater than the pre-war average. Not only did the retail price increase, but the changes in the price were greater than during the entire sixteen-year period 1899 to 1914.

The average retail prices are not a true indication of the retail price of plant food per unit, since there have been changes in the average analysis. During the sixteen-year period 1899 to 1914 the ammonia content remained practically constant and the phosphoric-acid content decreased

TABLE 76. AVERAGE RETAIL PRICE AND AVERAGE ANALYSIS OF COMPLETE FERTILIZERS IN PENNSYLVANIA, 1899 TO 1928

Year	Retail price per ton in Pennsylvania	Per cent of ammonia guaranteed	Per cent of nitrogen guaranteed	Per cent of phosphoric acid guaranteed	Per cent of potash guaranteed	Total units of plant food per ton	Average retail price of plant food per unit	Number of samples	Number of analyses
1899-1903.	\$23.54	1.70	1.40	8.04	3.05	12.48	\$1.89	675	172
1910-1914*	23.73	1.72	1.41	7.76	4.39	13.56	1.75	1,234	200
1924-1928.	32.89	2.21	1.81	9.19	5.09	16.10	2.05	1,259	85
1899.....	23.12	1.72	1.42	8.38	2.72	12.52	1.85	416	189
1900.....	24.66	1.75	1.44	7.92	3.12	12.48	1.98	547	171
1901.....	23.46	1.68	1.38	7.99	2.96	12.33	1.90	702	151
1902.....	23.12	1.67	1.37	7.92	3.11	12.40	1.86	808	172
1903.....	23.36	1.67	1.37	7.98	3.33	12.68	1.84	902	176
1904.....	23.21	1.63	1.34	7.91	3.42	12.67	1.83	955	173
1905.....	23.07	1.65	1.36	7.94	3.52	12.82	1.80	997	189
1906.....	23.18	1.67	1.37	7.92	3.65	12.94	1.79	1,003	193
1907.....	23.68	1.70	1.40	7.94	3.85	13.19	1.80	719	188
1908.....	24.23	1.75	1.44	7.83	3.83	13.10	1.85	817	196
1909.....	24.21	1.72	1.42	7.78	4.11	13.31	1.82	1,068	190
1910.....	23.88	1.71	1.41	7.76	4.14	13.31	1.79	1,229	197
1911.....	23.94	1.66	1.37	7.77	4.17	13.31	1.80	1,250	195
1912†	24.60	1.78	1.46	7.77	4.97	14.20	1.73	810	138
1913.....	23.69	1.75	1.44	7.73	4.64	13.81	1.72	1,239	196
1914.....	23.41	1.74	1.43	7.78	4.60	13.81	1.70	1,219	210
1915.....	24.24	1.77	1.46	8.26	2.43	12.15	2.00	965	153
1916.....	26.56	1.67	1.37	8.39	1.10	10.86	2.45	583	68
1917.....	28.48	1.73	1.42	8.42	1.16	11.00	2.59	597	78
1918.....	38.37	1.52	1.25	8.24	1.16	10.65	3.60	553	65
1919.....	39.01	1.37	1.13	8.37	1.66	11.16	3.50	724	80
1920.....	45.18	1.55	1.28	8.21	2.51	12.00	3.76	755	76
1921.....	36.45	1.50	1.23	8.30	2.61	12.14	3.00	992	66
1922.....	29.63	1.74	1.43	8.29	3.63	13.35	2.22	1,184	87
1923.....	30.85	1.81	1.49	8.34	4.15	13.98	2.21	804	74
1924.....	30.50	1.93	1.59	8.55	4.43	14.57	2.09	1,156	89
1925.....	33.71	2.02	1.66	8.74	4.60	15.00	2.25	1,475	114
1926.....	34.29	2.24	1.84	9.46	5.43	16.73	2.05	1,141	68
1927.....	31.92	2.41	1.98	9.52	5.55	17.05	1.87	1,177	73
1928.....	34.01	2.43	2.00	9.67	5.46	17.13	1.99	1,345	82

\* 1910 to 1914 except 1912.

† For the spring season only.

slightly, but the potash content increased (figure 38). For the two years 1899 and 1900 the potash content averaged 2.92 per cent, as compared with 4.62 per cent for the two years 1913 and 1914. Owing to the increase in the percentage of potash in the complete fertilizers, the total plant food content tended to increase, and there was a gradual decline in the average retail price of plant food per unit. The average retail price per unit for the two years 1899 and 1900 was \$1.91, as compared with \$1.71 for the two years 1913 and 1914.

During the war period there was a decrease in both the potash and the ammonia content of the complete fertilizers, owing to the difficulties of importing potash and to the use of nitrogen in war industries. Because of this decrease in plant-food content, the retail price of the plant food rose even higher than the price per ton would indicate.

In the post-war period higher-analysis fertilizers have been used. For the five years 1924 to 1928 the ammonia content of complete fertilizers in Pennsylvania averaged 28 per cent above the pre-war average, the phosphoric-acid content was 18 per cent higher, the potash content was 16 per cent higher, and the total plant food was 19 per cent higher. Dur-

TABLE 77. INDEX NUMBERS OF AVERAGE RETAIL PRICE AND AVERAGE ANALYSIS OF COMPLETE FERTILIZERS IN PENNSYLVANIA, 1899 TO 1928 (1910-1914\*=100)

Year	Retail price per ton	Ammonia guaranteed	Phosphoric acid guaranteed	Potash guaranteed	Total units of plant food per ton	Average retail price of plant food per unit	Number of samples	Number of analyses
1899-1903.....	99	99	104	69	92	108	55	86
1910-1914*.....	100	100	100	100	100	100	100	100
1924-1928.....	139	128	118	116	119	117	102	42
1899.....	97	100	108	62	92	106	34	94
1900.....	104	102	102	71	92	113	44	86
1901.....	99	98	103	67	91	109	57	76
1902.....	97	97	102	71	91	106	65	86
1903.....	98	97	103	76	94	105	73	88
1904.....	98	95	102	78	93	105	77	86
1905.....	97	96	102	80	95	103	81	94
1906.....	98	97	102	83	95	102	81	96
1907.....	100	99	102	88	97	103	58	94
1908.....	102	102	101	87	97	106	66	98
1909.....	102	100	100	94	98	104	87	95
1910.....	101	99	100	94	98	102	100	98
1911.....	101	97	100	95	98	103	101	98
1912†.....	104	103	100	113	105	99	66	69
1913.....	100	102	100	106	102	98	100	98
1914.....	99	101	100	105	102	97	99	105
1915.....	102	103	106	55	90	114	78	76
1916.....	112	97	108	25	80	140	47	34
1917.....	120	101	109	26	81	148	48	39
1918.....	162	88	106	26	79	206	45	32
1919.....	164	80	108	38	82	200	59	40
1920.....	190	90	106	57	88	215	61	38
1921.....	154	87	107	59	90	171	80	33
1922.....	125	101	107	83	98	127	96	44
1923.....	130	105	107	95	103	126	65	37
1924.....	129	112	110	101	107	119	94	44
1925.....	142	117	113	105	111	129	120	57
1926.....	145	130	122	124	123	117	92	34
1927.....	135	140	123	126	126	107	95	36
1928.....	143	141	125	124	126	114	109	41

\* 1910 to 1914 except 1912.

† For the spring season only.

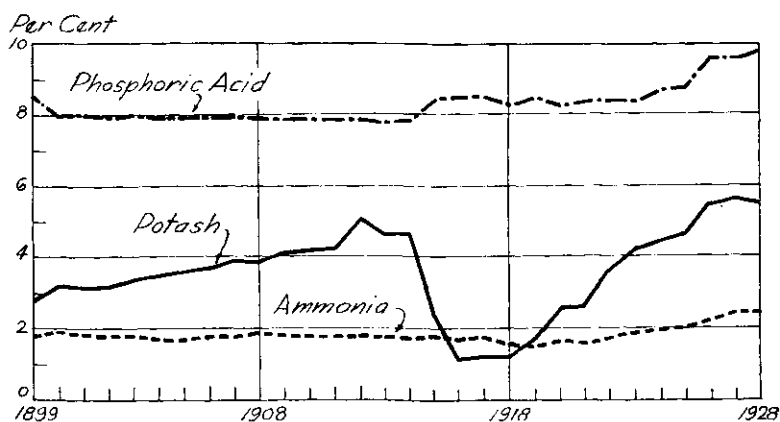


FIGURE 38. AVERAGE GUARANTEED ANALYSIS OF COMPLETE FERTILIZERS IN PENNSYLVANIA, 1899 TO 1928

During the pre-war period only the potash content tended to increase. Since the war the percentage of all the plant foods has increased

ing this period the retail price per ton of complete fertilizers averaged 39 per cent above the pre-war figure, but, because of the increase in concentration, the retail price of plant food per unit averaged only 17 per cent higher.

Even the average retail prices per unit are not exactly comparable, because of the changes in the relative proportions of the various plant foods. A comparison of the two periods 1899 to 1903 and 1910 to 1914 (except 1912) indicates that the percentage of the total plant food in the form of nitrogen declined from 11.2 to 10.4 per cent, phosphoric acid declined from 64.4 to 57.2 per cent, and potash increased from 24.4 to 32.4 per cent. A part of the decline in the average price per unit of plant food in the period from 1899 to 1914 was due to the decline in the proportion of nitrogen, the most expensive plant food.

During the five years 1924 to 1928 the percentage of the total plant food in the form of nitrogen, 11.2 per cent, was about the same as that which prevailed at the beginning of the century. Phosphoric acid made up 57.2 per cent, and potash 31.6 per cent, of the total. The increase in the proportion of nitrogen was one factor causing the increase in the retail price of plant food per unit.

For the five years 1924 to 1928, all commodity prices and farm prices in the United States averaged 54 per cent and 44 per cent, respectively, above the pre-war averages. The increase in the price of plant food per unit in complete fertilizers in Pennsylvania has been less than the increase in the prices of commodities in general and the prices of farm products.

It is difficult to make an accurate estimate of the wholesale cost of the materials used in making up a complete fertilizer of average analysis. Estimates of the wholesale cost of the phosphoric acid and the potash can be made comparatively easily by using the wholesale prices of phosphoric acid and potash in superphosphate and muriate of potash. These materials are the important sources of phosphoric acid and potash in complete fertilizers. Estimating the cost of the ammonia is more difficult. Many different ammonia carriers are used, with wide variations in the cost of the ammonia content. Data are not available on the proportions of the ammonia from each source. During the period from 1899 to 1928, important changes have taken place in the materials most commonly used as ammonia carriers. In the earlier years organic ammoniates predominated, while in the post-war period there has been an increased use of mineral ammoniates. It is difficult to weight the prices of ammonia in the various materials because of the changes in the materials used.

During the thirty-year period 1899 to 1928 the price of ammonia in dried blood tended to be higher than the price of ammonia in any of the other organic ammoniates. If the value of the ammonia is estimated from the price of ammonia in dried blood, the wholesale cost of the materials is overestimated. This is true especially for the post-war period, during which there has been a marked decline in the use of the high-priced organic ammoniates in complete fertilizers.

Since 1912, sulfate of ammonia has been one of the cheapest sources of nitrogen. Although it is used extensively in complete fertilizers, it is not used exclusively. If the wholesale cost is estimated by using the price of ammonia in sulfate of ammonia, the cost tends to be underestimated.



and the difference between the retail price and the cost tends to be too large. During the post-war period the use of sulfate of ammonia in complete fertilizers has increased rapidly. In the past few years, the estimated cost of materials at wholesale using the price of ammonia in sulfate would be more nearly correct than the estimate using the price of ammonia in dried blood.

In order to get an estimate of the changes that have occurred in the cost of manufacture and distribution, two estimates of the wholesale cost of materials necessary to make an average analysis were made, one using the price of ammonia in dried blood and the other using the price of ammonia in sulfate of ammonia (tables 78 and 79). The former is doubtless somewhat too large, and the latter too small. The true cost is somewhere between the two.

During the four pre-war years, the average estimated cost of materials, assuming the ammonia to be all from dried blood, was \$12.82. This was only \$1.15 more than the estimate in which the price of ammonia in sulfate was used. For the sixteen years 1899 to 1914, the estimate of the

TABLE 78. AVERAGE RETAIL PRICE OF COMPLETE FERTILIZERS IN PENNSYLVANIA, AND ESTIMATED COST OF MATERIALS AND COST OF MANUFACTURE AND DISTRIBUTION OF COMPLETE FERTILIZERS IN PENNSYLVANIA, 1899 TO 1928

Year	Retail price of complete fertilizers per ton	Wholesale cost of plant food						Cost of manufacture and distribution based on ammonia from	
		Ammonia in		Phosphoric acid in superphosphate	Potash in bagged muriate	Total with ammonia from		dried blood	sulfate of ammonia
		dried blood	sulfate of ammonia			dried blood	sulfate of ammonia		
1899-1914.	\$23.68	\$ 4.47	\$4.10	\$ 4.74	\$2.90	\$12.12	\$11.74	\$11.56	\$11.94
1910-1914*	23.73	5.20	4.06	4.25	3.36	12.82	11.67	10.92	12.06
1924-1928.	32.89	8.96	4.51	5.12	3.36	17.45	13.00	15.44	19.89
1899.....	23.12	3.16	3.96	5.20	2.01	10.37	11.17	12.75	11.95
1900.....	24.66	3.82	4.10	4.91	2.34	11.07	11.35	13.59	13.31
1901.....	23.46	3.90	3.73	5.03	2.22	11.15	10.98	12.31	12.48
1902.....	23.12	3.87	3.94	4.91	2.33	11.11	11.18	12.01	11.94
1903.....	23.36	4.29	4.14	5.03	2.53	11.85	11.70	11.51	11.66
1904.....	23.21	4.14	4.08	5.06	2.63	11.83	11.77	11.38	11.44
1905.....	23.07	4.31	4.12	5.08	2.78	12.17	11.98	10.90	11.09
1906.....	23.18	4.48	4.14	5.07	2.92	12.47	12.13	10.71	11.05
1907.....	23.68	4.68	4.22	5.16	3.08	12.92	12.46	10.76	11.22
1908.....	24.23	4.46	4.22	4.93	3.03	12.42	12.18	11.81	12.05
1909.....	24.21	4.66	3.96	4.51	3.21	12.38	11.68	11.83	12.53
1910.....	23.88	5.08	3.78	4.58	3.06	12.72	11.42	11.16	12.46
1911.....	23.94	5.33	4.07	4.66	3.09	13.08	11.82	10.86	12.12
1912†.....	24.60	4.97	4.66	4.04	3.88	12.89	12.58	11.71	12.02
1913.....	23.69	4.86	4.48	4.02	3.67	12.55	12.17	11.14	11.52
1914.....	23.41	5.55	3.92	3.73	3.63	12.91	11.28	10.50	12.13
1915.....	24.24	5.03	4.34	3.96	7.00	15.99	15.30	8.25	8.94
1916.....	26.56	5.13	4.94	6.54	8.56	20.23	20.04	6.33	6.52
1917.....	28.48	8.48	6.25	6.90	9.85	25.23	23.00	3.25	5.48
1918.....	38.37	10.21	6.13	9.15	7.80	27.16	23.08	11.21	15.29
1919.....	39.01	8.48	4.49	8.87	7.75	25.10	21.11	13.91	17.90
1920.....	45.18	12.18	5.33	10.02	6.25	28.45	21.60	16.73	23.58
1921.....	36.45	5.66	3.45	7.88	3.71	17.25	15.04	19.20	21.41
1922.....	29.63	6.79	3.51	4.89	2.58	14.26	10.98	15.37	18.65
1923.....	30.85	7.78	4.52	4.75	2.70	15.23	11.97	15.62	18.88
1924.....	30.50	6.52	4.11	4.28	2.79	13.59	11.18	16.91	19.32
1925.....	33.71	7.39	4.18	4.98	2.90	15.27	12.06	18.44	21.65
1926.....	34.29	8.83	4.77	5.77	3.48	18.08	14.02	16.21	20.27
1927.....	31.92	10.15	4.70	5.14	3.72	19.01	13.56	12.91	18.36
1928.....	34.01	11.93	4.81	5.42	3.93	21.28	14.16	12.73	19.85

\* 1910 to 1914 except 1912.

† For the spring season only.

TABLE 79. INDEX NUMBERS OF AVERAGE RETAIL PRICE OF COMPLETE FERTILIZERS IN PENNSYLVANIA, AND OF ESTIMATED COST OF MATERIALS AND COST OF MANUFACTURE AND DISTRIBUTION OF COMPLETE FERTILIZERS IN PENNSYLVANIA, 1899 TO 1928

(1910-1914\* = 100)

Year	Retail price of complete fertilizers per ton	Wholesale cost of plant food						Cost of manufacture and distribution based on ammonia from	
		Ammonia in		Phosphoric acid in superphosphate	Potash in bagged muriate	Total with ammonia from		dried blood	sulfate of ammonia
		dried blood	sulfate of ammonia			dried blood	sulfate of ammonia		
1899-1914	100	86	101	112	86	95	101	106	99
1910-1914*	100	100	100	100	100	100	100	100	100
1924-1928.	139	172	111	120	100	136	111	141	165
1899.....	97	61	98	122	60	81	96	117	99
1900.....	104	73	101	116	70	86	97	124	110
1901.....	99	75	92	118	66	87	94	113	103
1902.....	97	74	97	116	69	87	96	110	99
1903.....	98	82	102	118	75	92	100	105	97
1904.....	98	80	100	119	78	92	101	104	95
1905.....	97	83	101	120	83	95	103	100	92
1906.....	98	86	102	119	87	97	104	98	92
1907.....	100	90	104	121	92	101	107	99	93
1908.....	102	86	104	116	90	97	104	108	100
1909.....	102	90	98	106	96	97	100	108	104
1910.....	101	98	93	108	91	99	98	102	103
1911.....	101	102	100	110	92	102	101	99	100
1912†.....	104	96	115	95	115	101	108	107	100
1913.....	100	93	110	95	109	98	104	102	96
1914.....	99	107	97	88	108	101	97	96	101
1915.....	102	97	107	93	208	125	131	76	74
1916.....	112	99	122	154	255	158	172	58	54
1917.....	120	163	154	162	293	197	197	30	45
1918.....	162	196	151	215	232	212	198	103	127
1919.....	164	163	111	209	231	196	181	127	148
1920.....	190	234	131	236	186	222	185	153	196
1921.....	154	109	85	185	110	135	129	176	178
1922.....	125	131	86	115	77	111	94	141	155
1923.....	130	150	111	112	80	119	103	143	157
1924.....	129	125	101	101	83	106	96	155	160
1925.....	142	142	103	117	86	119	103	169	180
1926.....	145	170	117	136	104	141	120	148	168
1927.....	135	195	116	121	111	148	116	118	152
1928.....	143	229	118	128	117	166	121	117	165

\* 1910 to 1914 except 1912.

† For the spring season only.

cost of materials using dried blood averaged only 38 cents more than the estimate based on sulfate-of-ammonia prices. During this period the ammonia content of the complete fertilizers was relatively low, and the differences in the prices of ammonia in dried blood and in sulfate were also relatively small. Thus the two estimates were much the same. In the sixteen years 1899 to 1914, the difference between the retail price of the complete fertilizer and the estimated wholesale cost of the materials—that is, the cost of distribution and manufacture—was \$11.56 based on the estimate using dried blood, and \$11.94 based on the estimate using sulfate of ammonia. The cost of manufacture and distribution was about 50 per cent of the retail price. For the four pre-war years, the relation between the retail price and the cost of manufacture and distribution was much the same.

During the war period the cost of the materials increased much more than did the retail price. Potash was very high in price, and, even though only small amounts were used in complete fertilizers, the cost of the potash

was about one-third to one-half of the cost of materials necessary to make fertilizers of average analysis.

For the five years 1924 to 1928, the cost of materials based on the price of ammonia in dried blood was \$17.45, or 36 per cent more than the pre-war average. The difference between the retail price and the cost of materials (based on dried blood) was \$15.44, or 41 per cent more than the pre-war figure. If all of the ammonia had been obtained from the high-priced dried blood, the estimated cost of manufacture and distribution would be 41 per cent greater than for the four pre-war years. If the estimates based on the price of ammonia in sulfate of ammonia are used, the cost of manufacture and distribution during the years just prior to the war was \$12.06, and that for the five years 1924 to 1928 was \$19.89, an increase of 65 per cent.

It is probable that the estimate based on the dried blood was more nearly correct for the pre-war period, and that the estimate based on sulfate of ammonia was more nearly correct for the post-war period. If this is true, the cost of manufacture and distribution during the period from 1910 to 1914 was about \$10.92, and for the period from 1924 to 1928 about \$19.89, an increase of 82 per cent.

Each of the estimates indicate that the spread between the cost of materials and the retail price during the post-war period was distinctly greater than during the pre-war period. The estimated increase varies from 41 to 82 per cent. This is similar to the changes that occurred in the cost of distribution of fertilizer materials and in the cost of manufacture and distribution of phosphate and potash fertilizers.

The increase in the concentration of the fertilizers has been a method of reducing the cost of distribution of plant food per unit. The cost of distribution tends to be a uniform amount per ton. With the fertilizers of high analysis this cost is spread over a larger number of units. The increase in the cost of distribution has been an important factor in stimulating the development and use of high-analysis fertilizers.

#### *In New York*

The fertilizer reports for New York contained the average retail price and guaranteed analysis of only those grades of complete fertilizers of which five or more samples had been collected. Thus retail prices and analyses for many of the less common grades were not included. These data were available for the five years 1923, 1924, 1926, 1927, and 1928.

The correlation between price and analysis was highest in 1923 ( $R_{1-234} = 0.984$ ) and lowest in 1927 ( $R_{1-234} = 0.812$ ) (table 80). In 1923 the analysis accounted for 96.94 per cent of the variability in the retail price, as compared with only 65.94 per cent in 1927. In 1927 the analysis of the fertilizer was less important in determining what farmers had to pay than in any other year for which the data were available.

For these five years the ammonia content accounted, on the average, for 72.07 per cent of the variability in the retail price of the complete fertilizers in New York, as compared with 0.60 per cent for the phosphoric-acid content and 12.55 per cent for the potash content. Variations in

TABLE 80. MULTIPLE CORRELATIONS BETWEEN THE RETAIL PRICE AND THE ANALYSIS OF COMPLETE FERTILIZERS, AND COEFFICIENTS OF DETERMINATION OF THE RETAIL PRICE BY THE ANALYSIS, NEW YORK, 1923 TO 1928

Year	Multiple correlation between retail price and guaranteed ammonia, phosphoric-acid, and potash content $R_{1-234}$	Coefficients of determination of retail price by the analysis*				
		Total analysis $R^2_{1-234} \times 100$	Ammonia guaranteed $d_{12-24}$	Phosphoric acid guaranteed $d_{13-24}$	Potash guaranteed $d_{14-23}$	Factors other than the analysis $d_{127}$
1923-1928†	0.921	85.22	72.07	0.60	12.55	14.78
1923	0.984	96.94	73.73	1.18	22.03	3.06
1924	0.906	82.06	69.71	0.84	11.51	17.94
1925‡	.....	.....	.....	.....	.....	.....
1926	0.972	94.49	84.15	1.95	8.39	5.51
1927	0.812	65.94	64.90	-2.30	3.34	34.06
1928	0.931	86.67	67.85	1.34	17.49	13.33

\*  $x_1$  = retail price per ton;  $x_2$  = per cent of ammonia guaranteed;  $x_3$  = per cent of phosphoric acid guaranteed;  $x_4$  = per cent of potash guaranteed.

† Calculated by subtracting ( $R^2_{1-234} \times 100$ ) from 100.

‡ 1923 to 1928 except 1925.

§ Retail prices and analyses were not available for 1925.

the phosphoric-acid and the potash content were associated with the retail price, but to a much less degree than were variations in the ammonia content. The ammonia content was the most important single factor affecting the retail price, and was more important than the two other plant foods combined.

In 1928, for each 1-per-cent change in the ammonia content of the complete fertilizers there was a change of \$2.37 in the retail price (table 81). A 1-per-cent change in the phosphoric-acid content caused a change of

TABLE 81. CHANGE IN THE NEW YORK RETAIL PRICE OF COMPLETE FERTILIZERS PER UNIT INCREASE IN AMMONIA CONTENT, AND WHOLESALE PRICE OF AMMONIA IN DRIED BLOOD, TANKAGE, NITRATE OF SODA, AND SULFATE OF AMMONIA, 1923 TO 1928

Year	Change in retail price per ton of complete fertilizers ( $x_1$ ) in New York per unit increase in guaranteed ammonia content ( $x_2$ ) eliminating the effect of variations in the guaranteed phosphoric-acid ( $x_3$ ) and potash ( $x_4$ ) content $b_{12-24}$	Wholesale price of ammonia per unit				Difference between change in retail price per unit increase in ammonia content, and wholesale price of ammonia*			
		In dried blood	In tankage	In nitrate of soda	In sulfate of ammonia	In dried blood	In tankage	In nitrate of soda	In sulfate of ammonia
1923-1928†	\$3.14	\$4.15	\$3.61	\$2.63	\$2.17	-\$1.00	-\$0.47	\$0.51	\$0.97
1923	3.50	4.44	4.24	2.65	2.46	-0.94	-0.74	0.85	1.04
1924	3.27	3.45	3.00	2.63	2.26	-0.18	0.27	0.64	1.01
1925‡	.....	.....	.....	.....	.....	.....	.....	.....	.....
1926	3.84	3.93	3.39	2.75	2.17	-0.09	0.45	1.09	1.67
1927	2.74	4.10	3.75	2.68	1.98	-1.36	-1.01	0.06	0.76
1928	2.37	4.82	3.68	2.46	1.98	-2.45	-1.31	-0.09	0.39

\* The difference is equal to  $b_{12-24}$  minus the wholesale price.

† 1923 to 1928 except 1925.

‡ Retail prices and analyses were not available for 1925.

64 cents in the retail price, and a 1-per-cent change in the potash content caused a change of 70 cents in the retail price (tables 82 and 83).

For the five years the change in the retail price per unit change in ammonia content averaged \$3.14 (table 81). For the same years the wholesale price of ammonia in dried blood averaged \$4.15 per unit, in tankage \$3.61, in nitrate of soda \$2.63, and in sulfate of ammonia \$2.17. The change in the retail price of complete fertilizers in New York per unit change in ammonia content averaged less than the wholesale price of ammonia in dried blood and in tankage, but more than the wholesale price of ammonia in nitrate of soda and in sulfate of ammonia. For the five-year period for which the data were available, there was a general tendency for the change in the retail price of the complete fertilizers per unit variation in ammonia content to decline. This was probably owing to the lower prices for mineral and synthetic ammoniates.

In 1924 the average retail price of the 8-per-cent-phosphoric-acid brands was \$36.90 per ton, as compared with \$33.16 for the 12-per-cent brands. The retail price tended to decline 43 cents per ton per unit increase in phosphoric-acid content. In other years, however, the retail price tended to increase as the phosphoric-acid content increased (table 82).

TABLE 82. CHANGE IN THE NEW YORK RETAIL PRICE OF COMPLETE FERTILIZERS PER UNIT INCREASE IN PHOSPHORIC-ACID CONTENT, AND WHOLESALE PRICE OF PHOSPHORIC ACID, 1923 TO 1928

Year	Change in retail price per ton of complete fertilizers ( $x_1$ ) in New York per unit increase in guaranteed phosphoric-acid content ( $x_2$ ) eliminating the effect of variations in the guaranteed ammonia ( $x_3$ ) and potash ( $x_4$ ) content bu-24	Wholesale price of phosphoric acid per unit in superphosphate at Baltimore	Difference between change in retail price, and wholesale price
1923-1928*	\$0.46	\$0.56	-\$0.10
1923.....	1.06	0.58	+0.48
1924.....	- 0.43	0.50	-0.93
1925†.....	.....	0.54	.....
1926.....	0.65	0.61	+0.04
1927.....	0.37	0.55	-0.18
1928.....	0.64	0.54	+0.10

\* 1923 to 1928 except 1925.

† Retail prices and analyses were not available for 1925.

The average change in the retail price per ton of complete fertilizers per unit change in phosphoric-acid content was 46 cents. The wholesale price of phosphoric acid in superphosphate at Baltimore for the same years averaged 56 cents per unit. Even though the change in the retail price per unit change in phosphoric-acid content averaged less than the wholesale price of phosphoric acid, the change in the retail price tended to fluctuate around the wholesale price of phosphoric acid.

The change in the retail price of the complete fertilizers per unit change in potash content averaged 59 cents (table 83). This was 7 cents per unit less than the wholesale price of potash in bagged muriate.

TABLE 83. CHANGE IN THE NEW YORK RETAIL PRICE OF COMPLETE FERTILIZERS PER UNIT INCREASE IN POTASH CONTENT, AND WHOLESALE PRICE OF POTASH, 1923 TO 1928

Year	Change in retail price per ton of complete fertilizers ( $x_1$ ) in New York per unit increase in guaranteed potash content ( $x_2$ ) eliminating the effect of variations in the guaranteed ammonia ( $x_3$ ) and phosphoric-acid ( $x_4$ ) content <small><math>b_{12-22}</math></small>	Wholesale price of potash in bagged muriate per unit at ports	Difference between change in retail price, and wholesale price
1923-1928*	\$0.59	\$0.66	-\$0.07
1923	0.74	0.66	+ 0.08
1924	0.57	0.63	- 0.06
1925†		0.63	
1926	0.58	0.64	- 0.06
1927	0.37	0.66	- 0.29
1928	0.70	0.72	- 0.02

\* 1923 to 1928 except 1925.

† Retail prices and analyses were not available for 1925.

The change in the retail price of the complete fertilizers per unit change in both phosphoric-acid and potash content tended to fluctuate around the wholesale price. Owing to the fact that there are many different materials used as sources of ammonia, it is not possible to tell whether the same situation holds for ammonia.

These relationships between the wholesale prices of plant food and the change in the retail prices per unit change in plant-food content for New York are much the same as for the other States.

The coefficient of variability of the retail price averaged 13.34 for the five years, as compared with 17.16 for the phosphoric-acid content, 44.73 for the ammonia content, and 48.21 for the potash content (table 84). The variability of the price, the ammonia content, and the potash content tended to decrease; during this period the various grades were becoming

TABLE 84. STANDARD DEVIATIONS AND COEFFICIENTS OF VARIABILITY OF THE RETAIL PRICE AND THE ANALYSIS OF COMPLETE FERTILIZERS IN NEW YORK, 1923 TO 1928

Year	Standard deviations				Coefficients of variability			
	Retail price per ton	Per cent of ammonia guaranteed	Per cent of phosphoric acid guaranteed	Per cent of potash guaranteed	Retail price per ton	Ammonia guaranteed	Phosphoric acid guaranteed	Potash guaranteed
1923-1928*	\$5.00	1.34	1.55	2.55	13.34	44.73	17.16	48.21
1923	5.02	1.17	0.74	2.69	14.03	50.43	9.07	60.59
1924	5.84	1.44	0.94	2.56	15.92	47.84	11.28	49.90
1925†								
1926	5.49	1.30	2.03	2.54	13.15	42.21	21.69	44.17
1927	4.69	1.41	1.94	2.42	13.24	40.52	21.30	42.76
1928	3.96	1.40	2.08	2.54	10.37	42.67	22.48	43.65

\* 1923 to 1928 except 1925.

† Retail prices and analyses were not available for 1925.

more uniformly high in ammonia and potash content. The variability of the phosphoric-acid content more than doubled from 1923 to 1928.

The average retail price per ton and the average analysis for all the samples of complete fertilizers for New York for the years 1914 to 1928 (except 1925) are presented in table 86. The averages for all samples differ somewhat from the averages calculated from only those grades of which five or more samples were collected (table 85).

TABLE 85. AVERAGE RETAIL PRICE AND AVERAGE ANALYSIS OF COMPLETE FERTILIZERS IN NEW YORK, 1923 TO 1928, FOR SAMPLES USED IN CORRELATION ANALYSIS

Year	Retail price per ton in New York	Per cent of ammonia guaranteed	Per cent of nitrogen guaranteed	Per cent of phosphoric acid guaranteed	Per cent of potash guaranteed	Total units of plant food per ton	Retail price of plant food per unit	Number of samples	Number of analyses
1923-1928*	\$37.56	3.03	2.50	8.84	5.36	16.70	\$2.26	330	21
1923.....	35.78	2.32	1.91	8.16	4.44	14.51	2.47	263	21
1924.....	36.68	3.01	2.48	8.33	5.13	15.94	2.30	371	25
1925†									
1926.....	41.76	3.08	2.54	9.36	5.75	17.65	2.37	317	20
1927.....	35.42	3.48	2.87	9.11	5.66	17.64	2.01	382	22
1928.....	38.17	3.27	2.69	9.25	5.83	17.77	2.15	315	19

\* 1923 to 1928 except 1925.

† Retail prices and analyses were not available for 1925.

TABLE 86. AVERAGE RETAIL PRICE AND AVERAGE ANALYSIS OF COMPLETE FERTILIZERS IN NEW YORK, 1914 TO 1928

Year	Retail price per ton in New York	Per cent of nitrogen guaranteed	Per cent of phosphoric acid guaranteed	Per cent of potash guaranteed	Total units of plant food per ton	Retail price of plant food per unit
1914.....	\$28.53	2.08	7.60	5.70	15.38	\$1.86
1915.....	30.87	2.20	8.22	2.90	13.32	2.32
1916.....	35.00	2.14	8.50	1.28	11.92	2.94
1917.....	34.40	2.06	8.51	1.45	12.02	2.86
1918.....	47.70	1.90	8.32	1.58	11.80	4.04
1919.....	80.22	1.79	8.24	1.59	11.62	6.90
1920.....	51.60	1.74	8.22	3.18	13.14	3.93
1921.....	50.00	2.02	8.10	3.51	13.63	3.67
1922.....	38.06	2.20	7.64	4.41	14.25	2.67
1923.....	36.89	2.26	8.15	4.70	15.11	2.44
1924.....	36.15	2.61	8.39	5.05	16.05	2.25
1925*						
1926.....	34.24	2.65	9.13	5.60	17.38	1.97
1927.....	35.55	2.79	8.50	5.34	16.63	2.14
1928.....	38.98	2.80	9.30	5.63	17.73	2.20

\* Retail prices and analyses were not available for 1925.

In 1928 the complete fertilizers in New York contained, on the average, 15 per cent more plant food than in 1914 (table 87). The nitrogen content had increased 35 per cent and the phosphoric acid 22 per cent, while the potash content had declined 1 per cent. The retail price of the fertilizers per ton in 1928 was 37 per cent more than in 1914, but, owing to the increase in plant-food content, the average price of plant food per unit was only 18 per cent greater than the pre-war figure. With high costs of distribution there is an increased incentive to use high-analysis fertilizers.

TABLE 87. INDEX NUMBERS OF AVERAGE RETAIL PRICE AND AVERAGE ANALYSIS OF COMPLETE FERTILIZERS IN NEW YORK, 1914 TO 1928

(1914 = 100)

Year	Retail price per ton	Nitrogen guaranteed	Phosphoric acid guaranteed	Potash guaranteed	Total units of plant food per ton	Retail price of plant food per unit
1914.....	100	100	100	100	100	100
1915.....	108	106	108	51	87	125
1916.....	123	103	112	22	78	158
1917.....	121	99	112	25	78	154
1918.....	167	91	109	28	77	217
1919.....	281	86	108	28	76	371
1920.....	181	84	108	56	85	211
1921.....	175	97	107	62	89	197
1922.....	133	106	101	77	93	144
1923.....	129	109	107	82	98	131
1924.....	127	125	110	89	104	121
1925*						
1926.....	120	127	120	98	113	106
1927.....	125	134	112	94	108	115
1928.....	137	135	122	99	115	118

\* Retail prices and analyses were not available for 1925.

*In New Hampshire*

In 1920 the multiple correlation between the guaranteed analysis and the retail price of complete fertilizers in New Hampshire was 0.946 (table 88). Variations in the analysis accounted for 89.57 per cent of the variations in the retail price. Factors other than the analysis accounted

TABLE 88. MULTIPLE CORRELATIONS BETWEEN THE RETAIL PRICE AND THE ANALYSIS OF COMPLETE FERTILIZERS, AND COEFFICIENTS OF DETERMINATION OF THE RETAIL PRICE BY THE ANALYSIS, NEW HAMPSHIRE, 1920 TO 1929

Year	Multiple correlation between retail price and guaranteed ammonia, phosphoric-acid, and potash content $R_{1-234}$	Coefficients of determination of retail price by the analysis*				
		Total analysis $R_{1-234}^2 \times 100$	Ammonia guaranteed $d_{12-14}$	Phosphoric acid guaranteed $d_{13-24}$	Potash guaranteed $d_{11-23}$	Factors other than the analysis $d_{127}^\dagger$
1920-1929.....	0.825	69.62	57.98	3.64	7.99	30.38
1920.....	0.946	89.57	76.41	-0.67	13.83	10.43
1921.....	0.941	88.55	84.62	-1.78	5.71	11.45
1922.....	0.881	77.62	58.20	13.19	6.23	22.38
1923.....	0.825	68.11	61.05	5.28	1.77	31.89
1924.....	0.861	74.12	60.89	11.41	1.82	25.88
1925.....	0.920	84.70	62.99	5.57	16.13	15.30
1926.....	0.886	78.54	71.49	0.43	6.62	21.46
1927.....	0.809	65.44	47.85	-0.19	17.77	34.56
1928.....	0.551	30.32	24.11	-0.19	6.41	69.68
1929.....	0.626	39.25	32.22	3.40	3.63	60.75

\*  $x_1$  = retail price per ton;  $x_2$  = per cent of ammonia guaranteed;  $x_3$  = per cent of phosphoric acid guaranteed;  $x_4$  = per cent of potash guaranteed.† Calculated by subtracting  $(R_{1-234}^2 \times 100)$  from 100.

for only 10.43 per cent of the variability. In 1928 the correlation between price and analysis was 0.551; the analysis accounted for only 30.32 per cent of the variability in the retail price. During the ten-year period 1920 to 1929 the general tendency was for the correlation between price and analysis to decline (figure 39).



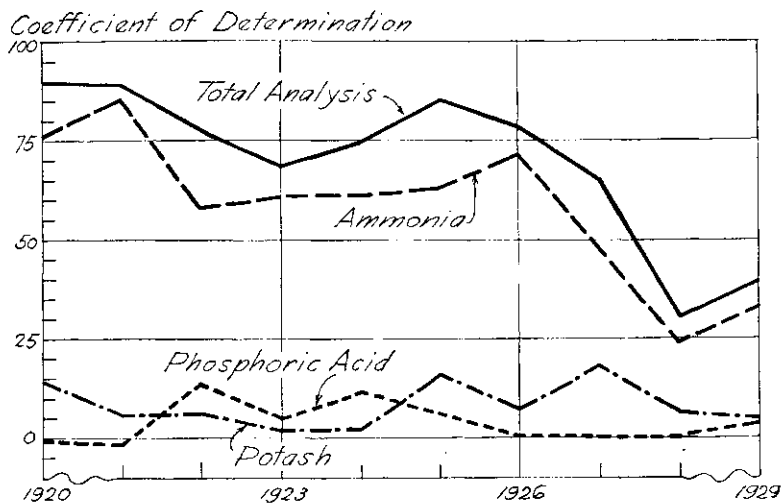


FIGURE 39. COEFFICIENTS OF DETERMINATION OF THE RETAIL PRICE OF COMPLETE FERTILIZERS IN NEW HAMPSHIRE BY THE GUARANTEED AMMONIA, PHOSPHORIC-ACID, AND POTASH CONTENT, 1920 TO 1929

The ammonia content of the fertilizer was the most important ingredient affecting the retail price

The retail price of complete fertilizers in New Hampshire was more closely associated with the ammonia content of the fertilizer than with either the phosphoric-acid or the potash content. During each of the seven years 1920 to 1926, the ammonia content accounted for more than half of the variation in the retail price. For the three years 1927 to 1929, while the ammonia content accounted for less than half of the variability of the retail price, it was the most important item in the analysis. Ammonia is the most expensive plant food in commercial fertilizers. This is one of the reasons why the retail price of complete fertilizers is so closely associated with the ammonia content.

For the two years 1920 and 1921 the coefficient of determination of the retail price by the ammonia content averaged 80, as compared with 28 for the two years 1928 and 1929. The decline in the relationship between the price and the analysis has been due primarily to a decline in the relationship between the ammonia content and the price. The ten-year period 1920 to 1929 was a period of declining prices for mineral and synthetic ammoniates.

While there were fluctuations from year to year in the relationship between the retail price and the phosphoric-acid content of complete fertilizers in New Hampshire, there was no consistent tendency for the correlations to increase or decrease. For the ten years 1920 to 1929, the coefficient of determination for the phosphoric acid averaged 3.64. This was the lowest for any of the three plant foods.

In 1927 approximately 18 per cent of the variability in the retail price was associated with variations in the potash content, as compared with only 1.77 per cent in 1923. While there were changes in the relationship

between the retail price and the potash content, there was no consistent tendency for the correlations to increase or decrease. For the ten-year period 1920 to 1929 the coefficient of determination for potash averaged 7.99, as compared with 3.64 for phosphoric acid and 57.98 for ammonia. The potash content of the fertilizer was more important than the phosphoric acid in affecting the price, but both the phosphoric acid and the potash were of relatively minor importance as compared with the ammonia.

During the period from 1920 to 1929 there was a downward trend in the average retail price per ton of complete fertilizers in New Hampshire. Prices were exceptionally high in 1920 and 1921. In five of the years from 1921 to 1929, the average retail price per ton was less than in the preceding year. In each of the years when the retail price declined, the degree of relationship between the analysis and the price also declined. In three of the four years when the retail price increased, the degree of relationship between the analysis and the price also increased. In eight of the nine years, the changes in the price and in the degree of relationship between price and analysis were similar. The relationship between price and analysis was highest when the retail price was highest, and was low when the retail price was low.

In Pennsylvania the correlations between price and analysis were highest during the war period, when prices were high; since 1922, however, there has been an upward trend in retail prices in Pennsylvania, but the correlations between price and analysis have declined.

In New Hampshire the year-to-year changes in the retail price, and the standard deviation of the retail price, were similar in eight out of nine years. In the years when the average retail price was less than in the preceding year, the variation in the retail price also was less. With declining prices all grades of complete fertilizers tended to sell for more nearly the same price than when prices increased. In Pennsylvania, during the period from 1920 to 1928, the changes in the retail price and the standard deviation of the price were similar in six out of eight years.

In 1929 each added unit of ammonia tended to raise the retail price of the complete fertilizers by \$2.95 (table 89). That is, 3-per-cent-ammonia goods tended to sell for \$2.95 per ton more than did 2-per-cent-ammonia goods which contained an equivalent amount of phosphoric acid and potash. During the 1928-29 fertilizer season the wholesale price of ammonia in sulfate of ammonia averaged \$1.87 per unit, in nitrate of soda \$2.31 per unit, and in tankage \$4.10 per unit. In 1929 the change in the retail price of complete fertilizers in New Hampshire per unit change in ammonia content was more than the wholesale price of ammonia in sulfate of ammonia or in nitrate of soda, but less than that in tankage or in dried blood.

During the five-year period 1925 to 1929, more than 70 per cent of the ammonia in fertilizers registered in Maryland was from sulfate of ammonia, nitrate of soda, and tankage.<sup>7</sup> The proportion of the total ammonia from each of these materials varied from year to year.

During the ten-year period 1920 to 1929, the change in the retail price of the complete fertilizers in New Hampshire per unit change in ammonia

<sup>7</sup> Materials used in Maryland fertilizers 1925 to 1930. Fertilizer economics, no. 16, p. 94, February, 1930.

TABLE 89. CHANGE IN THE NEW HAMPSHIRE RETAIL PRICE OF COMPLETE FERTILIZERS PER UNIT INCREASE IN AMMONIA CONTENT, AND WHOLESALE PRICE OF AMMONIA IN DRIED BLOOD, TANKAGE, NITRATE OF SODA, AND SULFATE OF AMMONIA, 1920 TO 1929

Year	Change in retail price per ton of complete fertilizers ( $x_1$ ) in New Hampshire per unit increase in guaranteed ammonia content ( $x_2$ ) eliminating the effect of variations in the guaranteed phosphoric-acid ( $x_3$ ) and potash ( $x_4$ ) content $b_{12-34}$	Wholesale price of ammonia per unit				Difference between change in retail price per unit increase in ammonia content, and wholesale price of ammonia*			
		In dried blood	In tankage	In nitrate of soda	In sulfate of ammonia	In dried blood	In tankage	In nitrate of soda	In sulfate of ammonia
1920-1929	\$4.00	\$4.49	\$3.98	\$2.74	\$2.26	-\$0.50	+\$0.02	+\$1.25	+\$1.73
1922-1929	3.52	4.05	3.54	2.59	2.08	- 0.54	- 0.02	+ 0.93	+ 1.44
1920	6.24	7.52	7.12	3.51	3.20	- 1.28	- 0.88	+ 2.73	+ 3.04
1921	5.58	5.00	4.36	3.20	2.83	+ 0.58	+ 1.22	+ 2.38	+ 2.75
1922	3.53	3.51	2.92	2.57	1.87	+ 0.02	+ 0.61	+ 0.96	+ 1.66
1923	3.76	4.44	4.24	2.65	2.46	- 0.68	- 0.48	+ 1.11	+ 1.30
1924	3.57	3.45	3.00	2.63	2.26	+ 0.12	+ 0.57	+ 0.94	+ 1.31
1925	5.06	3.54	3.24	2.67	2.02	+ 1.52	+ 1.82	+ 2.39	+ 3.04
1926	4.22	3.93	3.39	2.75	2.17	+ 0.29	+ 0.83	+ 1.47	+ 2.05
1927	2.50	4.10	3.75	2.68	1.98	- 1.60	- 1.25	- 0.18	+ 0.52
1928	2.54	4.82	3.68	2.46	1.98	- 2.28	- 1.14	+ 0.08	+ 0.56
1929	2.95	4.62	4.10	2.31	1.87	- 1.67	- 1.15	+ 0.64	+ 1.08

\* The difference is equal to  $b_{12-34}$  minus the wholesale price.

content averaged \$4.00. The average wholesale price of ammonia in tankage during this period was practically the same, \$3.98. During the eight-year period 1922 to 1929, the corresponding average prices were \$3.52 and \$3.54, respectively. Although these averages are almost identical, since 1925 there has been little or no similarity between the year-to-year changes in the price of ammonia in tankage and the change in the retail price of complete fertilizers per unit change in ammonia content (figure 40). The relatively high price of organic ammonia during the post-war period has stimulated the use of mineral and synthetic ammoniates.

The change in the retail price of complete fertilizers in New Hampshire per unit change in phosphoric-acid content, and the wholesale price of phosphoric acid, are shown in table 90 and figure 41. In 1924 the average retail price of twelve samples which contained 6 per cent of phosphoric acid was \$57.18; the average price of fifty-two samples which had a guarantee of 8 per cent of phosphoric acid was \$48.76. The 6-per-cent-phosphoric-acid grades had a higher percentage of ammonia and potash. Even when the differences in ammonia and potash content are taken into consideration, the average price of the 8-per-cent grades was less than that of the 6-per-cent grades.

In only two years of the ten was the change in the retail price of the complete fertilizers per unit change in phosphoric-acid content as great as the wholesale price of phosphoric acid in superphosphate. This seems to indicate that in eight of the ten years there was a wider gross margin on the brands containing a relatively small percentage of phosphoric acid.

The change in the retail price per unit change in potash content, and the wholesale price of potash in muriate and in 20-per-cent manure salts, are

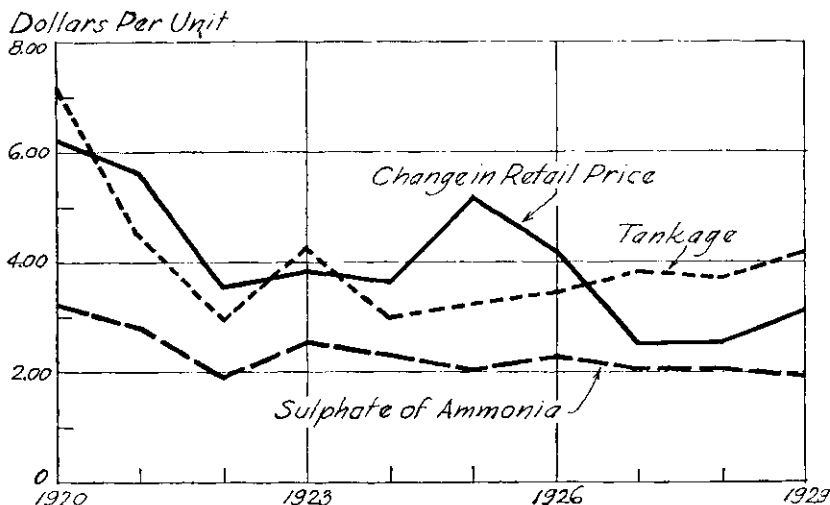


FIGURE 40. WHOLESALE PRICE OF AMMONIA PER UNIT IN TANKAGE AND IN SULPHATE OF AMMONIA, AND CHANGE IN THE RETAIL PRICE PER TON OF COMPLETE FERTILIZERS IN NEW HAMPSHIRE PER UNIT CHANGE IN AMMONIA CONTENT, 1920 TO 1929

(Change in retail price = net regression coefficient)

The change in the retail price of complete fertilizers per unit change in ammonia content has fluctuated around the wholesale price of ammonia in tankage. It is likely that in the future the change in the retail price of complete fertilizers per unit variation in ammonia content will be more equal to the wholesale price of sulfate of ammonia

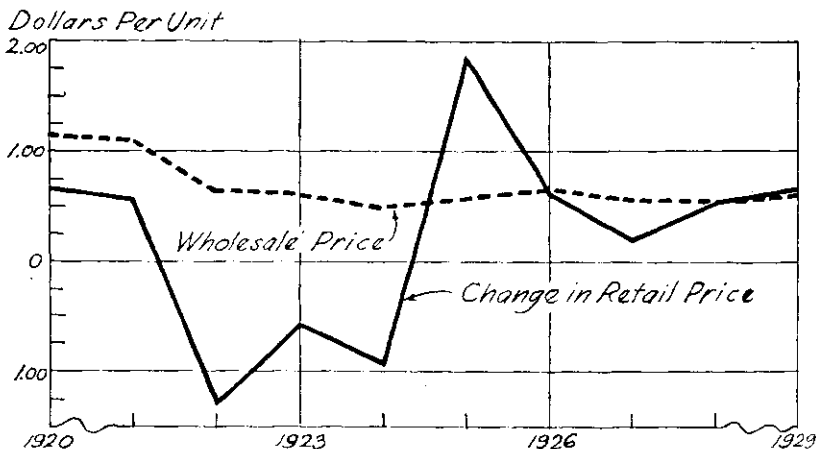


FIGURE 41. WHOLESALE PRICE OF PHOSPHORIC ACID IN SUPERPHOSPHATE AT BALTIMORE, AND CHANGE IN THE RETAIL PRICE PER TON OF COMPLETE FERTILIZERS IN NEW HAMPSHIRE PER UNIT CHANGE IN PHOSPHORIC-ACID CONTENT, 1920 TO 1929

(Change in retail price = net regression coefficient)

The change in the retail price of complete fertilizers per unit change in phosphoric-acid content has averaged less than the wholesale price

TABLE 90. CHANGE IN THE NEW HAMPSHIRE RETAIL PRICE OF COMPLETE FERTILIZERS PER UNIT INCREASE IN PHOSPHORIC-ACID CONTENT, AND WHOLESALE PRICE OF PHOSPHORIC ACID, 1920 TO 1929

Year	Change in retail price per ton of complete fertilizers ( $x_1$ ) in New Hampshire per unit increase in guaranteed phosphoric-acid content ( $x_2$ ) eliminating the effect of variations in the guaranteed ammonia ( $x_3$ ) and potash ( $x_4$ ) content D18-24	Wholesale price of phosphoric acid per unit in super-phosphate at Baltimore	Difference between change in retail price, and wholesale price
1920-1929	\$0.22	\$0.68	-\$0.46
1922-1929	0.12	0.57	- 0.45
1920	0.65	1.16	- 0.51
1921	0.53	1.08	- 0.55
1922	- 1.30	0.64	- 1.94
1923	- 0.59	0.58	- 1.17
1924	- 0.95	0.50	- 1.45
1925	1.84	0.54	+ 1.30
1926	0.59	0.61	- 0.02
1927	0.20	0.55	- 0.35
1928	0.53	0.54	- 0.01
1929	0.67	0.62	+ 0.05

shown in figure 42. In only two years of the ten was the change in the retail price per unit change in potash content more than the wholesale price of potash in either muriate or manure salts. The increase in the retail price per unit increase in potash content tended to fluctuate around the wholesale price. That is, the increase in the retail price per unit increase in potash content tended to be about the same as the wholesale price.

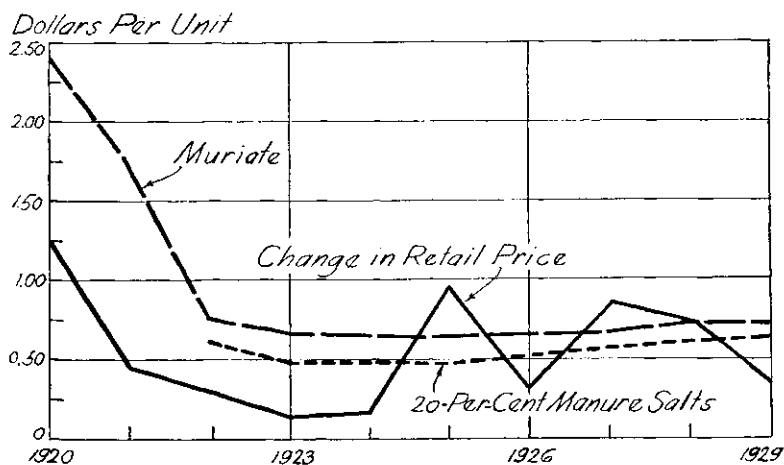


FIGURE 42. WHOLESALE PRICE OF POTASH PER UNIT IN MURIATE AND IN 20-PER-CENT MANURE SALTS, AND CHANGE IN THE RETAIL PRICE PER TON OF COMPLETE FERTILIZERS IN NEW HAMPSHIRE PER UNIT CHANGE IN POTASH CONTENT, 1920 TO 1929

(Change in retail price = net regression coefficient)

The change in the retail price of complete fertilizers per unit change in potash content has fluctuated around the wholesale price

TABLE 91. CHANGE IN THE NEW HAMPSHIRE RETAIL PRICE OF COMPLETE FERTILIZERS PER UNIT INCREASE IN POTASH CONTENT, AND WHOLESALE PRICE OF POTASH, 1920 TO 1929

Year	Change in retail price per ton of complete fertilizers ( $x_1$ ) in New Hampshire per unit increase in guaranteed potash content ( $x_2$ ) eliminating the effect of variations in the guaranteed ammonia ( $x_3$ ) and phosphoric-acid ( $x_4$ ) content b14-23	Wholesale price of potash per unit in bagged muriate at ports	Difference between change in retail price, and wholesale price
1920-1929.....	\$0.55	\$0.97	-\$0.42
1922-1929.....	0.47	0.68	- 0.21
1920.....	1.25	2.46	- 1.21
1921.....	0.46	1.81	- 1.35
1922.....	0.31	0.77	- 0.46
1923.....	0.12	0.66	- 0.54
1924.....	0.16	0.63	- 0.47
1925.....	0.94	0.63	+ 0.31
1926.....	0.34	0.64	- 0.30
1927.....	0.84	0.66	+ 0.18
1928.....	0.72	0.72	0.00
1929.....	0.35	0.72	- 0.37

For the ten years 1920 to 1929, the coefficient of variability of the phosphoric-acid content averaged 20.11, as compared with 47.22 for the ammonia content and 51.24 for the potash content (table 92 and figure 43). The coefficient of variability of the phosphoric-acid content increased from 7.68 in 1920 to 31.02 in 1929. This increase in variability was due

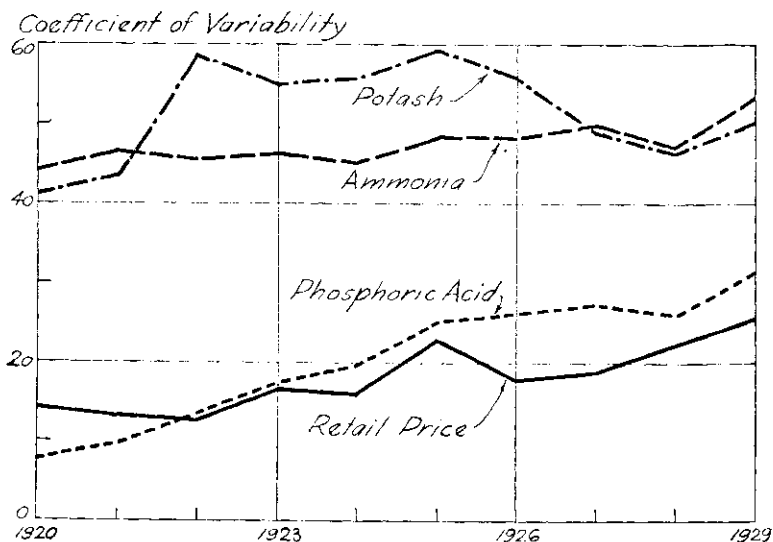


FIGURE 43. COEFFICIENTS OF VARIABILITY OF THE RETAIL PRICE AND THE ANALYSIS OF COMPLETE FERTILIZERS IN NEW HAMPSHIRE, 1920 TO 1929

The retail price was less variable than the analysis. The variability of the retail price increased

in large part to the introduction of double-strength or highly concentrated fertilizers. There was also some increase in the variability of the ammonia content.

TABLE 92. STANDARD DEVIATIONS AND COEFFICIENTS OF VARIABILITY OF THE RETAIL PRICE AND THE ANALYSIS OF COMPLETE FERTILIZERS IN NEW HAMPSHIRE, 1920 TO 1929

Year	Standard deviations				Coefficients of variability			
	Retail price per ton	Per cent of ammonia guaranteed	Per cent of phosphoric acid guaranteed	Per cent of potash guaranteed	Retail price per ton	Ammonia guaranteed	Phosphoric acid guaranteed	Potash guaranteed
1920-1929.....	\$ 9.04	1.67	1.65	2.58	17.71	47.22	20.11	51.24
1920.....	8.55	1.12	0.63	1.30	13.75	44.06	7.68	41.02
1921.....	7.70	1.25	0.76	1.41	12.84	46.43	9.33	42.81
1922.....	6.43	1.46	1.04	2.66	12.60	45.62	13.59	58.30
1923.....	7.85	1.56	1.31	2.80	16.27	45.89	17.06	54.94
1924.....	8.16	1.65	1.53	2.73	15.98	45.07	19.66	55.69
1925.....	11.89	1.79	2.04	3.33	22.29	47.96	24.55	58.75
1926.....	9.22	1.80	2.16	3.16	17.72	47.81	25.90	55.61
1927.....	7.91	1.97	2.26	2.75	18.48	49.71	26.88	48.93
1928.....	10.16	1.86	2.13	2.58	21.84	46.86	25.45	46.07
1929.....	12.49	2.25	2.68	3.03	25.33	52.81	31.02	50.24

The coefficient of variability of the retail price averaged only 17.71 for the period as a whole. With the exception of the two years 1920 and 1921, the variability of the price was less than the variability of the content of any of the three plant foods. The retail prices were more similar than the analyses.

The average plant-food content of the fertilizers has increased so that the decline in the average retail price of plant food per unit has been even greater than the decline in the average price per ton. In 1922 the average retail price per ton was \$50.98 (table 93). The plant-food content per ton averaged 14.87 units. The retail price was \$3.43 per unit, as compared

TABLE 93. AVERAGE RETAIL PRICE AND AVERAGE ANALYSIS OF COMPLETE FERTILIZERS IN NEW HAMPSHIRE, 1920 TO 1929

Year	Retail price per ton in New Hampshire	Per cent of ammonia guaranteed	Per cent of nitrogen guaranteed	Per cent of phosphoric acid guaranteed	Per cent of potash guaranteed	Total units of plant food per ton	Retail price of plant food per unit	Number of samples	Number of analyses
1920-1929...	\$51.64	3.52	2.90	8.16	4.96	16.02	\$3.28	82	26
1922-1929...	49.28	3.74	3.08	8.15	5.40	16.63	2.98	84	27
1920.....	62.15	2.55	2.10	8.23	3.17	13.50	4.60	71	21
1921.....	60.01	2.68	2.21	8.14	3.30	13.65	4.40	74	21
1922.....	50.98	3.20	2.64	7.66	4.57	14.87	3.43	70	24
1923.....	48.22	3.39	2.79	7.69	5.09	15.57	3.10	77	24
1924.....	51.05	3.66	3.01	7.79	4.90	15.70	3.25	90	28
1925.....	53.35	3.72	3.06	8.31	5.66	17.03	3.13	83	27
1926.....	52.03	3.77	3.10	8.35	5.69	17.14	3.04	81	25
1927.....	42.78	3.96	3.26	8.39	5.62	17.27	2.48	92	24
1928.....	46.54	3.97	3.27	8.38	5.61	17.26	2.70	90	26
1929.....	49.31	4.27	3.52	8.64	6.03	18.19	2.71	92	36

with \$2.71 in 1929. The decrease occurred even though there was an increase in the proportion of nitrogen. In 1922 about 17.8 per cent of the total plant food was nitrogen, as compared with 19.4 per cent in 1929. Lower prices for nitrogen have stimulated its use.

*In Indiana*

The average retail price and guaranteed analysis of complete fertilizers in Indiana for the period from 1906 to 1928 are presented in table 94. For the ten years 1906 to 1915 the average retail price per ton remained practically constant. The highest price for this period, \$24.56 in 1911, was only 4 per cent greater than the lowest price, \$23.66 in 1909.

TABLE 94. AVERAGE RETAIL PRICE, TONNAGE, AND AVERAGE ANALYSIS OF COMPLETE FERTILIZERS IN INDIANA, 1906 TO 1928

Year	Retail price per ton in Indiana	Number of tons	Per cent of nitrogen guaranteed	Per cent of phosphoric acid guaranteed	Per cent of potash guaranteed	Total units of plant food per ton	Retail price of plant food per unit	Per cent complete fertilizers were of total tonnage
1911-1914....	\$24.18	120,110	1.1	8.3	3.7	13.1	\$1.84	65
1924-1928....	37.76	125,390	1.6	11.5	4.2	17.4	2.18	56
1906.....	24.10	59,510	.....	.....	.....	.....	.....	60
1907.....	23.70	68,458	.....	.....	.....	.....	.....	68
1908.....	24.04	64,718	.....	.....	.....	.....	.....	63
1909.....	23.66	89,287	.....	.....	.....	.....	.....	67
1910.....	24.21	101,053	.....	.....	.....	.....	.....	67
1911.....	24.56	119,353	1.1	8.1	3.5	12.7	1.93	66
1912.....	24.09	94,968	1.1	8.2	3.7	13.0	1.85	66
1913.....	23.95	121,993	1.1	8.4	3.9	13.4	1.79	63
1914.....	24.12	144,126	1.1	8.5	3.7	13.3	1.81	66
1915.....	24.04	111,503	1.0	9.2	2.2	12.4	1.94	71
1916.....	26.91	58,699	1.0	9.6	1.2	11.8	2.28	44
1917.....	28.71	67,123	0.8	9.7	1.2	11.7	2.45	34
1918.....	36.68	78,266	0.6	9.5	1.2	11.3	3.25	32
1919.....	39.51	92,277	0.8	9.7	1.6	12.1	3.27	38
1920.....	43.72	80,868	0.9	9.7	2.1	12.7	3.44	35
1921.....	34.33	74,085	1.1	9.9	2.2	13.2	2.60	39
1922.....	31.35	91,903	1.3	10.3	2.8	14.4	2.18	44
1923.....	32.74	91,220	1.4	10.8	3.2	15.4	2.13	46
1924.....	35.63	86,714	1.5	11.1	3.8	16.4	2.17	45
1925.....	38.27	111,885	1.6	11.4	3.9	16.9	2.26	49
1926.....	38.08	131,529	1.6	10.6	4.2	16.4	2.32	58
1927.....	38.67	151,112	1.7	12.4	4.2	18.3	2.11	63
1928.....	38.15	145,709	1.8	12.2	4.9	18.9	2.02	66

The tonnage of complete fertilizers in 1914 was about 2.4 times as great as in 1906. This change in the fertilizer tonnage represented a change in the demand for fertilizer, since the retail price was practically constant.

The rising prices for agricultural products which occurred during this period was an important factor affecting the demand for fertilizer.

For the five years 1924 to 1928, the retail price of complete fertilizers in Indiana averaged \$37.76 per ton. This was 56 per cent more than the pre-war price, \$24.18 (table 95). The total plant-food content of the complete fertilizers averaged 33 per cent more than the pre-war figure, the nitrogen content was 45 per cent greater, the phosphoric-acid content was 39 per cent greater, and the potash content was 14 per cent greater.



TABLE 95. INDEX NUMBERS OF AVERAGE RETAIL PRICE, TONNAGE, AND AVERAGE ANALYSIS OF COMPLETE FERTILIZERS IN INDIANA, 1906 TO 1928

(1911-1914 = 100)

Year	Retail price per ton	Number of tons	Nitrogen guaranteed	Phosphoric acid guaranteed	Potash guaranteed	Total units of plant food per ton	Retail price of plant food per unit
1911-1914...	100	100	100	100	100	100	100
1924-1928...	156	104	145	139	114	133	118
1906.....	100	50	.....	.....	.....	.....	.....
1907.....	98	57	.....	.....	.....	.....	.....
1908.....	99	54	.....	.....	.....	.....	.....
1909.....	98	74	.....	.....	.....	.....	.....
1910.....	100	84	.....	.....	.....	.....	.....
1911.....	102	99	100	98	95	97	105
1912.....	100	79	100	99	100	99	101
1913.....	99	102	100	101	105	102	97
1914.....	100	120	100	102	100	102	98
1915.....	99	93	91	111	59	95	105
1916.....	111	49	91	116	32	90	124
1917.....	119	56	73	117	32	89	133
1918.....	152	65	55	114	32	86	177
1919.....	163	77	73	117	43	92	178
1920.....	181	67	82	117	57	97	187
1921.....	142	62	100	119	59	101	141
1922.....	130	77	118	124	76	110	118
1923.....	135	76	127	130	86	118	116
1924.....	147	72	136	134	103	125	118
1925.....	158	93	145	137	105	129	123
1926.....	157	110	145	128	114	125	126
1927.....	160	126	155	149	114	140	115
1928.....	158	121	164	147	132	144	110

Because of this increase in analysis, the average retail price of plant food per unit was 18 per cent greater than the pre-war average. These changes in analysis and price relationships were similar to those in other States.

The total cost of the materials that are used in making a ton of complete fertilizer is closely related to the analysis. A considerable proportion of the retail price of complete fertilizers, however, is made up of manufacturing, handling, and transportation costs. These costs are not closely related to the analysis; they tend to be comparatively uniform. Labor and transportation costs are practically double the pre-war figure. The increase in these fixed costs has made it more advantageous to use higher-analysis fertilizers. The high fixed charges and the increase in the average analysis have made the retail price per ton high. The increase in the number of units of plant food per ton has tended to reduce the retail price of plant food per unit.

For the four years 1911 to 1914, approximately 65 per cent of the total fertilizer tonnage in Indiana consisted of complete fertilizers (table 94). Owing to the scarcity of potash during the war period there was a marked decline in the tonnage of mixed fertilizers containing all three plant foods. In 1918 the complete fertilizers made up only 32 per cent of the total fertilizer tonnage. During the period from 1920 to 1928, both the tonnage and the relative importance of this class of fertilizers increased. In 1920 only 35 per cent of the total tonnage consisted of complete fertilizers, as compared with 66 per cent in 1928.

*In Texas*

The Texas fertilizer reports for the four seasons 1925-26 to 1928-29 contained the average retail selling price per ton and the guaranteed analysis of the various grades of fertilizers sold in the State. As defined in the reports, "the average retail selling price is the average of the cash retail price as furnished to the inspector by the dealer." The multiple correlations between the guaranteed analysis and the retail price were unusually high; none was lower than 0.986 (table 96). During these four seasons, variations in the analysis accounted for practically all the variations in price between the different grades.

TABLE 96. MULTIPLE CORRELATIONS BETWEEN THE RETAIL PRICE AND THE ANALYSIS OF COMPLETE FERTILIZERS, AND COEFFICIENTS OF DETERMINATION OF THE RETAIL PRICE BY THE ANALYSIS, TEXAS, 1925-26 TO 1928-29

Season	Multiple correlation between retail price and guaranteed nitrogen, phosphoric acid, and potash content $R_{1-234}$	Coefficients of determination of retail price by the analysis*				
		Total analysis $R^2_{1-234} \times 100$	Nitrogen guaranteed $d_{12-34}$	Phosphoric acid guaranteed $d_{13-24}$	Potash guaranteed $d_{14-23}$	Factors other than the analysis $d_{12}^\dagger$
Average.....	0.992	98.30	62.57	13.88	21.84	1.70
1925-26.....	0.993	98.57	76.84	7.37	14.36	1.43
1926-27.....	0.986	97.24	51.76	9.36	36.12	2.76
1927-28.....	0.996	99.11	60.93	20.19	17.99	0.89
1928-29.....	0.991	98.27	60.76	18.62	18.90	1.73

\*  $x_1$  = retail price per ton;  $x_2$  = per cent of nitrogen guaranteed;  $x_3$  = per cent of phosphoric acid guaranteed;  $x_4$  = per cent of potash guaranteed.

† Calculated by subtracting  $(R^2_{1-234} \times 100)$  from 100.

Retail prices in Texas were available for only fifteen to sixteen different grades of complete fertilizers per annum. The average retail price of each grade was based on a relatively large number of samples. Thus the margin and the geographic differences tended to be completely eliminated leaving only differences due to variations in analysis. In the other States the average number of samples per grade was considerably lower. Some of the differences in the correlations between the analysis and the retail price for the various States may be due to the number of samples per grade. With a large number of samples per grade the correlations between price and analysis would probably tend to be higher than when there were relatively few samples per grade, because margin and geographic differences may not have been entirely eliminated.

For the four seasons the coefficient of determination of the retail price by nitrogen averaged 62.57, as compared with 13.88 by phosphoric acid and 21.84 by potash. The nitrogen content of the fertilizer was the most important factor affecting the retail price, with potash second in importance and phosphoric acid third. The relative importance of the different items in the analysis was much the same as in the other States.

The increase in the retail price per unit change in nitrogen content averaged \$3.92 for the four seasons (table 97). This was less than the

wholesale price of nitrogen in either dried blood or tankage, but greater than the wholesale price of nitrogen in nitrate of soda or in sulfate of ammonia.

TABLE 97. CHANGE IN THE TEXAS RETAIL PRICE OF COMPLETE FERTILIZERS PER UNIT INCREASE IN NITROGEN CONTENT, AND WHOLESAL PRICE OF NITROGEN IN DRIED BLOOD, TANKAGE, NITRATE OF SODA, AND SULFATE OF AMMONIA, 1925-26 TO 1928-29

Season	Change in retail price per ton of complete fertilizers ( $x_1$ ) in Texas per unit increase in guaranteed nitrogen content ( $x_2$ ) eliminating the effect of variations in the guaranteed phosphoric-acid ( $x_3$ ) and potash ( $x_4$ ) content $b_{12-24}$	Wholesale price of nitrogen per unit				Difference between change in retail price per unit increase in nitrogen content, and wholesale price of nitrogen*			
		In dried blood	In tankage	In nitrate of soda	In sulfate of ammonia	In dried blood	In tankage	In nitrate of soda	In sulfate of ammonia
Average...	\$3.92	\$5.30	\$4.53	\$3.10	\$2.43	-\$1.39	-\$0.62	+\$0.82	+\$1.49
1925-26...	4.57	4.77	4.12	3.34	2.64	-0.20	+0.45	+1.23	+1.93
1926-27...	3.72	4.98	4.55	3.25	2.40	-1.26	-0.83	+0.47	+1.32
1927-28...	3.51	5.85	4.47	2.99	2.40	-2.34	-0.96	+0.52	+1.11
1928-29...	3.86	5.61	4.98	2.81	2.27	-1.75	-1.12	+1.05	+1.59

\* The difference is equal to  $b_{12-24}$  minus the wholesale price.

The change in the retail price per unit change in phosphoric-acid content averaged 84 cents (table 98). This was 26 cents more than the wholesale price of phosphoric acid at Baltimore. In each of the four seasons the

TABLE 98. CHANGE IN THE TEXAS RETAIL PRICE OF COMPLETE FERTILIZERS PER UNIT INCREASE IN PHOSPHORIC-ACID CONTENT, AND WHOLESAL PRICE OF PHOSPHORIC ACID, 1925-26 TO 1928-29

Season	Change in the retail price per ton of complete fertilizers ( $x_1$ ) in Texas per unit increase in guaranteed phosphoric-acid content ( $x_2$ ) eliminating the effect of variations in the guaranteed nitrogen ( $x_3$ ) and potash ( $x_4$ ) content $b_{12-24}$	Wholesale price of phosphoric acid per unit in superphosphate at Baltimore	Difference between change in retail price, and wholesale price
Average.....	\$0.84	\$0.58	+\$0.26
1925-26.....	0.66	0.61	+0.05
1926-27.....	0.87	0.55	+0.32
1927-28.....	0.94	0.54	+0.40
1928-29.....	0.87	0.62	+0.25

change in the retail price per unit change in phosphoric-acid content was greater than the wholesale price of phosphoric acid. Wholesale prices of phosphoric acid at Baltimore, however, are probably not strictly comparable with wholesale prices at manufacturing points nearer Texas. The change in the retail price of complete fertilizers in Texas per unit change in phosphoric-acid content should be compared with wholesale prices at a market typical for those companies that manufacture fertilizers for the Texas trade.

The change in the retail price of complete fertilizers in Texas per unit change in potash content averaged \$1.21 for the four seasons (table 99). This was 52 cents more than the wholesale price per unit of potash in bagged muriate. In the other States the change in the retail price per unit

TABLE 99. CHANGE IN THE TEXAS RETAIL PRICE OF COMPLETE FERTILIZERS PER UNIT CHANGE IN POTASH CONTENT, AND WHOLESALE PRICE OF POTASH, 1925-26 TO 1928-29

Season	Change in the retail price per ton of complete fertilizers ( $x_1$ ) in Texas per unit increase in guaranteed potash content ( $x_1$ ) eliminating the effect of variations in the guaranteed nitrogen ( $x_2$ ) and phosphoric-acid ( $x_3$ ) content b14-2	Wholesale price of potash per unit in bagged muriate at ports	Difference between change in retail price, and wholesale price
Average.....	\$1.21	\$0.68	+\$0.52
1925-26.....	0.78	0.64	+ 0.14
1926-27.....	1.87	0.66	+ 1.21
1927-28.....	1.00	0.72	+ 0.28
1928-29.....	1.18	0.72	+ 0.46

increase in potash content fluctuated around the wholesale price. In Texas the change in the retail price per unit increase in potash content has been consistently greater than the wholesale price of potash.

The nitrogen content of the complete fertilizers in Texas averaged 3.66 per cent for the four seasons (table 100); the potash content was

TABLE 100. AVERAGE RETAIL PRICE AND AVERAGE ANALYSIS OF COMPLETE FERTILIZERS IN TEXAS, 1925-26 TO 1928-29

Season	Retail price per ton in Texas	Per cent of nitrogen guaranteed	Per cent of phosphoric acid guaranteed	Per cent of potash guaranteed	Total units of plant food per ton	Retail price of plant food per unit	Number of samples	Number of analyses
Average.....	\$39.32	3.66	10.50	3.76	17.92	\$2.20	684	16
1925-26.....	41.72	3.42	10.40	3.38	17.20	2.43	593	15
1926-27.....	37.78	3.54	10.22	3.83	17.59	2.15	567	16
1927-28.....	38.77	3.75	10.57	3.76	18.06	2.15	655	16
1928-29.....	38.99	3.96	10.79	4.07	18.82	2.07	919	15

practically the same, 3.76 per cent. Many of the grades contained equal amounts of nitrogen and potash. This relationship between the nitrogen and the potash content was rather unusual, as compared with the situation in other States. In New York, for the three years 1926 to 1928 the complete fertilizers averaged 2.75 per cent of nitrogen and 5.52 per cent of potash. Similarly, in Pennsylvania, New Hampshire, Connecticut, and Indiana, the potash content of the fertilizers was distinctly greater than the nitrogen content. The total plant-food content of the complete fertilizers sold in Texas was about the same as in other States.

Even with the high degree of relationship between price and analysis, the price was much less variable than was the analysis (table 101). Relatively large variations in the analysis were associated with small percentage

variations in the retail price. The retail price of a fertilizer varies with the costs of the materials used in manufacturing it; a large part of the retail price, however, is made up of costs of manufacture and distribution, and, since these costs tend to be a uniform amount per ton, the variability of the retail price tends to be low as compared with the variability of the analysis.

TABLE 101. STANDARD DEVIATIONS AND COEFFICIENTS OF VARIABILITY OF THE RETAIL PRICE AND THE ANALYSIS OF COMPLETE FERTILIZERS IN TEXAS, 1925-26 TO 1928-29

Season	Standard deviations				Coefficients of variability			
	Retail price per ton	Per cent of nitrogen guaranteed	Per cent of phosphoric acid guaranteed	Per cent of potash guaranteed	Retail price per ton	Nitrogen guaranteed	Phosphoric acid guaranteed	Potash guaranteed
Average.....	\$5.66	0.96	1.90	1.32	14.45	26.22	18.07	35.10
1925-26.....	4.98	0.87	1.73	1.22	11.95	25.55	16.59	36.01
1926-27.....	6.13	0.93	1.83	1.47	16.24	26.34	17.91	38.23
1927-28.....	5.40	1.00	1.90	1.26	13.93	26.90	18.00	33.59
1928-29.....	6.11	1.03	2.13	1.33	15.68	26.09	19.78	32.58

### *In Connecticut*

The fertilizer reports for New York, New Hampshire, and Texas contained the average retail price of the various analyses or grades of complete fertilizers, and the number of samples that were obtained of each grade. The retail price of each sample was not given. In making the correlations between the retail price and the analysis, each grade or analysis was weighted by the number of samples reported. The Pennsylvania reports for some of the years contained the average retail price of each grade or analysis. For the other years the average retail price for each grade was calculated from the prices of the individual samples. The correlations between price and analysis were calculated in the same way as for the other States, each grade being weighted according to the number of samples.

There is some variation in the retail price of the same grade, or analysis, of complete fertilizers. Some of this variation is due to geographical differences in price. Retail prices of the same grade of fertilizer tend to be higher as the distance from the manufacturing point increases, owing to the increased cost of transportation. By taking the average retail price of each grade, this geographical variation in prices tends to be eliminated.

The Connecticut fertilizer reports contained the retail price of most of the samples reported. In calculating the coefficients of correlation between price and analysis for Connecticut, each sample was used individually. None of the variation in the retail price was eliminated by calculating the average price of each grade. Thus the coefficients of correlation for Connecticut are not precisely comparable with those for the other States.

In 1923 the multiple correlation between the retail price and the analysis of complete fertilizers in Connecticut was 0.958 (table 102). The variation in the analysis accounted for 91.88 per cent of the variability

in the retail price. This was a higher degree of relationship than for any other year during the forty years 1884 to 1923. In 1922 the analysis accounted for only 56.10 per cent of the variability in the retail price; factors other than the analysis accounted for 43.90 per cent.

The coefficients of determination of the Connecticut retail price of complete fertilizers by the guaranteed analysis for the forty-year period 1884 to 1923 are presented in table 102 and figure 44. During the fifteen-year period 1884 to 1898 there was a tendency for the relationship between price and analysis to decline. For the three years 1884 to 1886 the coefficient of determination averaged 70.58, as compared with 65.15 for the three years 1896 to 1898.

TABLE 102. MULTIPLE CORRELATIONS BETWEEN THE RETAIL PRICE AND THE ANALYSIS OF COMPLETE FERTILIZERS, AND COEFFICIENTS OF DETERMINATION OF THE RETAIL PRICE BY THE ANALYSIS, CONNECTICUT, 1884 TO 1923

Year	Multiple correlation between retail price and guaranteed nitrogen, phosphoric acid, and potash content $R_{1-23}$	Coefficients of determination of retail price by the analysis*				
		Total analysis $R^2_{1-23}$ $\times 100$	Nitrogen guaranteed $d_{12-23}$	Phosphoric acid guaranteed $d_{13-23}$	Potash guaranteed $d_{14-23}$	Factors other than the analysis $d_{15-23}$ †
1884-1888...	0.839	70.40	45.89	-3.73	28.24	29.60
1890-1894...	0.873	76.31	53.89	-5.07	27.50	23.69
1900-1904...	0.866	75.19	50.23	-4.52	29.48	24.81
1910-1913...	0.885	78.46	59.13	-5.20	24.54	21.54
1922-1923...	0.854	73.99	52.77	12.66	8.56	26.01
1884.....	0.837	70.06	44.41	-7.00	32.65	29.94
1885.....	0.809	65.49	34.97	0.69	29.82	34.51
1886.....	0.873	76.19	60.54	-5.54	21.19	23.81
1887.....	0.865	74.84	51.03	-1.21	25.03	25.16
1888.....	0.809	65.41	38.50	-5.59	32.50	34.59
1889.....	0.784	61.50	52.40	-10.05	19.15	38.50
1890.....	0.892	79.56	57.25	-1.61	23.93	20.44
1891.....	0.848	71.94	53.20	-4.60	23.34	28.06
1892.....	0.872	76.04	51.90	-6.79	30.93	23.96
1893.....	0.894	80.01	51.30	-7.69	36.40	19.99
1894.....	0.860	74.02	55.79	-4.67	22.90	25.98
1895.....	0.765	58.56	51.00	-2.72	10.28	41.44
1896.....	0.826	68.18	43.42	-2.66	27.49	31.82
1897.....	0.806	65.05	45.80	-2.68	21.93	34.95
1898.....	0.789	62.22	38.46	-1.44	25.21	37.78
1899.....	0.771	59.48	37.12	-2.29	24.66	40.52
1900.....	0.808	65.31	38.10	-2.47	29.68	34.69
1901.....	0.865	74.89	49.75	-5.22	30.36	25.11
1902.....	0.879	77.24	56.13	-5.40	26.52	22.76
1903.....	0.898	80.71	55.11	-5.27	30.87	19.29
1904.....	0.882	77.79	52.05	-4.23	29.97	22.21
1905.....	0.881	77.67	57.14	-2.38	22.91	22.33
1906.....	0.838	70.22	50.35	-2.52	22.39	29.78
1907.....	0.861	74.18	58.09	-3.41	19.49	25.82
1908.....	0.863	74.47	55.91	-3.81	22.37	25.53
1909.....	0.914	83.63	62.94	-5.51	26.20	16.37
1910.....	0.857	73.50	56.17	-4.31	21.65	26.50
1911.....	0.913	83.35	61.79	-5.23	26.79	16.65
1912.....	0.911	83.03	62.96	-6.19	26.26	16.97
1913.....	0.860	73.97	55.59	-5.07	23.45	26.03
1914.....	.....	.....	.....	.....	.....	.....
1915.....	0.891	79.38	73.08	-4.27	10.57	20.62
1916.....	0.933	87.07	85.07	-7.56	9.57	12.93
1917.....	0.925	85.64	66.81	-4.99	23.81	14.36
1918.....	0.930	86.42	70.27	2.76	13.39	13.58
1919.....	0.824	67.83	50.98	-4.70	21.54	32.17
1920.....	0.885	78.28	38.05	25.84	14.39	21.72
1921.....	0.814	66.26	39.21	11.89	15.16	33.74
1922.....	0.749	56.10	38.40	9.66	8.04	43.90
1923.....	0.958	91.88	67.14	15.67	9.08	8.12

\*  $x_1$  = retail price per ton;  $x_2$  = per cent of nitrogen guaranteed;  $x_3$  = per cent of phosphoric acid guaranteed;  $x_4$  = per cent of potash guaranteed.

† Calculated by subtracting ( $R^2_{1-23} \times 100$ ) from 100.

‡ Retail prices for 1914 were not available.

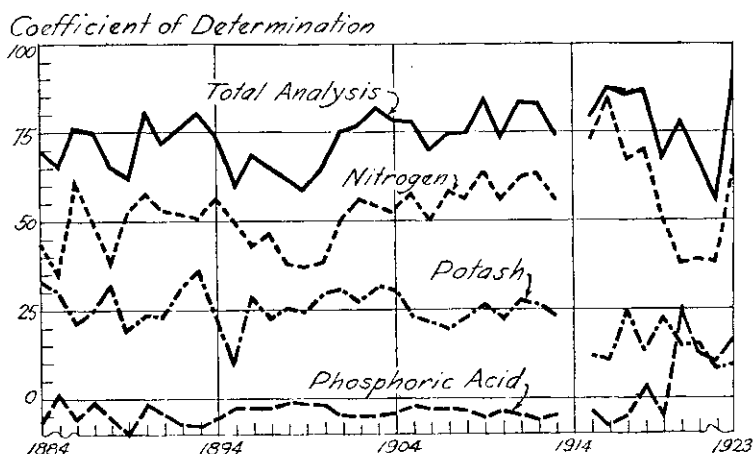


FIGURE 44. COEFFICIENTS OF DETERMINATION OF THE RETAIL PRICE OF COMPLETE FERTILIZERS IN CONNECTICUT BY THE NITROGEN, PHOSPHORIC-ACID, AND POTASH CONTENT, 1884 TO 1923

The nitrogen content of the fertilizer was the most important ingredient affecting the retail price

During the following sixteen-year period, 1899 to 1914, the tendency was reversed. The correlations between price and analysis tended to increase. This was much the same change as that which took place in the relationship between the price and the analysis of complete fertilizers in Pennsylvania.

For the four years 1915 to 1918 the multiple correlations between the price and the analysis were exceptionally high, averaging 0.920.

The retail price of the mixed fertilizer was more closely associated with the nitrogen content than with either of the other plant foods. This was true throughout the entire period. In all but twelve of the thirty-nine years the nitrogen content accounted for more than 50 per cent of the variability in the retail price. Thus, for two-thirds of the time, the nitrogen content of the fertilizers was more important in affecting the retail price than were all the other factors combined. Even in those years when the nitrogen content accounted for less than half of the total variability in the retail price, it was more important than either of the other two plant foods in affecting the retail price. The general increase in the relationship between price and analysis during the period from 1899 to 1914 was due primarily to higher correlations between the price and the nitrogen content.

In only four of the years did the phosphoric-acid content account for more than 10 per cent of the variability in the retail price of complete fertilizers in Connecticut. During the period from 1884 to 1919 there was no tendency for the importance of the phosphoric acid in affecting the retail price to increase or decrease. For the four years 1920 to 1923, however, the coefficient of determination for phosphoric acid averaged 15.76, as compared with 5.20 for the four years 1910 to 1913.

For the period from 1884 to 1923 (except 1914), the coefficient of determination of the retail price by the potash content averaged 23, as

compared with 53 for nitrogen and 4 for phosphoric acid. The potash content was thus more important than the phosphoric-acid content in affecting the retail price, but less important than the nitrogen content. During the four years 1920 to 1923 the potash content accounted for 11.67 per cent of the variation in the retail price, as compared with 15.76 per cent for the phosphoric-acid content. The general tendency for the period as a whole was for the coefficient of determination of the retail price by the potash content to decline.

The relationship between price and analysis of fertilizers in Connecticut, and the changes in this relationship from year to year, were much the same as in Pennsylvania.

More important than the degree of relationship between the analysis and the price is the effect of variations in the analysis on the retail price. In 1923 the retail price of complete fertilizers in Connecticut guaranteed to contain 4 per cent of nitrogen averaged \$5.81 per ton higher than that of grades guaranteed to contain only 3 per cent of nitrogen but with the same amount of phosphoric acid and potash (table 103). The retail price per ton varied by \$5.81 per unit variation in nitrogen content. In that year the wholesale price of nitrogen in dried blood was \$5.40 per unit, in nitrate of soda \$3.22 per unit, and in sulfate of ammonia \$2.99 per unit. The change in the retail price of the complete fertilizers in Connecticut per unit change in nitrogen content was greater than the wholesale price of nitrogen in any of these nitrogen carriers. This indicates that in 1923 there was a wider gross margin on those grades containing a relatively high percentage of nitrogen.

The change in the retail price per unit change in nitrogen content, and the wholesale price of nitrogen in dried blood, are shown in table 103 and figure 45. During the period from 1884 to 1899 the change in the

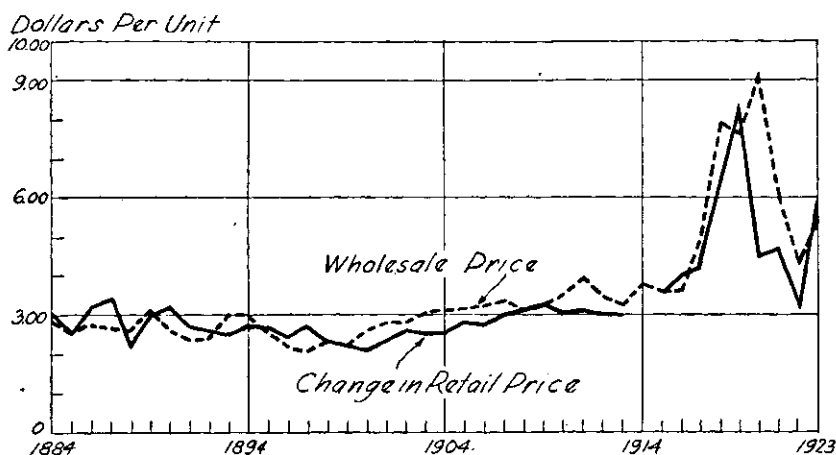


FIGURE 45. WHOLESALE PRICE OF NITROGEN PER UNIT IN DRIED BLOOD, AND CHANGE IN THE RETAIL PRICE PER TON OF COMPLETE FERTILIZERS IN CONNECTICUT PER UNIT CHANGE IN NITROGEN CONTENT, 1884 TO 1923

(Change in retail price = net regression coefficient)

The change in the retail price of complete fertilizers per unit change in nitrogen content has tended to fluctuate around the wholesale price of nitrogen in dried blood



TABLE 103. CHANGE IN THE CONNECTICUT RETAIL PRICE OF COMPLETE FERTILIZERS PER UNIT INCREASE IN NITROGEN CONTENT, AND WHOLESALE PRICE OF NITROGEN IN DRIED BLOOD, NITRATE OF SODA, AND SULFATE OF AMMONIA, 1884 TO 1923

Year	Change in retail price per ton of complete fertilizers (x <sub>1</sub> ) in Connecticut per unit increase in guaranteed nitrogen content (x <sub>2</sub> ) eliminating the effect of variations in the guaranteed phosphoric acid (x <sub>3</sub> ) and potash (x <sub>4</sub> ) content b <sub>12-24</sub>	Wholesale price of nitrogen per unit			Difference between change in retail price per unit increase in nitrogen content, and wholesale price of nitrogen*		
		In dried blood	In nitrate of soda	In sulfate of ammonia	In dried blood	In nitrate of soda	In sulfate of ammonia
1884-1888.....	\$2.87	\$2.73	\$2.84	\$3.03	+\$0.14	+\$0.03	-\$0.16
1890-1894.....	2.73	2.67	2.47	3.13	+ 0.05	+ 0.26	- 0.40
1900-1904.....	2.39	2.86	2.54	2.90	- 0.47	- 0.14	- 0.50
1910-1913.....	3.05	3.56	2.89	2.97	- 0.51	+ 0.16	+ 0.08
1922-1923.....	4.53	4.84	3.17	2.63	- 0.39	+ 1.36	+ 1.90
1884.....	3.02	2.89	2.94	3.26	+ 0.13	+ 0.08	- 0.24
1885.....	2.58	2.62	2.82	3.01	- 0.04	- 0.24	- 0.43
1886.....	3.18	2.81	3.12	3.03	+ 0.37	+ 0.06	+ 0.15
1887.....	3.38	2.74	2.77	2.91	+ 0.64	+ 0.61	+ 0.47
1888.....	2.19	2.57	2.57	2.96	- 0.38	- 0.38	- 0.77
1889.....	3.00	3.09	2.84	3.18	- 0.09	+ 0.16	- 0.18
1890.....	3.17	2.60	2.38	3.06	+ 0.57	+ 0.79	+ 0.11
1891.....	2.67	2.36	2.45	3.28	+ 0.31	+ 0.22	- 0.61
1892.....	2.62	2.41	2.42	2.96	+ 0.21	+ 0.20	- 0.34
1893.....	2.47	3.03	2.61	2.99	- 0.56	- 0.14	- 0.52
1894.....	2.70	2.97	2.47	3.34	- 0.27	+ 0.23	- 0.64
1895.....	2.67	2.61	2.43	3.18	+ 0.06	+ 0.24	- 0.51
1896.....	2.35	2.24	2.20	2.38	+ 0.11	+ 0.15	- 0.03
1897.....	2.69	2.11	2.30	2.14	+ 0.58	+ 0.39	+ 0.55
1898.....	2.30	2.27	2.26	2.26	+ 0.03	+ 0.04	+ 0.04
1899.....	2.20	2.19	2.02	2.65	+ 0.01	+ 0.18	- 0.45
1900.....	2.08	2.57	2.31	2.93	- 0.49	- 0.23	- 0.85
1901.....	2.28	2.80	2.32	2.71	- 0.52	- 0.04	- 0.43
1902.....	2.60	2.78	2.69	2.80	- 0.18	- 0.09	- 0.20
1903.....	2.47	3.06	2.58	2.99	- 0.59	- 0.11	- 0.52
1904.....	2.53	3.10	2.78	3.05	- 0.57	- 0.25	- 0.52
1905.....	2.80	3.14	2.97	3.03	- 0.34	- 0.17	- 0.23
1906.....	2.74	3.23	2.87	3.02	- 0.49	- 0.13	- 0.28
1907.....	2.98	3.34	3.22	3.02	- 0.36	- 0.24	- 0.04
1908.....	3.13	3.14	3.05	2.98	- 0.01	+ 0.08	+ 0.15
1909.....	3.28	3.26	2.81	2.85	+ 0.02	+ 0.47	+ 0.43
1910.....	3.05	3.53	2.70	2.66	- 0.48	+ 0.35	+ 0.39
1911.....	3.14	3.88	2.71	2.89	- 0.74	+ 0.43	+ 0.25
1912.....	3.02	3.53	2.89	3.15	- 0.51	+ 0.13	- 0.13
1913.....	2.99	3.31	3.26	3.17	- 0.32	- 0.27	- 0.18
1914†.....	.....	3.83	2.92	2.82	.....	.....	.....
1915.....	3.50	3.56	2.65	2.78	- 0.06	+ 0.85	+ 0.72
1916.....	3.99	3.60	3.89	3.55	+ 0.39	+ 0.10	+ 0.44
1917.....	4.20	4.96	4.30	4.01	- 0.76	- 0.10	+ 0.19
1918.....	6.43	8.00	5.97	4.96	- 1.57	+ 0.46	+ 1.47
1919.....	8.26	7.67	5.63	4.26	+ 0.59	+ 2.63	+ 4.00
1920.....	4.50	9.14	4.27	3.89	- 4.64	+ 0.23	+ 0.61
1921.....	4.66	6.08	3.89	3.44	- 1.42	+ 0.77	+ 1.22
1922.....	3.25	4.27	3.12	2.27	- 1.02	+ 0.13	+ 0.98
1923.....	5.81	5.40	3.22	2.99	+ 0.41	+ 2.59	+ 2.82

 \* The difference is equal to b<sub>12-24</sub> minus the wholesale price.

† Retail prices for 1914 were not available.

retail price of the complete fertilizers per unit change in nitrogen content fluctuated around the wholesale price of nitrogen in dried blood. For the period as a whole, the change in the retail price averaged \$2.70 per unit change in nitrogen content, while the wholesale price per unit of nitrogen in dried blood averaged \$2.59 and in sulfate of ammonia \$2.91. During this period the major part of the nitrogen in complete fertilizers was organic nitrogen. The change in the retail price of complete fertilizers per unit change in nitrogen content was much the same as the wholesale price of nitrogen in dried blood.

TABLE 104. INDEX NUMBERS OF THE CHANGE IN THE CONNECTICUT RETAIL PRICE OF COMPLETE FERTILIZERS PER UNIT INCREASE IN NITROGEN CONTENT, AND WHOLESALE PRICE OF NITROGEN IN DRIED BLOOD, NITRATE OF SODA, AND SULFATE OF AMMONIA, 1884 TO 1923

(1910-1913 = 100)

Year	Change in retail price per ton of complete fertilizers ( $x_1$ ) in Connecticut per unit increase in guaranteed nitrogen content ( $x_2$ ) eliminating the effect of variations in the guaranteed phosphoric-acid ( $x_3$ ) and potash ( $x_4$ ) content b12-24	Wholesale price of nitrogen per unit		
		In dried blood	In nitrate of soda	In sulfate of ammonia
1884-1888.....	94	77	98	102
1890-1894.....	90	75	85	105
1900-1904.....	78	80	88	98
1910-1913.....	100	100	100	100
1922-1923.....	149	136	110	89
1884.....	99	81	102	110
1885.....	85	74	98	101
1886.....	104	79	108	102
1887.....	111	77	96	98
1888.....	72	72	89	100
1889.....	98	87	98	107
1890.....	104	73	82	103
1891.....	88	66	85	110
1892.....	86	68	84	100
1893.....	81	85	90	101
1894.....	89	83	85	112
1895.....	88	73	84	107
1896.....	77	63	76	80
1897.....	88	59	80	72
1898.....	75	64	78	76
1899.....	72	62	70	89
1900.....	68	72	80	99
1901.....	75	79	80	91
1902.....	85	78	93	94
1903.....	81	86	89	101
1904.....	83	87	96	103
1905.....	92	88	103	102
1906.....	90	91	99	102
1907.....	98	94	111	102
1908.....	103	88	106	100
1909.....	108	92	97	96
1910.....	100	99	93	90
1911.....	103	109	94	97
1912.....	99	99	100	106
1913.....	98	93	113	107
1914*.....	.....	108	101	95
1915.....	115	100	92	94
1916.....	131	101	135	120
1917.....	138	139	149	135
1918.....	211	225	207	167
1919.....	271	215	195	143
1920.....	148	257	148	131
1921.....	153	171	135	116
1922.....	107	120	108	76
1923.....	190	152	111	101

\* Retail prices for 1914 were not available.

During the fourteen-year period 1900 to 1913, the change in the retail price of the complete fertilizers per unit change in nitrogen content averaged \$2.79 while the price of nitrogen in dried blood averaged \$3.19. That is, the change in the retail price averaged 40 cents per unit less than the wholesale price of nitrogen in dried blood, but was practically the same as the price of nitrogen in nitrate of soda. Prices of both organic and mineral ammoniates increased, but prices of organic ammoniates increased more rapidly, and there was an increase in the amount of mineral nitrogen used in complete fertilizers and a decrease in the amount of organic nitrogen.

For the thirty years 1884 to 1913, the change in the retail price of the complete fertilizers per unit change in nitrogen content averaged \$2.74. This was 8 cents per unit more than the average wholesale price of nitrogen in nitrate of soda, 13 cents per unit less than the price of nitrogen in dried blood, and 19 cents less than the price of nitrogen in sulfate of ammonia. This indicates that, for the period as a whole, variations in the retail price of the complete fertilizers per unit change in nitrogen content were approximately equal to the wholesale cost of the nitrogen, although there were variations from year to year. The cost of manufacture and distribution did not tend to vary with the analysis.

For the twenty-four-year period 1890 to 1913, the wholesale price of phosphoric acid in superphosphate averaged 62 cents per unit (table 105).

TABLE 105. CHANGE IN THE CONNECTICUT RETAIL PRICE OF COMPLETE FERTILIZERS PER UNIT INCREASE IN PHOSPHORIC-ACID CONTENT, AND WHOLESALE PRICE OF PHOSPHORIC ACID, 1884 TO 1923

Year	Change in retail price per ton of complete fertilizers ( $x_1$ ) in Connecticut per unit increase in guaranteed phosphoric-acid content ( $x_2$ ) eliminating the effect of variations in the guaranteed nitrogen ( $x_3$ ) and potash ( $x_4$ ) content b13-24	Wholesale price of phosphoric acid per unit in superphosphate at Baltimore	Difference between change in retail price, and wholesale price	Index numbers (1910-1913 = 100)	
				Change in retail price per ton per unit increase in phosphoric-acid content b13-24	Wholesale price of phosphoric acid in superphosphate
1884-1888	\$0.67			131	
1890-1894	0.69	\$0.71	-\$0.02	135	127
1900-1904	0.65	0.63	+0.02	127	112
1910-1913	0.51	0.56	-0.06	100	100
1922-1923	-1.04	0.61	-1.65	-204	109
1884	0.89			175	
1885	0.73			143	
1886	0.54			106	
1887	0.80			157	
1888	0.40			78	
1889	0.63			124	
1890	0.72	0.81	-0.09	141	145
1891	0.62	0.74	-0.12	122	132
1892	0.81	0.74	+0.07	159	132
1893	0.71	0.65	+0.06	139	116
1894	0.60	0.61	-0.01	118	109
1895	0.45	0.65	-0.20	88	116
1896	0.65	0.57	+0.08	127	102
1897	0.80	0.54	+0.26	157	96
1898	0.68	0.50	+0.18	133	89
1899	0.61	0.62	-0.01	120	111
1900	0.44	0.61	-0.17	86	109
1901	0.66	0.64	+0.02	122	114
1902	0.62	0.62	0.00	129	111
1903	0.69	0.63	+0.06	135	112
1904	0.83	0.64	+0.19	163	114
1905	0.66	0.64	+0.02	129	114
1906	0.47	0.64	-0.17	92	114
1907	0.63	0.64	-0.01	124	114
1908	0.65	0.66	-0.01	127	118
1909	0.74	0.57	+0.17	145	102
1910	0.41	0.58	-0.17	80	104
1911	0.52	0.63	-0.11	102	112
1912	0.56	0.53	+0.03	110	95
1913	0.54	0.52	+0.02	106	93
1914*		0.48			86
1915	0.63	0.48	+0.15	124	86
1916	0.62	0.72	-0.10	122	129
1917	0.51	0.76	-0.25	100	136
1918	-0.32	1.08	-1.40	-63	193
1919	0.87	1.07	-0.20	171	191
1920	-2.55	1.16	-3.71	-500	207
1921	-1.54	1.08	-2.62	-302	193
1922	-0.89	0.64	-1.53	-175	114
1923	-1.19	0.58	-1.77	-233	104

\* Retail prices for 1914 were not available.

For the same years the change in the retail price of complete fertilizers in Connecticut per unit change in phosphoric-acid content averaged 63 cents. Even though these two averages are practically the same, the change in the retail price per unit change in phosphoric-acid content and the wholesale price of phosphoric acid did not tend to be the same each year. The change in the retail price of the complete fertilizers per unit change in phosphoric-acid content fluctuated around the wholesale price of phosphoric acid (figure 46).

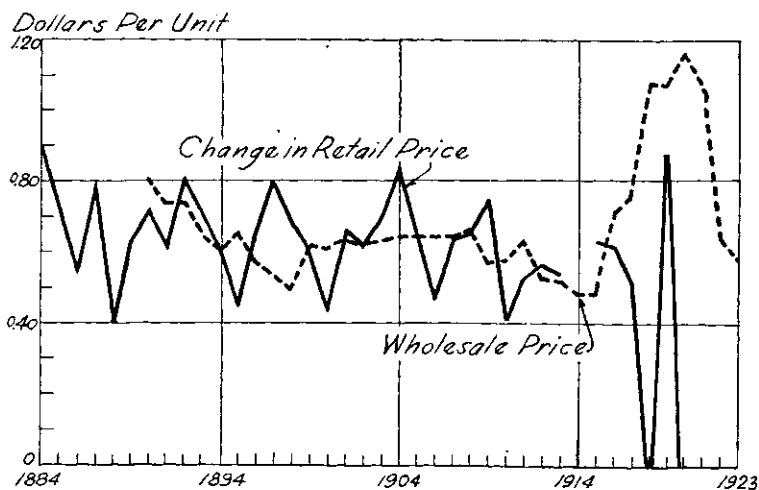


FIGURE 46. WHOLESALE PRICE OF PHOSPHORIC ACID PER UNIT IN SUPER-PHOSPHATE AT BALTIMORE, AND CHANGE IN THE RETAIL PRICE PER TON OF COMPLETE FERTILIZERS IN CONNECTICUT PER UNIT CHANGE IN PHOSPHORIC-ACID CONTENT, 1884 TO 1923

(Change in retail price = net regression coefficient)

During the pre-war period the change in the retail price of complete fertilizers per unit change in phosphoric acid tended to fluctuate around the wholesale price

For the four years 1920 to 1923, and in 1918, the retail price tended to decline as the phosphoric-acid content increased. As compared with the other years, this was a very unusual relationship. These years were years of violent changes in the prices of fertilizers and of commodities in general.

The change in the retail price of the complete fertilizers in Connecticut per unit change in potash content, and the wholesale price of potash in bagged muriate, are shown in table 106 and figure 47. The change in the retail price of the fertilizers per unit change in potash content fluctuated around the wholesale price of potash. For the thirty years 1884 to 1913, the wholesale price of potash in bagged muriate averaged 75 cents per unit. This was 3 cents per unit higher than the average change in the retail price of the complete fertilizers per unit change in potash content. In only eight of the thirty years was the difference between the wholesale price of the potash, and the change in the retail price per unit variation in the potash content of the fertilizers,

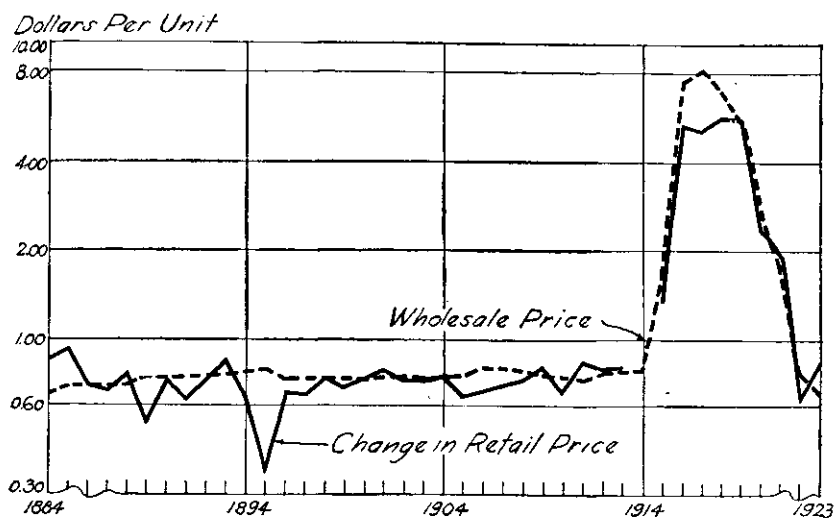


FIGURE 47. WHOLESALE PRICE OF POTASH IN BAGGED MURIATE, AND CHANGE IN THE RETAIL PRICE PER TON OF COMPLETE FERTILIZERS IN CONNECTICUT PER UNIT CHANGE IN POTASH CONTENT, 1884 TO 1923

(Change in retail price = net regression coefficient)

The change in the retail price of complete fertilizers per unit change in potash content has tended to fluctuate around the wholesale price of potash

more than 10 cents. The difference in the retail price between low-potash mixtures and high-potash mixtures tended to equal the wholesale cost of the additional potash.

During the period from 1915 to 1921, potash was high-priced. While the differences between the wholesale price of potash and the change in the retail price of complete fertilizers per unit change in potash content were considerably greater than during the pre-war period, the year-to-year changes in both prices were much the same.

Retail prices of complete fertilizers in Connecticut were available for only two post-deflation years, 1922 and 1923. For these two years the relationship between the wholesale price of potash and the change in the retail price was the same as for the pre-war period.

These data on the change in the retail price of complete fertilizers in Connecticut per unit change in analysis indicate that the retail prices of the various grades of fertilizers tend to differ by an amount approximately equal to the difference in the cost at wholesale prices of the plant food which they contain. This indicates that the costs of manufacture and distribution tend to be a uniform amount per ton and are not affected by the analysis of the fertilizer.

These results for Connecticut are somewhat different from the results for Pennsylvania. In Pennsylvania the change in the retail price of the complete fertilizers per unit change in ammonia content was consistently greater than the wholesale price of ammonia in dried blood, while in Connecticut, for the same years, the change in the retail price per unit change in

TABLE 106. CHANGE IN THE CONNECTICUT RETAIL PRICE OF COMPLETE FERTILIZERS PER UNIT INCREASE IN POTASH CONTENT, AND WHOLESALE PRICE OF POTASH 1884 TO 1923

Year	Change in retail price per ton of complete fertilizers ( $x_1$ ) in Connecticut per unit increase in guaranteed potash content ( $x_2$ ) eliminating the effect of variations in the guaranteed nitrogen ( $x_3$ ) and phosphoric-acid ( $x_4$ ) content b14-23	Wholesale price of potash per unit in bagged muriate at ports	Difference between change in retail price, and wholesale price	Index numbers (1910-1913 = 100)	
				Change in retail price per ton per unit increase in potash content b14-23	Wholesale price of potash in bagged muriate
1884-1888	\$0.79	\$0.70	+\$0.09	101	92
1890-1894	0.72	0.76	- 0.04	92	100
1900-1904	0.75	0.75	- 0.00	96	99
1910-1913	0.78	0.76	+ 0.01	100	100
1922-1923	0.72	0.72	0.00	92	95
1884	0.86	0.67	+ 0.19	110	88
1885	0.93	0.70	+ 0.23	119	92
1886	0.70	0.70	0.00	90	92
1887	0.68	0.70	- 0.02	87	92
1888	0.76	0.71	+ 0.05	97	93
1889	0.52	0.75	- 0.23	67	99
1890	0.73	0.75	- 0.02	94	99
1891	0.63	0.75	- 0.12	81	99
1892	0.72	0.76	- 0.04	92	100
1893	0.85	0.76	+ 0.09	109	100
1894	0.65	0.78	- 0.13	83	103
1895	0.35	0.79	- 0.44	45	104
1896	0.66	0.74	- 0.08	85	97
1897	0.64	0.74	- 0.10	82	97
1898	0.74	0.75	- 0.01	95	99
1899	0.69	0.74	- 0.05	88	97
1900	0.74	0.74	0.00	95	97
1901	0.78	0.75	+ 0.03	100	99
1902	0.73	0.75	- 0.02	94	99
1903	0.75	0.76	- 0.01	96	100
1904	0.77	0.77	0.00	99	101
1905	0.65	0.78	- 0.13	83	103
1906	0.67	0.80	- 0.13	86	105
1907	0.70	0.80	- 0.10	90	105
1908	0.73	0.79	- 0.06	94	104
1909	0.80	0.78	+ 0.02	103	103
1910	0.68	0.75	- 0.07	87	99
1911	0.83	0.73	+ 0.10	106	96
1912	0.79	0.78	+ 0.01	101	103
1913	0.80	0.79	+ 0.01	103	104
1914*	.....	0.79	.....	.....	104
1915	1.34	1.59	- 0.25	172	209
1916	5.32	7.42	- 2.10	682	976
1917	5.11	8.21	- 3.10	655	1,080
1918	5.98	7.13	- 1.15	767	938
1919	5.88	5.77	+ 0.11	754	759
1920	2.46	2.46	0.00	315	324
1921	1.92	1.81	+ 0.11	246	238
1922	0.62	0.77	- 0.15	79	101
1923	0.81	0.66	+ 0.15	104	87

\* Retail prices for 1914 were not available.

nitrogen content was less than the wholesale price of nitrogen in dried blood. In Pennsylvania, during the pre-war period, the change in the retail price of the complete fertilizers per unit change in phosphoric-acid content was consistently less than the wholesale price of phosphoric acid. The tendency, however, was for the difference between the wholesale price of phosphoric acid and the change in the retail price per unit change in phosphoric-acid content to decrease. Thus, in Pennsylvania the relationship between the wholesale price of phosphoric acid and the change in the retail price of complete fertilizers per unit change in phosphoric-acid

content seemed to be approaching the same relationship as existed in Connecticut for the entire period from 1890 to 1913.

In regard to the relationship between the wholesale price of potash and the change in the retail price of complete fertilizers per unit change in potash content, the results were the same for both States.

The correlations between the retail price and the analysis of the complete fertilizers indicate that there were factors other than the analysis which affected the retail price. The variations in the relationship between the wholesale prices of plant food and the change in the retail price of complete fertilizer per unit change in analysis indicate that there are some discrepancies between the normal price relationship and the relationship that actually does exist. Changes in the demand for fertilizer, and competition between manufacturers and dealers, are probably factors which account in part for the year-to-year differences in the relationship.

In Connecticut, as in the other States, the variability in the retail price of the different grades of fertilizer was much less than the variability in the analysis (table 107 and figure 48). During the period from 1884 to

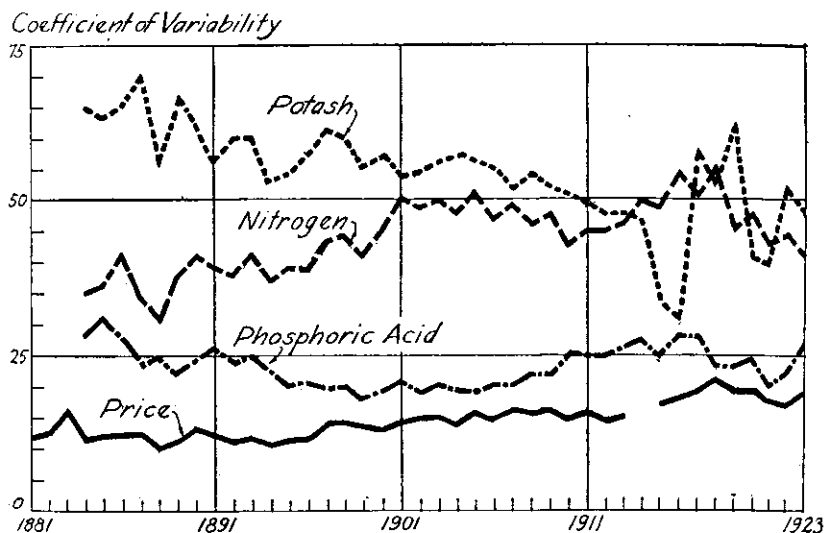


FIGURE 48. COEFFICIENTS OF VARIABILITY OF THE RETAIL PRICE AND THE ANALYSIS OF COMPLETE FERTILIZERS IN CONNECTICUT, 1881 TO 1923

The variability of the retail price and of the phosphoric-acid content were low as compared with the variability of the nitrogen and the potash content

1923, the coefficient of the variability of the retail price of complete fertilizers in Connecticut averaged 15, as compared with 23 for the phosphoric-acid content, 44 for nitrogen, and 55 for potash. For each year the variability of the retail price was less than the variability of any of the three plant foods.

Variations in the analysis, or plant-food content, of fertilizers are closely associated with variations in the cost of the materials necessary to make the fertilizers, and with the retail price. The cost of materials,

TABLE 107. STANDARD DEVIATIONS AND COEFFICIENTS OF VARIABILITY OF THE  
 RETAIL PRICE AND THE ANALYSIS OF COMPLETE FERTILIZERS IN CONNECTICUT  
 1881 TO 1923

Year	Standard deviations				Coefficients of variability			
	Retail price per ton	Per cent of nitrogen guaranteed	Per cent of phosphoric acid guaranteed	Per cent of potash guaranteed	Retail price per ton	Nitrogen guaranteed	Phosphoric acid guaranteed	Potash guaranteed
1884-1888	\$ 4.53	0.95	1.98	2.43	11.68	35.34	26.96	63.63
1890-1894	4.16	1.03	1.81	2.43	11.65	39.21	24.29	58.28
1900-1904	4.59	1.22	1.43	2.65	14.31	48.52	19.78	55.85
1910-1914	5.23*	1.32	1.71	2.68	15.13*	45.80	25.69	48.76
1922-1923	8.52	1.33	1.76	2.22	18.17	42.69	24.40	49.90
1881	5.56	.....	.....	.....	11.91	.....	.....	.....
1882	5.52	.....	.....	.....	12.16	.....	.....	.....
1883	7.23	.....	.....	.....	16.44	.....	.....	.....
1884	4.88	0.95	2.00	2.60	11.61	35.33	28.25	65.13
1885	4.86	0.98	2.18	2.42	12.18	35.64	30.67	62.71
1886	4.70	1.09	2.02	2.29	12.43	40.52	27.69	64.70
1887	4.64	0.91	1.79	2.70	12.51	34.05	23.50	69.85
1888	3.55	0.84	1.89	2.15	9.66	31.14	24.68	55.74
1889	3.90	0.96	1.73	2.88	10.78	38.17	22.04	65.59
1890	4.69	1.04	1.81	2.47	13.19	41.45	23.78	62.03
1891	4.31	1.09	1.91	2.53	11.90	39.26	25.86	55.77
1892	3.88	1.00	1.73	2.56	10.91	37.91	23.58	60.25
1893	4.05	1.05	1.84	2.47	11.49	40.54	24.83	60.48
1894	3.85	0.99	1.74	2.13	10.75	36.91	23.41	52.85
1895	4.00	1.03	1.53	2.28	11.31	39.03	20.42	54.34
1896	3.97	0.98	1.53	2.57	11.55	38.62	20.64	56.76
1897	4.57	1.04	1.48	2.60	13.96	43.47	19.76	61.07
1898	4.47	1.06	1.48	2.54	14.27	44.10	19.90	59.55
1899	4.21	1.01	1.37	2.46	13.48	41.06	18.34	55.06
1900	4.15	1.05	1.37	2.54	13.34	45.04	18.93	57.42
1901	4.54	1.28	1.51	2.70	14.14	50.32	21.13	53.90
1902	4.75	1.26	1.41	2.59	14.83	49.47	19.31	54.42
1903	4.88	1.31	1.44	2.78	15.16	49.81	20.20	56.32
1904	4.61	1.18	1.41	2.65	14.07	47.95	19.34	57.19
1905	5.09	1.25	1.37	2.67	15.67	50.68	19.04	55.93
1906	5.12	1.22	1.45	2.74	15.45	47.47	20.27	55.07
1907	5.43	1.32	1.45	2.58	16.18	48.94	20.40	52.18
1908	5.32	1.21	1.53	2.70	15.70	45.75	21.89	54.44
1909	5.48	1.26	1.51	2.69	16.04	48.04	21.66	52.14
1910	5.10	1.19	1.68	2.69	14.88	42.82	25.12	50.90
1911	5.45	1.30	1.66	2.71	15.71	45.34	24.94	49.54
1912	5.02	1.29	1.65	2.68	14.51	44.80	24.90	48.10
1913	5.35	1.32	1.76	2.68	15.43	46.14	26.36	48.10
1914†	.....	1.50	1.78	2.64	.....	49.92	27.13	47.18
1915	6.07	1.50	1.78	1.07	16.73	48.66	24.64	34.25
1916	6.79	1.63	2.15	0.32	18.05	53.99	27.97	30.68
1917	7.17	1.50	2.14	0.71	18.56	51.10	27.75	58.08
1918	11.52	1.52	1.86	0.68	20.96	55.26	23.13	52.66
1919	11.97	1.09	1.82	0.94	19.39	45.31	22.59	62.49
1920	12.63	1.30	1.74	1.34	19.46	47.56	23.70	41.18
1921	10.78	1.16	1.50	1.45	17.97	43.48	19.73	40.40
1922	7.89	1.31	1.59	2.21	16.85	44.52	21.63	51.81
1923	9.16	1.35	1.94	2.23	19.49	40.86	27.16	48.00

\* For 1910 to 1913 only.

† Retail prices for 1914 were not available.

however, is only a part of the retail price. The costs of manufacture and distribution also constitute a part of the retail price, but these costs do not vary greatly with the analysis. Thus the variability of the retail price tends to be low as compared with the variability of the analysis.

There has been some tendency, however, for the variability of the retail price to increase. For the five years 1884 to 1888 the coefficient of variability of the price averaged 11.68, as compared with 15.13 for the four years 1910 to 1913, and 18.17 for the two years 1922 and 1923.



Superphosphate is used as a basis for most mixed fertilizers. To it are added various amounts of nitrogen and potash. Thus the variability of the phosphoric-acid content tends to be low as compared with that of the other plant foods. The small amount of variability of the phosphoric-acid content, together with its low price per unit, indicate why a relatively small part of the total variability in the retail price of the complete fertilizers is associated with the variations in the phosphoric-acid content.

Of the three plant foods, the potash was the most variable. There has been some tendency for the variability of the potash content to decline. For the five years 1884 to 1888 the coefficient of variability of the potash content averaged 63.63, as compared with 48.76 for the period from 1910 to 1914.

The nitrogen content was decidedly more variable than the phosphoric-acid content, but less variable than the potash content.

During the period from 1881 to 1900 there was a general downward trend in the average retail price per ton of complete fertilizers in Connecticut (tables 108 and 109). For the five years 1881 to 1885 the price averaged \$44.53 per ton, as compared with \$31.14 per ton for the three years 1898 to 1900. During the period from 1900 to 1913, however, there was a gradual upward trend in the price. For the four years 1910 to 1913 the price per ton averaged \$34.57, or 11 per cent more than during the three years of lowest prices, 1898 to 1900. This general upward trend in price was somewhat different from the situation in Pennsylvania and in Indiana. In Pennsylvania the average price per ton was practically constant during the sixteen years prior to the war, and in Indiana the price was practically constant for the eight years prior to the war.

The difference in the pre-war trend of the price in Connecticut as compared with the situation in Pennsylvania and in Indiana was probably due to the differences in average analysis of the fertilizers. The Connecticut fertilizers contained, on the average, about twice as much nitrogen per ton as did the Pennsylvania fertilizers, and more than twice as much as did the Indiana fertilizers. During the pre-war period the nitrogen content of the Connecticut fertilizers was made up primarily of organic nitrogen.

The price of cottonseed meal, which is an important source of organic nitrogen in Connecticut, rose about 50 per cent from 1897 to 1913. The general trend in the price of other organic ammoniates was much the same. The upward trend in the price of complete fertilizers in Connecticut was probably caused in large part by the rise in the price of organic ammoniates. This tended to affect the price in Connecticut more than in Pennsylvania and Indiana, because of the greater use of organic nitrogen in Connecticut.

There was a marked rise in price in all these States during the war period. In 1920 the price in Connecticut was 188 per cent, in Pennsylvania 190 per cent, and in Indiana 181 per cent, of the pre-war price.

Following 1920 the decline in price was similar in Connecticut, Pennsylvania, and Indiana. In 1923 the index numbers of the prices were 136, 130, and 135, respectively.

TABLE 108. AVERAGE RETAIL PRICE AND AVERAGE ANALYSIS OF COMPLETE FERTILIZERS IN CONNECTICUT, 1881 TO 1928

Year	Retail price per ton in Connecticut	Per cent of nitrogen guaranteed	Per cent of phosphoric acid guaranteed	Per cent of potash guaranteed	Total units of plant food per ton	Retail price of plant food per unit	Number of samples
1884-1888.....	\$38.71	2.70	7.34	3.82	13.86	\$2.80	43
1890-1894.....	35.69	2.64	7.44	4.18	14.26	2.50	97
1900-1904.....	32.03	2.50	7.23	4.75	14.48	2.21	272
1910-1913.....	34.57	2.85	6.66	5.47	14.98	2.31	240
1922-1923.....	46.92	3.12	7.24	4.46	14.82	3.17	217
1924-1928.....	.....	3.67	7.37	5.43	16.48	.....	246
1881.....	46.70	.....	.....	.....	.....	.....	46
1882.....	45.40	.....	.....	.....	.....	.....	47
1883.....	43.99	.....	.....	.....	.....	.....	77
1884.....	42.05	2.70	7.06	3.98	13.74	3.06	40
1885.....	39.87	2.74	7.12	3.85	13.71	2.91	55
1886.....	37.85	2.69	7.28	3.54	13.51	2.80	40
1887.....	37.07	2.67	7.60	3.86	14.13	2.62	56
1888.....	36.73	2.69	7.65	3.85	14.19	2.59	26
1889.....	36.16	2.53	7.84	4.39	14.76	2.45	57
1890.....	35.55	2.50	7.60	3.99	14.09	2.52	76
1891.....	36.22	2.78	7.41	4.53	14.72	2.46	73
1892.....	35.57	2.64	7.36	4.25	14.25	2.50	70
1893.....	35.29	2.59	7.42	4.09	14.10	2.50	86
1894.....	35.81	2.68	7.43	4.03	14.14	2.53	182
1895.....	35.38	2.64	7.51	4.20	14.35	2.47	250
1896.....	34.34	2.53	7.43	4.53	14.49	2.37	205
1897.....	32.75	2.39	7.51	4.26	14.16	2.31	201
1898.....	31.34	2.40	7.45	4.26	14.11	2.22	290
1899.....	31.22	2.45	7.49	4.48	14.42	2.17	244
1900.....	31.12	2.33	7.24	4.42	13.99	2.22	232
1901.....	32.08	2.54	7.17	5.00	14.71	2.18	244
1902.....	32.00	2.54	7.31	4.76	14.61	2.19	277
1903.....	32.18	2.63	7.15	4.94	14.72	2.19	301
1904.....	32.79	2.47	7.28	4.63	14.38	2.28	307
1905.....	32.45	2.46	7.20	4.78	14.44	2.25	325
1906.....	33.13	2.57	7.14	4.97	14.68	2.26	324
1907.....	33.57	2.70	7.10	4.94	14.74	2.28	403
1908.....	33.91	2.64	7.00	4.96	14.60	2.32	379
1909.....	34.14	2.63	6.99	5.17	14.79	2.31	409
1910.....	34.29	2.79	6.70	5.27	14.76	2.32	235
1911.....	34.70	2.88	6.65	5.47	15.00	2.31	220
1912.....	34.61	2.87	6.63	5.57	15.07	2.30	235
1913.....	34.68	2.86	6.66	5.56	15.08	2.30	269
1914*.....	.....	3.01	6.56	5.59	15.16	.....	278
1915.....	36.28	3.08	7.22	3.13	13.43	2.70	202
1916.....	37.62	3.02	7.70	1.05	11.77	3.20	160
1917.....	38.64	2.94	7.70	1.22	11.86	3.26	114
1918.....	54.97	2.75	8.06	1.29	12.10	4.54	86
1919.....	61.73	2.40	8.04	1.51	11.95	5.17	84
1920.....	64.92	2.73	7.34	3.26	13.33	4.87	175
1921.....	60.02	2.67	7.59	3.58	13.84	4.34	204
1922.....	46.82	2.93	7.36	4.26	14.55	3.22	222
1923.....	47.03	3.30	7.13	4.65	15.08	3.12	212
1924.....	.....	3.54	7.07	4.88	15.49	.....	245
1925.....	.....	3.58	7.19	5.09	15.86	.....	252
1926.....	.....	3.63	7.48	5.61	16.72	.....	245
1927.....	.....	3.66	7.45	5.65	16.76	.....	242
1928.....	.....	3.94	7.68	5.93	17.55	.....	246

\* Retail prices for 1914 were not available.

For the two years 1922 and 1923 the retail price of plant food in complete fertilizers in Connecticut averaged \$3.17 per unit, or 37 per cent more than the pre-war figure. Owing to the decrease in the plant-food content of complete fertilizers during the war period, the index number of the retail price per unit rose to a much higher point than the index of the price per ton—224 in 1919 for the price per unit, as compared with 188 in 1920 for the price per ton.

TABLE 109. INDEX NUMBERS OF AVERAGE RETAIL PRICE AND AVERAGE ANALYSIS OF COMPLETE FERTILIZERS IN CONNECTICUT, 1881 TO 1928  
(1910-1913 = 100)

Year	Retail price per ton	Nitrogen guaranteed	Phosphoric acid guaranteed	Potash guaranteed	Total units of plant food per ton	Retail price of plant food per unit
1884-1888.....	112	95	110	70	93	121
1890-1894.....	103	93	112	76	95	108
1900-1904.....	93	88	109	87	97	96
1910-1913.....	100	100	100	100	100	100
1922-1923.....	136	109	109	82	99	137
1924-1928.....	.....	129	111	99	110	.....
1881.....	135	.....	.....	.....	.....	.....
1882.....	131	.....	.....	.....	.....	.....
1883.....	127	.....	.....	.....	.....	.....
1884.....	122	95	106	73	92	132
1885.....	115	96	107	70	92	126
1886.....	109	94	109	66	90	121
1887.....	107	94	114	71	94	113
1888.....	106	94	115	70	95	112
1889.....	105	89	118	80	99	106
1890.....	103	88	114	73	94	109
1891.....	105	98	111	83	98	106
1892.....	103	93	111	78	95	108
1893.....	102	91	111	75	94	108
1894.....	104	94	112	74	94	110
1895.....	102	93	113	77	96	107
1896.....	99	89	112	83	97	103
1897.....	95	84	113	78	95	100
1898.....	91	84	112	78	94	96
1899.....	90	86	112	82	96	94
1900.....	90	82	109	81	93	96
1901.....	93	89	108	91	98	94
1902.....	93	89	110	87	98	95
1903.....	93	92	107	90	98	95
1904.....	95	87	109	85	96	99
1905.....	94	86	108	87	96	97
1906.....	96	90	107	91	98	98
1907.....	97	95	107	90	98	99
1908.....	98	93	105	91	97	100
1909.....	99	92	105	95	99	100
1910.....	99	98	101	96	99	100
1911.....	100	101	100	100	100	100
1912.....	100	101	100	102	101	100
1913.....	100	100	100	102	101	100
1914*.....	.....	106	98	102	101	.....
1915.....	105	108	108	57	90	117
1916.....	109	106	116	19	79	139
1917.....	112	103	116	22	79	141
1918.....	159	96	121	24	81	197
1919.....	179	84	121	28	80	224
1920.....	188	96	110	60	89	211
1921.....	174	94	114	65	92	188
1922.....	135	103	111	78	97	139
1923.....	136	116	107	85	101	135
1924.....	.....	124	106	89	103	.....
1925.....	.....	126	108	93	106	.....
1926.....	.....	127	112	103	112	.....
1927.....	.....	128	112	103	112	.....
1928.....	.....	138	115	108	117	.....

\* Retail prices for 1914 were not available.

During the period of generally declining prices, from 1884 to 1899, the price of plant food per unit declined somewhat more rapidly than did the price per ton, because of the increase in number of units of plant food per ton. During the period of rising prices, from 1900 to 1913, the price per unit rose less rapidly than did the price per ton, because of the increase in the average analysis.

The changes in the average analysis of the complete fertilizers in Connecticut were similar to the changes that occurred in other States for

which similar data were available. During the period from 1884 to 1914 there was a slight upward trend in the nitrogen content, a slight downward trend in the phosphoric-acid content, and a decided upward trend in the potash content (tables 108 and 109, and figure 49).

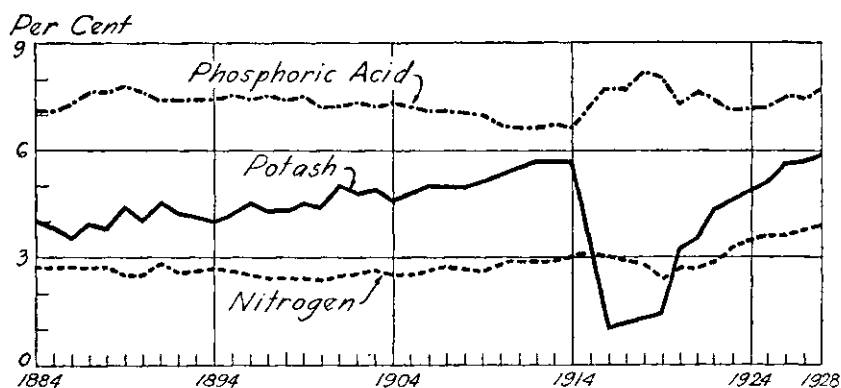


FIGURE 49. AVERAGE GUARANTEED ANALYSIS OF COMPLETE FERTILIZERS IN CONNECTICUT, 1884 TO 1928

During the pre-war period the potash content increased. Since the war both the potash and the nitrogen content have increased

There are many different nitrogenous materials that are used as sources of nitrogen in mixed fertilizers. The nitrogen in these materials occurs in different forms. In the Connecticut fertilizer reports the total nitrogen found in the samples of complete fertilizers was classified as nitrate, ammonia, and organic nitrogen. During the forty-five-year period 1881 to 1925, there was more organic nitrogen in the fertilizers than either nitrate or ammonia nitrogen. In the three years 1926 to 1928 the ammonia nitrogen was the most important form, and in 1928 this made up 51 per cent of the total nitrogen (tables 110 and 111, and figure 50).

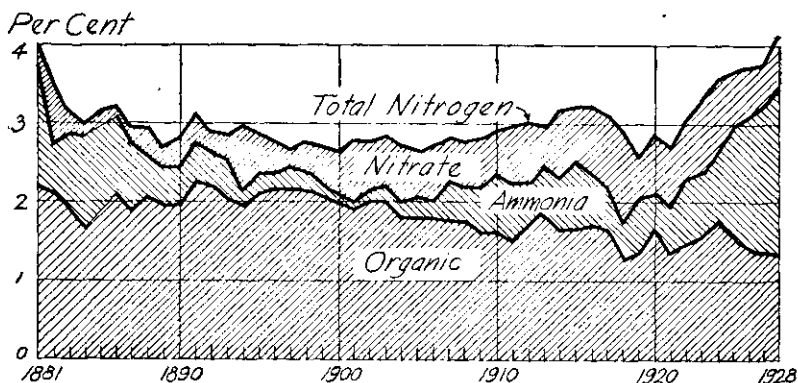


FIGURE 50. FORMS OF NITROGEN IN COMPLETE FERTILIZERS IN CONNECTICUT, 1881 TO 1928

Prior to 1926 the organic nitrogen was the most important form of nitrogen in mixed fertilizers in Connecticut. Since 1926 the ammonia nitrogen has been the most important

TABLE 110. GUARANTEED AND ACTUAL NITROGEN CONTENT, AND FORMS OF NITROGEN, IN COMPLETE FERTILIZERS IN CONNECTICUT, 1881 TO 1928

Year	Per cent of nitrogen guaranteed	Per cent of nitrogen found	Nitrogen overrun (per cent found minus guarantee)	Per cent of nitrate nitrogen found	Per cent of ammonia nitrogen found	Per cent of organic nitrogen found
1886-1889.....	2.64	2.96	0.31	0.23	0.72	2.00
1890-1894.....	2.64	2.93	0.29	0.43	0.43	2.08
1900-1904.....	2.50	2.74	0.23	0.64	0.16	1.93
1910-1914.....	2.88	2.99	0.11	0.67	0.67	1.65
1924-1928.....	3.67	3.75	0.08	0.69	1.58	1.48
1881.....	.....	4.01	.....	0.20	1.61	2.20
1882.....	.....	3.49	.....	0.72	0.65	2.12
1883.....	.....	3.16	.....	0.31	0.98	1.87
1884.....	2.70	3.02	0.32	0.18	1.21	1.63
1885.....	2.74	3.15	0.41	.....	.....	.....
1886.....	2.69	3.20	0.51	0.10	1.01	2.09
1887.....	2.67	2.96	0.29	0.21	0.84	1.91
1888.....	2.69	2.94	0.25	0.35	0.55	2.04
1889.....	2.53	2.72	0.19	0.25	0.50	1.97
1890.....	2.50	2.81	0.31	0.36	0.48	1.97
1891.....	2.78	3.11	0.33	0.37	0.49	2.25
1892.....	2.64	2.92	0.28	0.28	0.45	2.19
1893.....	2.59	2.86	0.27	0.33	0.49	2.04
1894.....	2.68	2.96	0.28	0.80	0.23	1.93
1895.....	2.64	2.90	0.26	0.54	0.24	2.12
1896.....	2.53	2.80	0.27	0.47	0.19	2.14
1897.....	2.39	2.72	0.33	0.26	0.33	2.13
1898.....	2.40	2.73	0.33	0.33	0.27	2.13
1899.....	2.45	2.71	0.26	0.44	0.17	2.10
1900.....	2.33	2.66	0.33	0.56	0.12	1.98
1901.....	2.54	2.73	0.19	0.72	0.13	1.88
1902.....	2.54	2.75	0.21	0.59	0.17	1.99
1903.....	2.63	2.86	0.23	0.67	0.20	1.99
1904.....	2.47	2.68	0.21	0.66	0.20	1.82
1905.....	2.46	2.63	0.17	0.60	0.21	1.82
1906.....	2.57	2.69	0.12	0.69	0.22	1.78
1907.....	2.70	2.80	0.10	0.53	0.53	1.74
1908.....	2.64	2.74	0.10	0.54	0.47	1.73
1909.....	2.63	2.79	0.16	0.61	0.56	1.62
1910.....	2.79	2.90	0.11	0.56	0.76	1.58
1911.....	2.88	2.96	0.08	0.71	0.75	1.50
1912.....	2.87	2.98	0.11	0.74	0.56	1.68
1913.....	2.86	2.97	0.11	0.52	0.59	1.86
1914.....	3.01	3.14	0.13	0.82	0.69	1.63
1915.....	3.08	3.22	0.14	0.71	0.84	1.67
1916.....	3.02	3.18	0.16	0.78	0.70	1.70
1917.....	2.94	3.08	0.14	0.88	0.54	1.66
1918.....	2.75	2.90	0.15	1.15	0.50	1.25
1919.....	2.40	2.54	0.14	0.48	0.71	1.35
1920.....	2.73	2.85	0.12	0.74	0.47	1.64
1921.....	2.67	2.72	0.05	0.76	0.61	1.35
1922.....	2.93	3.03	0.10	0.73	0.86	1.44
1923.....	3.30	3.31	0.01	0.98	0.80	1.53
1924.....	3.54	3.53	-0.01	0.88	0.89	1.76
1925.....	3.58	3.65	0.07	0.71	1.41	1.53
1926.....	3.63	3.73	0.10	0.63	1.68	1.42
1927.....	3.66	3.75	0.09	0.54	1.84	1.37
1928.....	3.94	4.09	0.15	0.67	2.09	1.33

For the twenty years 1881 to 1900, the organic-nitrogen content of the fertilizers remained relatively constant at about 2 per cent. From 1900 to 1928 there was a downward trend in the average amount of organic nitrogen in Connecticut fertilizers. During this period there was an upward trend in the total nitrogen content, so that the proportion of the total nitrogen content in the organic form declined from 70 per cent for the five years 1900 to 1904, to 56 per cent for the pre-war period and 40 per cent for the post-war period.

During the period from 1900 to 1914 there was only a slight upward trend in the price of mineral ammoniates, as compared with a marked

TABLE 111. INDEX NUMBERS OF GUARANTEED AND ACTUAL NITROGEN CONTENT AND OF FORMS OF NITROGEN IN COMPLETE FERTILIZERS IN CONNECTICUT, 1886 TO 1928

(1910-1914 = 100)

Year	Nitrogen guaranteed	Nitrogen found	Nitrogen overrun (per cent found minus guarantee)	Nitrate nitrogen found	Ammonia nitrogen found	Organic nitrogen found
1886-1889	92	99	282	34	107	121
1890-1894	92	98	264	64	64	126
1900-1904	87	92	209	96	24	117
1910-1914	100	100	100	100	100	100
1924-1928	127	125	73	103	236	90
1881		134		30	240	133
1882		117		107	97	128
1883		106		46	146	113
1884	94	101	291	27	181	99
1885	95	105	373			
1886	93	107	464	15	151	127
1887	93	99	264	31	125	116
1888	93	98	227	52	82	124
1889	88	91	173	37	75	119
1890	87	94	282	54	72	119
1891	97	104	300	55	73	136
1892	92	98	255	42	67	133
1893	90	96	245	49	73	124
1894	93	99	255	119	34	117
1895	92	97	236	81	36	128
1896	88	94	245	70	28	130
1897	83	91	300	39	49	129
1898	83	91	300	49	40	129
1899	85	91	236	66	25	127
1900	81	89	300	84	18	120
1901	88	91	173	107	19	114
1902	88	92	191	88	25	121
1903	91	96	209	100	30	121
1904	86	90	191	99	30	110
1905	85	88	155	90	31	110
1906	89	90	109	103	33	108
1907	94	94	91	79	79	105
1908	92	92	91	81	70	105
1909	91	93	145	91	84	98
1910	97	97	100	84	113	96
1911	100	99	73	106	112	91
1912	100	100	100	110	84	102
1913	99	99	100	78	88	113
1914	105	105	118	122	103	99
1915	107	108	127	106	125	101
1916	105	106	145	116	104	103
1917	102	103	127	131	81	101
1918	95	97	136	172	75	76
1919	83	85	127	72	106	82
1920	95	95	109	110	70	99
1921	93	91	45	113	91	82
1922	102	101	91	109	128	87
1923	115	111	9	146	119	93
1924	123	118	- 9	131	133	107
1925	124	122	64	106	210	93
1926	126	125	91	94	251	86
1927	127	125	82	81	275	83
1928	137	137	136	100	312	81

upward trend in the price of organic ammoniates. Because of these changes in price, there was a decline in the amount of organic nitrogen and a still greater decline in the proportion of the total nitrogen in the organic form. During the post-war period 1924 to 1928, the index number of the price of organic ammoniates averaged 136 per cent of the pre-war figure, while the price of mineral ammoniates averaged 96 per cent of the pre-war figure.

The rapid increase in the amount of ammonia nitrogen from 0.47 per cent in 1920 to 2.09 per cent in 1928 was the most striking change that occurred in the form of nitrogen used in mixed fertilizers. While there was a tendency during the pre-war period for the amount of nitrate nitrogen to increase, this tendency has not been maintained during the post-war period.

The index number of the price of sulfate of ammonia declined from 102 in 1923 to 82 in 1928. During the same period the index number of the price of nitrate of soda dropped from 112 to 100. The relative cheapness of sulfate of ammonia has been an important factor in causing an increase in the use of ammonia nitrogen in complete fertilizers.

The guaranteed available phosphoric-acid content of the complete fertilizers in Connecticut declined gradually from 1888 to 1914. For the years 1924 to 1928 the guarantee averaged 7.37 units per ton, or 11 per cent higher than the five-year pre-war average of 6.64 units (tables 112 and 113). As compared with the other plant foods, the phosphoric-acid content of the mixed fertilizers has been the most stable.

While superphosphate is the principal source of phosphoric acid in most mixed fertilizers, the phosphorus compounds in superphosphate vary in their solubility. For the forty-five years 1884 to 1928, the total phosphoric-acid content of the complete fertilizers in Connecticut averaged 9.74 units per ton (table 112 and figure 51). Of this total, 14.4 per

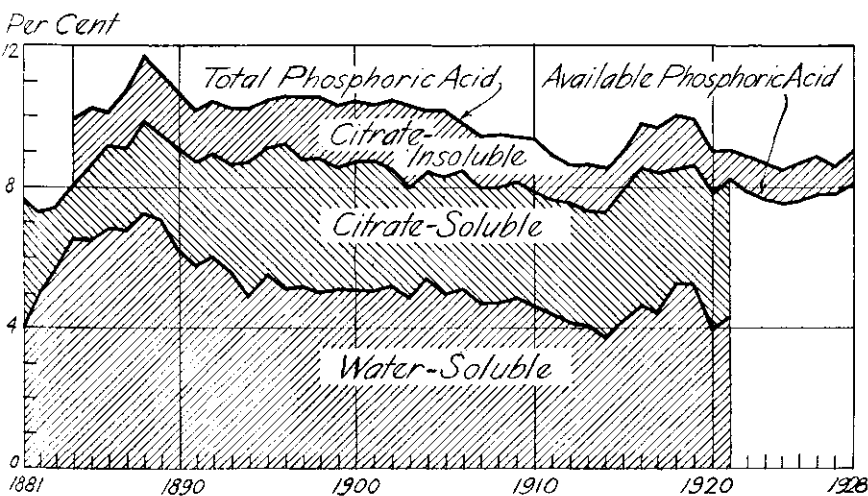


FIGURE 51. FORMS OF PHOSPHORIC ACID IN COMPLETE FERTILIZERS IN CONNECTICUT, 1881 TO 1928

The water-soluble and the citrate-soluble are the important forms of phosphoric acid in complete fertilizers

cent was classified as citrate-insoluble phosphoric acid, leaving 85.6 per cent as available phosphoric acid. For the five years 1924 to 1928 about 10 per cent of the total phosphoric-acid content was insoluble in citric acid, as compared with 14 per cent for the five years 1910 to 1914.

TABLE 112. GUARANTEED AND ACTUAL PHOSPHORIC-ACID CONTENT, AND FORMS OF PHOSPHORIC ACID, IN COMPLETE FERTILIZERS IN CONNECTICUT, 1881 TO 1928

Year	Per cent of available phosphoric acid guaranteed	Per cent of available phosphoric acid found	Phosphoric acid over-run (per cent found minus guarantee)	Per cent of total phosphoric acid found	Per cent of water-soluble phosphoric acid found	Per cent of citrate-soluble phosphoric acid found	Per cent of citrate-insoluble phosphoric acid found
1884-1888.....	7.34	8.93	1.59	10.51	6.78	2.15	1.58
1890-1894.....	7.44	8.78	1.33	10.33	5.73	3.05	1.55
1900-1904.....	7.23	8.46	1.23	10.27	5.12	3.33	1.81
1910-1914.....	6.64	7.51	0.87	8.76	4.22	3.29	1.25
1924-1928.....	7.37	7.78	0.40	8.69	.....	.....	0.91
1881.....	.....	7.57	.....	.....	3.95	3.62	2.20
1882.....	.....	7.33	.....	.....	4.87	2.46	2.09
1883.....	.....	7.41	.....	.....	5.48	1.93	2.50
1884.....	7.06	8.06	1.00	9.90	6.50	1.56	1.84
1885.....	7.12	8.61	1.49	10.15	6.53	2.08	1.54
1886.....	7.28	9.06	1.78	10.13	6.76	2.30	1.07
1887.....	7.60	9.13	1.53	10.63	6.89	2.24	1.50
1888.....	7.65	9.79	2.14	11.74	7.21	2.58	1.95
1889.....	7.84	9.49	1.65	11.09	7.08	2.41	1.60
1890.....	7.60	9.01	1.41	10.69	6.27	2.74	1.68
1891.....	7.41	8.72	1.31	10.08	5.81	2.91	1.36
1892.....	7.36	8.86	1.50	10.45	6.01	2.85	1.59
1893.....	7.42	8.56	1.14	10.21	5.60	2.96	1.65
1894.....	7.43	8.74	1.31	10.21	4.94	3.80	1.47
1895.....	7.51	9.13	1.62	10.45	5.49	3.64	1.32
1896.....	7.43	9.15	1.72	10.47	5.15	4.00	1.32
1897.....	7.51	8.75	1.24	10.51	5.21	3.54	1.76
1898.....	7.45	8.76	1.31	10.48	5.02	3.74	1.72
1899.....	7.49	8.65	1.16	10.32	5.09	3.56	1.67
1900.....	7.24	8.69	1.45	10.42	5.13	3.56	1.73
1901.....	7.17	8.67	1.50	10.31	5.03	3.64	1.64
1902.....	7.31	8.48	1.17	10.40	5.17	3.31	1.92
1903.....	7.15	8.02	0.87	10.15	4.88	3.14	2.13
1904.....	7.28	8.42	1.14	10.07	5.41	3.01	1.65
1905.....	7.20	8.29	1.09	10.13	4.96	3.33	1.84
1906.....	7.14	8.36	1.22	9.80	5.09	3.27	1.44
1907.....	7.10	7.99	0.89	9.54	4.70	3.29	1.55
1908.....	7.00	7.99	0.99	9.49	4.73	3.26	1.50
1909.....	6.99	8.06	1.07	9.38	4.84	3.22	1.32
1910.....	6.70	7.84	1.14	9.27	4.63	3.21	1.43
1911.....	6.65	7.59	0.94	8.83	4.40	3.19	1.24
1912.....	6.63	7.46	0.83	8.64	4.17	3.29	1.18
1913.....	6.66	7.34	0.68	8.58	4.09	3.25	1.24
1914.....	6.56	7.32	0.76	8.48	3.82	3.50	1.16
1915.....	7.22	7.94	0.72	9.05	4.17	3.77	1.11
1916.....	7.70	8.52	0.82	9.83	4.64	3.88	1.31
1917.....	7.70	8.40	0.70	9.74	4.39	4.01	1.34
1918.....	8.06	8.54	0.48	9.95	5.18	3.36	1.41
1919.....	8.04	8.58	0.54	9.90	5.18	3.40	1.32
1920.....	7.34	7.78	0.44	9.01	3.98	3.80	1.23
1921.....	7.59	8.16	0.57	8.99	4.31	3.85	0.83
1922.....	7.36	7.80	0.44	8.80	.....	.....	1.00
1923.....	7.13	7.56	0.43	8.62	.....	.....	1.06
1924.....	7.07	7.53	0.46	8.44	.....	.....	0.91
1925.....	7.19	7.60	0.41	8.59	.....	.....	0.99
1926.....	7.48	7.80	0.32	8.82	.....	.....	1.02
1927.....	7.45	7.82	0.37	8.61	.....	.....	0.79
1928.....	7.68	8.14	0.46	8.97	.....	.....	0.83

There has been some tendency for the proportion of the citrate-insoluble phosphoric acid to decline and for the proportion of available phosphoric acid to increase. It is the available phosphoric acid that is the more important in the fertilizer analysis.

For the thirty-eight years 1884 to 1921 the available phosphoric acid averaged 8.44 units per ton, and of this amount 61.8 per cent was water-soluble and 38.2 per cent was citrate-soluble. The proportion of the



TABLE 113. INDEX NUMBERS OF GUARANTEED AND ACTUAL PHOSPHORIC-ACID CONTENT AND OF FORMS OF PHOSPHORIC ACID IN COMPLETE FERTILIZERS IN CONNECTICUT, 1881 TO 1928

(1910-1914 = 100)

Year	Available phosphoric acid guaranteed	Available phosphoric acid found	Phosphoric acid over-run (per cent found minus guarantee)	Total phosphoric acid found	Water-soluble phosphoric acid found	Citrate-soluble phosphoric acid found	Citrate-insoluble phosphoric acid found
1884-1888...	111	119	183	120	161	65	126
1890-1894...	112	117	153	118	136	93	124
1900-1904...	109	113	141	117	121	101	145
1910-1914...	100	100	100	100	100	100	100
1924-1928...	111	104	46	99	.....	.....	73
1881.....	.....	101	.....	.....	94	110	176
1882.....	.....	98	.....	.....	115	75	167
1883.....	.....	99	.....	.....	130	59	200
1884.....	106	107	115	113	154	47	147
1885.....	107	115	171	116	155	63	123
1886.....	110	121	205	116	160	70	86
1887.....	114	122	176	121	163	68	120
1888.....	115	130	246	134	171	78	156
1889.....	118	126	190	127	168	73	128
1890.....	114	120	162	122	149	83	134
1891.....	112	116	151	115	138	88	109
1892.....	111	118	172	119	142	87	127
1893.....	112	114	131	117	133	90	132
1894.....	112	116	151	117	117	116	118
1895.....	113	122	186	119	130	111	106
1896.....	112	122	198	120	122	122	106
1897.....	113	117	143	120	123	108	141
1898.....	112	117	151	120	119	114	138
1899.....	113	115	133	118	121	108	134
1900.....	109	116	167	119	122	108	138
1901.....	108	115	172	118	119	111	131
1902.....	110	113	134	119	123	101	154
1903.....	108	107	100	116	116	95	170
1904.....	110	112	131	115	128	91	132
1905.....	108	110	125	116	118	101	147
1906.....	108	111	140	112	121	99	115
1907.....	107	106	102	109	111	100	124
1908.....	105	106	114	108	112	99	120
1909.....	105	107	123	107	115	98	106
1910.....	101	104	131	106	110	98	114
1911.....	100	101	108	101	104	97	99
1912.....	100	99	95	99	99	100	94
1913.....	100	98	78	98	97	99	99
1914.....	99	97	87	97	91	106	93
1915.....	109	106	83	103	99	115	89
1916.....	116	113	94	112	110	118	105
1917.....	116	112	80	111	104	122	107
1918.....	121	114	55	114	123	102	113
1919.....	121	114	62	113	123	103	106
1920.....	111	104	51	103	94	116	98
1921.....	114	109	66	103	102	117	66
1922.....	111	104	51	100	.....	.....	80
1923.....	107	101	49	98	.....	.....	85
1924.....	106	100	53	96	.....	.....	73
1925.....	108	101	47	98	.....	.....	79
1926.....	113	104	37	101	.....	.....	82
1927.....	112	104	43	98	.....	.....	63
1928.....	116	108	53	102	.....	.....	66

available phosphoric acid that was citrate-soluble increased from 24 per cent for the five years 1884 to 1888, to 44 per cent for the five pre-war years 1910 to 1914.

There were more violent changes in the potash content of the complete fertilizers in Connecticut than in either the phosphoric-acid or the nitrogen content. During the period from 1881 to 1914 there was a decided upward trend in the potash content as compared with a slight

downward trend in the other two plant foods. For the five years 1910 to 1914 the potash content averaged 5.85 units per ton, or 37 per cent more than during the five-year period from 1884 to 1888 (table 114). During the war period, imports of potash practically ceased and the potash content of fertilizers was greatly reduced (tables 114 and 115, and figure 52). In 1916 the average potash content of complete fertilizers in

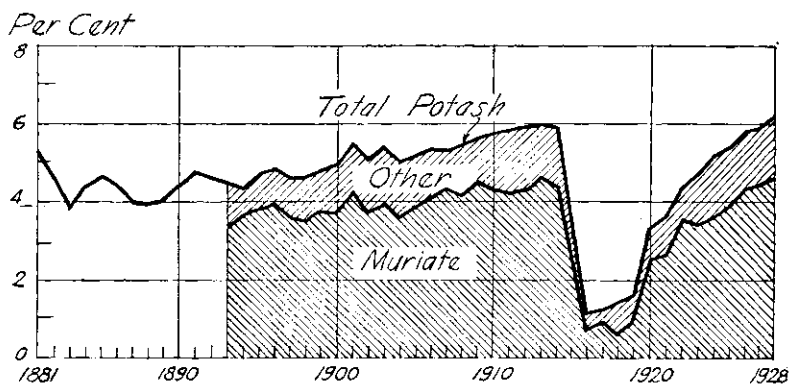


FIGURE 52. FORMS OF POTASH IN COMPLETE FERTILIZERS IN CONNECTICUT, 1881 TO 1928

Muriate of potash, or potassium chloride, is the most important form of potash in complete fertilizers; the other potash includes sulfate of potash and some carbonate of potash. Except for the war period there has been little variation in the proportion of muriate of potash

Connecticut was only 18 per cent of the average for the five pre-war years. During the post-war period, however, the potash content rapidly recovered to about the pre-war level.

There are several different potash salts that can be used as sources of potash in complete fertilizers. The salts most generally used contain potassium chloride; some salts containing potassium sulfate and potassium carbonate also are used. In the Connecticut fertilizer reports the potash found in the form of muriate, or potassium chloride, was reported. For the 36 years 1893 to 1928 the total potash content averaged 4.64 units per ton; 75.2 per cent of this was in the form of muriate, and 24.8 per cent was other potash, primarily sulfate of potash although some carbonate also was included.

The cost of potash per unit in the sulfate or the carbonate form is considerably higher than in the form of chloride. Therefore the major part of the potash in mixed fertilizers is generally in the chloride form. For some crops, however, sulfate of potash is often used. During the period from 1893 to 1928, with the exception of the war years, there has been relatively little change in the proportion of the muriate of potash to the total potash.

The data available concerning the forms of plant food in complete fertilizers in Connecticut made it possible to estimate fairly closely the average annual wholesale cost of the plant food in a ton of fertilizer

TABLE 114. GUARANTEED AND ACTUAL POTASH CONTENT, AND FORMS OF POTASH, IN COMPLETE FERTILIZERS IN CONNECTICUT, 1881 TO 1928

Year	Per cent of potash guaranteed	Per cent of potash found	Potash over-run (per cent found minus guarantee)	Per cent of muriate of potash found	Per cent of other potash found
1884-1888	3.82	4.26	0.45		
1893-1897	4.22	4.55	0.32	3.62	0.93
1900-1904	4.75	5.18	0.43	3.82	1.36
1910-1914	5.49	5.85	0.36	4.36	1.50
1924-1928	5.43	5.70	0.27	4.18	1.51
1881		5.33			
1882		4.73			
1883		3.85			
1884	3.98	4.35	0.37		
1885	3.85	4.59	0.74		
1886	3.54	4.36	0.82		
1887	3.86	4.04	0.18		
1888	3.85	3.98	0.13		
1889	4.39	4.06	-0.33		
1890	3.99	4.39	0.40		
1891	4.53	4.77	0.24		
1892	4.25	4.59	0.34		
1893	4.09	4.47	0.38	3.34	1.13
1894	4.03	4.27	0.24	3.55	0.72
1895	4.20	4.66	0.46	3.75	0.91
1896	4.53	4.77	0.24	3.86	0.91
1897	4.26	4.56	0.30	3.58	0.98
1898	4.26	4.61	0.35	3.52	1.09
1899	4.48	4.85	0.37	3.73	1.12
1900	4.42	4.92	0.50	3.70	1.22
1901	5.00	5.48	0.48	4.22	1.26
1902	4.76	5.11	0.35	3.71	1.40
1903	4.94	5.39	0.45	3.91	1.48
1904	4.63	5.00	0.37	3.57	1.43
1905	4.78	5.16	0.38	3.84	1.32
1906	4.97	5.27	0.30	4.14	1.13
1907	4.94	5.29	0.35	4.28	1.01
1908	4.96	5.37	0.41	4.18	1.19
1909	5.17	5.62	0.45	4.46	1.16
1910	5.27	5.72	0.45	4.31	1.41
1911	5.47	5.81	0.34	4.22	1.59
1912	5.57	5.86	0.29	4.26	1.60
1913	5.56	5.97	0.41	4.55	1.42
1914	5.59	5.90	0.31	4.44	1.46
1915	3.13	3.31	0.18	2.47	0.84
1916	1.05	1.06	0.01	0.70	0.36
1917	1.22	1.23	0.01	0.87	0.36
1918	1.29	1.40	0.11	0.61	0.79
1919	1.51	1.55	0.04	0.94	0.61
1920	3.26	3.33	0.07	2.52	0.81
1921	3.58	3.63	0.05	2.64	0.99
1922	4.26	4.38	0.12	3.49	0.89
1923	4.65	4.74	0.09	3.43	1.31
1924	4.88	5.22	0.34	3.63	1.59
1925	5.09	5.41	0.32	3.89	1.52
1926	5.61	5.85	0.24	4.34	1.51
1927	5.65	5.86	0.21	4.45	1.41
1928	5.93	6.15	0.22	4.61	1.54

(tables 116 and 117). During the period from 1890 to 1897 there was a downward trend in the wholesale cost of the plant food. This decline was due in large part to the decline in the cost of the phosphoric acid. In the period from 1898 to 1914 this trend was reversed, owing to the increase in the total plant-food content of the fertilizers and to the rising price of nitrogen. During the war period there was an abrupt increase in the price of materials. The wholesale price of materials rose more rapidly than did the retail price of the fertilizers, and the margin between the two declined. For the two years 1922 and 1923, the cost of materials

TABLE 115. INDEX NUMBERS OF GUARANTEED AND ACTUAL POTASH CONTENT AND OF FORMS OF POTASH IN COMPLETE FERTILIZERS IN CONNECTICUT, 1881-1928

(1910-1914 = 100)

Year	Potash guaranteed	Potash found	Potash overrun (per cent found minus guarantee)	Muriate of potash found	Other potash found
1884-1888	70	73	125		
1893-1897	77	78	89	83	62
1900-1904	87	89	119	88	91
1910-1914	100	100	100	100	100
1924-1928	99	97	75	96	101
1881		91			
1882		81			
1883		66			
1884	72	74	103		
1885	70	78	206		
1886	64	75	228		
1887	70	69	50		
1888	70	68	36		
1889	80	69	-92		
1890	73	75	111		
1891	83	82	67		
1892	77	78	94		
1893	74	76	106	77	75
1894	73	73	67	81	48
1895	77	80	128	86	61
1896	83	82	67	89	61
1897	78	78	83	82	65
1898	78	79	97	81	73
1899	82	83	103	86	75
1900	81	84	139	85	81
1901	91	94	133	97	84
1902	87	87	97	85	93
1903	90	92	125	90	99
1904	84	85	103	82	95
1905	87	88	106	88	88
1906	91	90	83	95	75
1907	90	90	97	98	67
1908	90	92	114	96	79
1909	94	96	125	102	77
1910	96	98	125	99	94
1911	100	99	94	97	106
1912	101	100	81	98	107
1913	101	102	114	104	95
1914	102	101	86	102	97
1915	57	57	50	57	56
1916	19	18	3	16	24
1917	22	21	3	20	24
1918	23	24	31	14	53
1919	28	26	11	22	41
1920	59	57	19	58	54
1921	65	62	14	61	66
1922	78	75	33	80	59
1923	85	81	25	79	87
1924	89	89	94	83	106
1925	93	92	89	89	101
1926	102	100	67	100	101
1927	103	100	58	102	94
1928	108	105	61	106	103

averaged 109 per cent of the pre-war cost, while the retail price of complete fertilizers averaged 136 per cent of the pre-war figure.

During the period from 1910 to 1913, the margin between the retail price and the cost of materials, or the cost of manufacture and distribution, averaged \$15.94. While there have been fluctuations in the margin from year to year, the most violent changes have occurred since 1915. During the war period the margin was unusually small. For the post-

TABLE 116. AVERAGE RETAIL PRICE OF COMPLETE FERTILIZERS IN CONNECTICUT, AND ESTIMATED WHOLESALE COST OF MATERIALS AND COST OF MANUFACTURE AND DISTRIBUTION, 1890 TO 1923

Year	Retail price per ton	Wholesale cost of materials						Total cost of materials	Cost of manufacture and distribution
		Nitrate nitrogen	Ammonia nitrogen	Organic nitrogen	Phosphoric acid	Muriate of potash	Other potash		
1890-1894	\$35.69	\$1.06	\$1.33	\$ 5.54	\$6.24	\$2.72	\$0.84	\$17.72	\$17.97
1900-1904	32.03	1.62	0.48	5.50	5.31	2.88	1.19	16.98	15.05
1910-1913	34.57	1.82	1.96	5.87	4.28	3.31	1.41	18.64	15.94
1922-1923	46.92	2.72	2.17	7.21	4.69	2.48	1.03	20.29	26.63
1890	35.55	0.86	1.47	5.15	7.30	2.63	0.86	18.27	17.28
1891	36.22	0.91	1.61	5.33	6.45	2.86	0.86	18.02	18.20
1892	35.57	0.68	1.33	5.30	6.56	2.79	0.83	17.49	18.08
1893	35.29	0.86	1.47	6.18	5.56	2.54	1.01	17.62	17.67
1894	35.81	1.98	0.77	5.73	5.33	2.76	0.63	17.20	18.61
1895	35.38	1.31	0.76	5.53	5.93	2.96	0.85	17.34	18.04
1896	34.34	1.03	0.45	4.77	5.22	2.86	0.78	15.11	19.23
1897	32.75	0.60	0.71	4.47	4.72	2.66	0.82	13.98	18.77
1898	31.34	0.75	0.61	4.79	4.38	2.64	0.92	14.09	17.25
1899	31.22	0.89	0.45	4.60	5.36	2.77	0.94	15.01	16.21
1900	31.12	1.29	0.35	5.09	5.30	2.72	1.02	15.77	15.35
1901	32.08	1.67	0.35	5.26	5.55	3.17	1.10	17.10	14.98
1902	32.00	1.59	0.48	5.50	5.26	2.79	1.25	16.87	15.13
1903	32.18	1.73	0.60	6.06	5.05	2.97	1.30	17.71	14.47
1904	32.79	1.83	0.61	5.61	5.39	2.74	1.27	17.45	15.34
1905	32.45	1.78	0.64	5.71	5.31	2.98	1.19	17.61	14.84
1906	33.13	1.98	0.66	5.72	5.35	3.30	1.04	18.05	15.08
1907	33.57	1.71	1.60	5.81	5.11	3.42	0.93	18.58	14.99
1908	33.91	1.65	1.40	5.43	5.27	3.30	1.08	18.13	15.78
1909	34.14	1.71	1.60	5.28	4.59	3.48	1.06	17.72	16.42
1910	34.29	1.51	2.02	5.58	4.55	3.23	1.24	18.13	16.16
1911	34.70	1.92	2.17	5.86	4.78	3.08	1.45	19.26	15.44
1912	34.61	2.14	1.76	5.93	3.95	3.32	1.55	18.65	15.96
1913	34.68	1.70	1.87	6.12	3.82	3.60	1.39	18.50	16.18
1914*		2.39	1.95	6.24	3.51	3.51	1.43	19.03	
1915	36.28	1.88	2.34	5.95	3.81	3.93	1.39	19.30	16.98
1916	37.62	3.03	2.48	6.16	6.13	5.34	2.29	25.43	12.19
1917	38.64	3.78	2.17	8.28	6.38	7.22	2.16	29.99	8.65
1918	54.97	6.87	2.48	10.16	9.22	4.49	5.58	38.80	16.17
1919	61.73	2.70	3.02	10.43	9.18	5.42	3.91	34.66	27.07
1920	64.92	3.16	1.83	15.08	9.02	6.17	3.13	38.39	26.53
1921	60.02	2.96	2.10	8.27	8.81	4.80	2.48	29.42	30.60
1922	46.82	2.28	1.95	6.15	4.99	2.69	0.93	18.99	27.83
1923	47.03	3.16	2.39	8.26	4.38	2.26	1.13	21.58	25.45

\* Retail prices for 1914 were not available.

war period 1922 to 1923, however, it averaged 167 per cent of the pre-war figure. This was much the same change as occurred in Pennsylvania. The data for all of the States, both for materials and for complete fertilizers, indicate that the margin between wholesale and retail prices is much greater than the pre-war average. For the post-war period, 57 per cent of the Connecticut retail price was the charge for manufacture and distribution, as compared with a pre-war average of 46 per cent. Of each dollar which the farmer spends for fertilizer, the manufacturers of fertilizer materials get a considerably smaller percentage than they did before the war. The increase in the cost of distribution is a reflection primarily of increased costs for transportation and handling.

#### *Relation between guaranteed and actual analysis of complete fertilizers*

The guaranteed analysis of complete fertilizers is a minimum guarantee. The actual analysis generally exceeds the guaranteed. For the forty-five years 1884 to 1928 the actual nitrogen content of the samples

TABLE 117. INDEX NUMBERS OF AVERAGE RETAIL PRICE OF COMPLETE FERTILIZER IN CONNECTICUT AND OF ESTIMATED WHOLESALE COST OF MATERIALS AND COST OF MANUFACTURE AND DISTRIBUTION, 1890 TO 1923

(1910-1913 = 100)

Year	Retail price per ton	Wholesale cost of materials					Total cost of materials	Cost of manufacture and distribution	
		Nitrate nitrogen	Ammonia nitrogen	Organic nitrogen	Phosphoric acid	Muriate of potash			Other potash
1890-1894.....	103	58	68	94	146	82	60	95	113
1900-1904.....	93	89	24	94	124	87	84	91	94
1910-1913.....	100	100	100	100	100	100	100	100	100
1922-1923.....	136	149	111	123	109	75	73	109	167
1890.....	103	47	75	88	171	79	61	98	108
1891.....	105	50	82	91	151	86	61	97	114
1892.....	103	37	68	90	153	84	59	94	113
1893.....	102	47	75	105	130	77	72	95	111
1894.....	104	109	39	98	125	83	45	92	117
1895.....	102	72	39	94	139	89	60	93	113
1896.....	99	57	23	81	122	86	55	81	121
1897.....	95	33	36	76	110	80	58	75	118
1898.....	91	41	31	82	102	80	65	76	108
1899.....	90	49	23	78	125	84	67	81	102
1900.....	90	71	18	87	124	82	72	85	96
1901.....	93	92	18	90	130	96	78	92	94
1902.....	93	87	24	94	123	84	89	91	95
1903.....	93	95	31	103	118	90	92	95	91
1904.....	95	101	31	96	126	83	90	94	96
1905.....	94	98	33	97	124	90	84	94	93
1906.....	96	109	34	97	125	100	74	97	95
1907.....	97	94	82	99	119	103	66	100	94
1908.....	98	91	71	93	123	100	77	97	99
1909.....	99	94	82	90	107	105	75	95	103
1910.....	99	83	103	95	106	98	88	97	101
1911.....	100	105	111	100	112	93	103	103	97
1912.....	100	118	90	101	92	100	110	100	100
1913.....	100	93	95	104	89	109	99	99	102
1914*.....	.....	131	99	106	82	106	101	102	.....
1915.....	105	103	119	101	89	119	99	104	107
1916.....	109	166	127	105	143	161	162	136	76
1917.....	112	208	111	141	149	218	153	161	54
1918.....	159	377	127	173	215	136	396	208	101
1919.....	179	148	154	178	214	164	277	186	170
1920.....	188	174	93	257	211	186	222	206	166
1921.....	174	163	107	141	206	145	176	158	192
1922.....	135	125	99	105	117	81	66	102	175
1923.....	136	174	122	141	102	68	80	116	160

\* Retail prices for 1914 were not available.

of complete fertilizers in Connecticut averaged 2.99 per cent, while the guaranteed analysis averaged 2.79 per cent. While there were individual cases in which the actual analysis was less than the guaranteed analysis, the general tendency was for the actual nitrogen content to be in excess of the guaranteed. The fertilizer laws of most States make it unlawful to sell fertilizer that contains less than its guaranteed analysis. The average guaranteed and actual analyses indicate that, although there have been violations of the law, in general the actual analysis has been as indicated by the guarantee.

For the four years 1886 to 1889 the average actual nitrogen content exceeded the average guarantee by 0.31 unit per ton. For the five years 1924 to 1928, however, the overrun averaged only 0.08 unit, or about one-fourth as much as for the earlier period. With improved methods of chemical analysis, manufacture, and control, the general tendency has been for the overrun to decrease.

The available phosphoric-acid content averaged 8.34 per cent for the period from 1884 to 1928. This was 1.03 units per ton greater than the guarantee, and was about five times as great as the average overrun for nitrogen. For the five years 1884 to 1888 the overrun of available phosphoric acid averaged 1.59 units per ton, as compared with an average overrun of only 0.40 unit for the five years 1924 to 1928. The overrun was about one-fourth as great for the later period as for the earlier period. This was the same relative decline as occurred in the nitrogen overrun.

For the five-year period 1924 to 1928 the potash overrun averaged 0.27 unit per ton, as compared with 0.45 unit for the five years 1884 to 1888. The overrun for the later period was 51 per cent of that of the earlier period. The decline in the potash overrun was less than that for the other plant foods.

For the forty-five-year period 1884 to 1928, the nitrogen overrun averaged 0.20 unit, the phosphoric acid overrun 1.03 units, and the potash overrun 0.29 unit. Nitrogen is the most expensive plant food, while phosphoric acid is the cheapest. The overrun was lowest for the most expensive plant food, and was greatest for the cheapest plant food. This relationship occurred during the post-war period, although the overrun of each plant food was less than during the pre-war period.

In each of the forty years 1884 to 1923 the correlation between the guaranteed and the actual nitrogen content of the complete fertilizers in Connecticut was greater than 0.87, and there was a tendency for the correlations to be highest during the latter half of the period (table 118). Not only was there a high degree of relationship between the guaranteed and the actual analysis, but the degree of relationship tended to increase.

The correlations between the guaranteed and the actual potash content were high throughout the entire period, while the correlations between the guaranteed and the actual phosphoric-acid content were lower than those for either of the other two plant foods.

The correlations between the guaranteed and the actual analysis of each plant food indicate that there is a high degree of relationship between the two. The amount by which the actual analysis increased per unit increase in the guaranteed analysis is shown in table 118. For most of the period the increase in the actual analysis per unit increase in the guarantee was somewhat less than 1. This was especially true of the phosphoric acid. It would seem to indicate that the overrun tends to be somewhat less on the higher analyses.

#### *Relation of the retail price of complete fertilizers to the guaranteed and the actual analysis*

The correlations between price and analysis of complete fertilizers discussed in the preceding pages have all been between the guaranteed analysis and the retail price. In some cases the actual analysis was less than the guaranteed analysis, but in most cases the actual analysis exceeded the guaranteed. It might be expected that the retail price of those brands which had a relatively large overrun would tend to be greater than those whose actual and guaranteed analyses were more nearly the same.

TABLE 118. CORRELATIONS BETWEEN GUARANTEED AND ACTUAL ANALYSIS OF COMPLETE FERTILIZERS IN CONNECTICUT, AND INCREASE IN THE ACTUAL ANALYSIS PER UNIT INCREASE IN THE GUARANTEED ANALYSIS, 1884 TO 1923

Year	Correlations between guaranteed and actual			Increase in actual analysis per unit increase in guaranteed		
	nitrogen content (r)	phosphoric-acid content (r)	potash content (r)	nitrogen content	phosphoric-acid content	potash content
1884-1888.....	0.897	0.752	0.927	0.94	0.73	0.93
1890-1894.....	0.944	0.796	0.950	0.92	0.79	1.00
1900-1904.....	0.969	0.815	0.981	0.96	0.84	0.98
1910-1914.....	0.979	0.891	0.971	0.94	0.82	0.96
1922-1923.....	0.981	0.934	0.975	0.96	0.88	0.95
1884.....	0.913	0.658	0.952	0.95	0.62	1.00
1885.....	0.910	0.844	0.962	1.04	0.93	1.06
1886.....	0.875	0.811	0.885	0.88	0.86	0.92
1887.....	0.872	0.759	0.907	0.98	0.71	0.79
1888.....	0.915	0.688	0.931	0.83	0.51	0.89
1889.....	0.895	0.703	0.861	0.86	0.64	0.70
1890.....	0.925	0.801	0.910	0.87	0.81	0.89
1891.....	0.951	0.845	0.959	0.97	0.86	1.04
1892.....	0.948	0.726	0.965	0.89	0.72	1.01
1893.....	0.937	0.786	0.956	0.90	0.78	1.04
1894.....	0.958	0.822	0.959	0.96	0.80	1.03
1895.....	0.956	0.774	0.956	0.92	0.79	1.01
1896.....	0.920	0.768	0.967	0.90	0.81	0.99
1897.....	0.972	0.793	0.974	0.95	0.85	0.99
1898.....	0.933	0.793	0.971	0.93	0.83	1.00
1899.....	0.960	0.745	0.959	0.95	0.77	0.98
1900.....	0.925	0.749	0.979	0.93	0.76	0.97
1901.....	0.981	0.777	0.976	0.95	0.74	0.96
1902.....	0.980	0.877	0.979	0.98	0.91	0.98
1903.....	0.979	0.862	0.986	0.98	0.93	1.00
1904.....	0.978	0.812	0.984	0.97	0.84	0.99
1905.....	0.978	0.805	0.977	0.93	0.78	0.96
1906.....	0.973	0.836	0.975	0.95	0.82	0.96
1907.....	0.967	0.798	0.974	0.92	0.78	0.97
1908.....	0.982	0.894	0.969	0.95	0.86	0.99
1909.....	0.981	0.825	0.976	0.95	0.78	0.99
1910.....	0.977	0.842	0.950	0.93	0.83	0.98
1911.....	0.986	0.888	0.978	0.97	0.84	0.96
1912.....	0.972	0.913	0.974	0.93	0.81	0.94
1913.....	0.981	0.904	0.982	0.94	0.80	0.99
1914.....	0.980	0.909	0.970	0.95	0.84	0.94
1915.....	0.980	0.927	0.948	0.95	0.88	1.06
1916.....	0.985	0.960	0.808	0.98	0.94	1.17
1917.....	0.969	0.948	0.896	0.92	0.98	0.78
1918.....	0.990	0.956	0.896	1.00	0.93	1.07
1919.....	0.981	0.943	0.982	0.98	0.88	0.92
1920.....	0.977	0.913	0.962	0.94	0.83	0.92
1921.....	0.975	0.899	0.944	0.98	0.81	0.92
1922.....	0.983	0.955	0.983	0.98	0.90	0.98
1923.....	0.979	0.914	0.967	0.95	0.85	0.92

For thirty-two of the thirty-nine years 1884 to 1923 (except 1914) the correlation between the retail price and the guaranteed analysis was greater; for seven of the years the correlation between the price and the actual analysis was greater; for some of the years the differences were very small. The largest difference between the two correlations, 0.003, occurred in 1899. The average difference between the correlations was only  $0.014 \pm 0.019$ . The difference was not significant. The coefficients of determination based on the correlations between retail price and guaranteed and actual analysis, are given in table 119.

Fertilizers are sold according to the grade, or guaranteed analysis. The actual and the guaranteed analysis are highly correlated. The difference between the two, or the variations in overrun, were not important in affecting the retail price.



TABLE 119. COEFFICIENTS OF DETERMINATION OF THE RETAIL PRICE OF COMPLETE FERTILIZERS IN CONNECTICUT BY THE GUARANTEED AND THE ACTUAL ANALYSIS, 1881 TO 1923

Year	Guaranteed analysis	Actual analysis, 3 factors*	Actual analysis, 8 factors†
1884-1923‡	73.78	71.22	
1896-1923‡	74.95	71.80	73.76
1881		42.53	
1882		56.43	
1883		65.58	
1884	70.06	63.21	
1885	65.49	74.31	
1886	76.19	69.34	
1887	74.84	71.89	
1888	65.41	62.44	
1889	61.50	71.75	
1890	79.56	76.32	
1891	71.94	70.11	
1892	76.04	70.69	
1893	80.01	79.85	
1894	74.02	69.83	
1895	58.56	59.21	
1896	68.18	60.63	62.20
1897	65.05	64.46	66.91
1898	62.22	61.64	63.70
1899	59.48	60.31	62.34
1900	65.31	66.15	70.39
1901	74.89	74.48	77.52
1902	77.24	77.79	78.81
1903	80.71	78.62	80.13
1904	77.79	71.78	72.76
1905	77.67	77.54	78.30
1906	70.22	69.84	71.06
1907	74.18	69.78	72.67
1908	74.47	75.36	75.53
1909	83.63	81.17	81.62
1910	73.50	69.65	70.77
1911	83.35	80.62	81.04
1912	83.03	79.38	80.55
1913	73.97	69.88	74.63
1914§			
1915	79.38	74.69	76.94
1916	87.07	81.97	82.90
1917	85.64	75.20	77.64
1918	86.42	77.47	78.53
1919	67.83	64.60	69.13
1920	78.28	76.19	79.26
1921	66.26	60.71	68.82
1922	56.10	54.21	60.79
1923	91.88	84.46	76.69

\* Three factors — total nitrogen, available phosphoric acid, and potash.

† Eight factors — nitrate, ammonia, and organic nitrogen, water-soluble, citrate-soluble, and citrate-insoluble phosphoric acid, and muriate and other potash. For the two years 1922 and 1923 the water-soluble and the citrate-soluble phosphoric acid were not reported separately. For those two years the available phosphoric acid was used.

‡ Except 1914.

§ Retail prices for 1914 were not available.

Even though two fertilizers may contain the same amounts of nitrogen, phosphoric acid, and potash, quite different materials may have been used in making them. The Connecticut fertilizer bulletins contained, in addition to the total nitrogen found, the nitrogen found in the nitrate, ammonia, and organic forms. The total phosphoric acid was divided into water-soluble, citrate-soluble, and citrate-insoluble. The potash was divided into muriate and "other potash." The muriate of potash is the chloride, while the "other potash" is primarily sulfate although some carbonate is included.

For the twenty-seven-year period 1896 to 1923 (except 1914), correlations were made between the retail price and the eight different forms of plant food mentioned above. These correlations were only slightly

greater than the correlations in which only the three items in the analysis were considered, and the difference was not significant. The correlations between the price and the actual analysis were the same regardless of whether only the total of each plant food was considered or whether each of the eight forms of plant food were considered separately. The correlations between the retail price and the actual analysis were not significantly different from the correlations between the retail price and the guaranteed analysis.

For the twenty-seven years 1896 to 1923 (except 1914), the coefficient of determination of the retail price by the nitrate nitrogen averaged 25.54, by the ammonia nitrogen 11.09, and by the organic nitrogen 14.20 (table 120). For the period as a whole, the nitrate-nitrogen content of

TABLE 120. COEFFICIENTS OF DETERMINATION OF THE RETAIL PRICE OF COMPLETE FERTILIZERS IN CONNECTICUT BY THE GUARANTEED AND THE ACTUAL NITROGEN CONTENT, 1881 TO 1923

Year	Guaranteed nitrogen content	Actual nitrogen content	Total nitrate, ammonia, and organic nitrogen	Nitrogen		
				Nitrate	Ammonia	Organic
1884-1923*	53.03	46.96				
1896-1923*	54.29	50.15	50.84	25.54	11.09	14.20
1881		41.41				
1882		36.17				
1883		55.46				
1884	44.41	34.73				
1885	34.97	39.62				
1886	60.54	40.06				
1887	51.03	32.91				
1888	38.50	28.87				
1889	52.40	45.16				
1890	57.25	40.97				
1891	53.20	42.40				
1892	51.90	39.44				
1893	51.30	50.49				
1894	55.79	42.32				
1895	51.00	41.07				
1896	43.42	32.84	36.87	8.27	19.37	9.23
1897	45.80	43.75	49.76	12.32	22.74	14.70
1898	38.46	33.90	36.23	9.28	18.64	8.31
1899	37.12	35.47	37.86	13.66	13.82	10.38
1900	38.10	40.09	43.26	27.91	7.81	7.54
1901	49.75	47.53	46.27	41.51	2.14	2.62
1902	56.13	55.69	55.39	35.44	3.29	16.66
1903	55.11	51.73	49.23	35.71	4.07	9.43
1904	52.05	45.78	45.62	34.24	1.70	9.68
1905	57.14	55.14	54.62	39.29	7.16	8.17
1906	50.35	45.47	47.07	28.50	10.51	8.06
1907	58.09	50.87	49.95	28.59	16.42	4.94
1908	55.91	55.27	53.92	29.02	12.89	12.01
1909	62.94	54.26	53.57	33.48	12.98	7.11
1910	56.17	51.70	49.66	23.12	12.06	14.48
1911	61.79	57.22	55.33	28.81	16.04	10.48
1912	62.96	53.89	52.76	35.36	6.61	10.79
1913	55.59	50.85	51.90	30.22	14.07	7.61
1914†						
1915	73.08	70.43	67.38	29.94	20.04	17.40
1916	85.07	81.67	78.99	33.48	21.53	23.98
1917	66.81	53.07	53.70	31.52	9.76	12.42
1918	70.27	58.82	63.17	37.36	4.99	20.82
1919	50.98	47.39	52.30	3.43	27.07	21.80
1920	38.05	40.87	45.80	16.20	0.32	29.28
1921	39.21	38.86	45.78	18.52	1.00	26.26
1922	38.40	38.56	43.50	15.03	8.00	20.47
1923	67.14	63.02	52.69	9.45	4.41	38.83

\* Except 1914.

† Retail prices for 1914 were not available.

TABLE 121. COEFFICIENTS OF DETERMINATION OF THE RETAIL PRICE OF COMPLETE FERTILIZERS IN CONNECTICUT BY THE GUARANTEED AND THE ACTUAL PHOSPHORIC ACID CONTENT, 1881 TO 1923

Year	Guaranteed available phosphoric-acid content	Actual available phosphoric-acid content	Total water-soluble, citrate-soluble, and citrate-insoluble phosphoric acid	Phosphoric acid		
				Water-soluble	Citrate-soluble	Citrate-insoluble
1884-1923*	-2.12	-1.26				
1896-1923*	-0.96	-0.46	-1.43			
1896-1921*	-2.04	-1.20	-1.76	-4.80	+3.14	-0.10
1881.....		+3.69				
1882.....		-3.30				
1883.....		+1.55				
1884.....	-7.00	-1.54				
1885.....	+0.69	+6.32				
1886.....	-5.54	-5.49				
1887.....	-1.21	-3.01				
1888.....	-5.59	-3.69				
1889.....	-10.05	-6.86				
1890.....	-1.61	+1.05				
1891.....	-4.60	-7.95				
1892.....	-6.79	-4.99				
1893.....	-7.69	-5.62				
1894.....	-4.67	-3.34				
1895.....	-2.72	-1.71				
1896.....	-2.66	-3.21	-4.90	-1.42	-2.01	-1.47
1897.....	-2.68	-0.35	-5.32	-2.40	+0.73	-3.65
1898.....	-1.44	-1.16	+0.41	-5.42	+4.46	+1.37
1899.....	-2.29	-1.17	-4.26	-4.09	+1.93	-2.10
1900.....	-2.47	-2.77	-4.82	-6.37	+1.76	-0.21
1901.....	-5.22	-2.19	-0.16	-11.95	+11.71	+0.08
1902.....	-5.40	-4.83	-5.53	-11.43	+5.96	-0.06
1903.....	-5.27	-3.87	-4.38	-8.07	+3.15	+0.54
1904.....	-4.23	-3.11	-5.90	-6.84	+1.16	-0.22
1905.....	-2.38	-0.12	-1.42	-5.68	+4.75	-0.49
1906.....	-2.52	-0.25	-1.06	-8.10	+6.51	+0.53
1907.....	-3.41	-1.05	-2.81	-6.08	+2.22	+1.05
1908.....	-3.81	-1.75	+0.62	-9.00	+10.09	-0.47
1909.....	-5.51	-2.05	-1.47	-9.04	+7.79	-0.22
1910.....	-4.31	-2.77	-2.66	-5.35	+2.68	+0.01
1911.....	-5.23	-3.02	-2.18	-4.89	+2.72	-0.01
1912.....	-6.19	-4.06	-6.09	-8.95	+3.05	-0.19
1913.....	-5.07	-2.70	-1.49	-4.07	+1.67	+0.91
1914†.....						
1915.....	-4.27	-3.67	+1.93	-4.99	+6.93	-0.01
1916.....	-7.56	-7.65	-4.47	-5.67	+0.65	+0.55
1917.....	-4.99	-5.18	-3.64	-4.69	+1.66	-0.61
1918.....	+2.76	+2.51	-0.06	+1.08	-1.44	+0.30
1919.....	-4.70	-3.48	-2.26	-3.48	+1.13	+0.09
1920.....	+25.84	+21.68	+13.36	+14.00	-1.20	+0.56
1921.....	+11.89	+6.33	+4.66	+2.91	+0.48	+1.27
1922.....	+9.66	+6.71	+2.51		+2.61	-0.10
1923.....	+15.67	+10.70	+2.81		+2.11	+0.70

\* Except 1914.

† Retail prices for 1914 were not available.

During the post-war period it tended to decline in Pennsylvania, New Hampshire, and New York, but in Texas it was unusually high.

From 1900 to 1914 the fertilizer tonnage in the United States more than tripled. There was a marked increase in tonnage in all of the fertilizer States. Costs of distribution were relatively low as compared with retail prices. With this increase in demand, low cost of distribution, and a growing knowledge in regard to fertilizers, the relationship between the analysis and the retail price increased, so that during the period just

TABLE 122. COEFFICIENTS OF DETERMINATION OF THE RETAIL PRICE OF COMPLETE FERTILIZERS IN CONNECTICUT BY THE GUARANTEED AND THE ACTUAL POTASH CONTENT, 1881 TO 1923

Year	Guaranteed potash content	Actual potash content	Total muriate and other potash	Muriate of potash	Other potash
1884-1923*	22.87	25.50			
1896-1923*	21.62	22.11	24.36	6.31	18.04
1881		-2.57			
1882		23.57			
1883		8.57			
1884	32.65	30.02			
1885	29.82	28.38			
1886	21.19	34.77			
1887	25.03	41.99			
1888	32.50	37.26			
1889	19.15	33.45			
1890	23.93	34.30			
1891	23.34	35.66			
1892	30.90	36.24			
1893	36.40	34.98			
1894	22.90	30.85			
1895	10.28	19.85			
1896	27.49	31.00	30.23	12.85	17.38
1897	21.93	21.05	22.47	9.73	12.74
1898	25.21	28.90	27.07	7.94	19.13
1899	24.66	26.01	28.73	7.73	21.00
1900	29.68	28.84	31.95	8.34	23.61
1901	30.36	29.14	31.41	11.94	19.47
1902	26.52	26.93	28.97	7.18	21.79
1903	30.87	30.76	35.27	8.54	26.73
1904	29.97	29.11	33.04	11.50	21.54
1905	22.91	22.52	25.09	9.06	16.03
1906	22.39	24.62	25.06	11.24	13.82
1907	19.49	19.97	25.52	4.46	21.06
1908	22.37	21.84	20.99	5.91	15.08
1909	26.20	28.96	29.51	11.98	17.53
1910	21.65	20.71	23.76	3.45	20.31
1911	26.79	26.43	27.89	3.53	24.36
1912	26.26	29.55	33.88	5.16	28.72
1913	23.45	21.74	24.21	5.99	18.22
1914†					
1915	10.57	7.93	7.64	0.60	7.04
1916	9.57	7.96	8.39	2.86	5.53
1917	23.81	27.31	27.58	14.32	13.26
1918	13.39	16.13	15.42	5.20	10.22
1919	21.54	20.69	19.10	7.43	11.67
1920	14.39	13.64	20.10	-2.59	22.69
1921	15.16	15.51	18.38	0.69	19.07
1922	8.04	8.94	14.78	0.18	14.60
1923	9.08	10.74	21.19	-3.39	24.58

\* Except 1914.

† Retail prices for 1914 were not available.

prior to the war and during the war the analysis accounted for the major part of the variations in price between the different grades.

During the post-war period conditions have been decidedly different. There has been a marked increase in the cost of distribution, so that this constitutes a larger part of the retail price than it did in the pre-war period. The agricultural depression has tended to curtail the demand for fertilizer. High costs of distribution and only a slight increase in demand have probably been important factors associated with the decrease in relationship between the retail price and the analysis.

In Texas, however, the relationship between price and analysis has been very high. This may be owing in part to the fact that a large number of samples were used in obtaining the averages for each grade, and to the rapid increase in fertilizer consumption in Texas. The fertilizer

tonnage in Texas practically doubled during the period from 1925 to 1929. With this marked increase in demand, the relationship between the retail price and the analysis has been high even though distribution charges also have been high.

When demand is increasing, it is probable that the relation between price and analysis tends to be high. When demand does not increase there is increased competition and price cutting, factors other than the analysis are important in affecting the price, and it is probable that the relationship between price and analysis declines.

#### SUMMARY

During the past twenty years there have been violent fluctuations in the price of fertilizer materials, which have been a disturbing factor in the fertilizer industry and have caused manufacturers and farmers to shift from one material to another as a source of plant food.

When the price of cottonseed meal was high, it was more closely associated with the analysis than when it was low. The retail price of nitrogen in cottonseed meal tends to be lowest in the higher grades.

Prices of most organic nitrogen carriers followed the same course. The retail price of tankage, however, was affected by the cattle cycle. When cattle prices were high, the price of tankage was high relative to other ammoniates.

During the period from 1882 to 1914, the trends in wholesale and retail prices of nitrate of soda were the same. The wholesale prices fluctuated widely from year to year, and these fluctuations were reflected in the retail prices. With passing time there was a tendency for retail prices to fluctuate less violently than wholesale prices.

For the five years 1924 to 1928, retail prices were high as compared with wholesale prices. The average wholesale price of nitrate of soda was 11 per cent above the pre-war figure, the retail price was 25 per cent above, and the margin between the wholesale and the retail price was 86 per cent above.

Prior to the war, relatively few data were available on the retail price of sulfate of ammonia, probably reflecting the limited use of this form of nitrogen. During the post-war period the situation has been reversed, and sulfate of ammonia has become one of the cheapest sources of nitrogen. Its use has been greatly stimulated, and it is now the most important source of nitrogen in complete fertilizers.

During the period from 1890 to 1914, the trends in wholesale and retail prices of phosphoric acid were approximately the same. In the pre-war period the changes in the wholesale price from year to year were small and were not closely associated with the changes in the retail price. Although many different grades of superphosphate are sold, phosphoric acid is cheapest in the higher grades. There are greater differences in the retail price per unit between the low and the medium grades than between the medium and the high grades. The bulk of the tonnage is composed of the medium grades.

With the inflation, wholesale prices of superphosphate rose more than did retail prices; and conversely, with the deflation, wholesale prices fell more, and fell more rapidly, than did retail prices.

The high cost of distribution following the war stimulated the use of higher-grade superphosphate. The increase in the use of high-analysis superphosphate has been greater in Indiana than in other States. The cost of distribution in Indiana is a larger proportion of the retail price than is the case in other States which are nearer the main source of supply.

During the pre-war period the trends in wholesale and retail prices of potash salts were similar. As compared with the nitrogen carriers, there was relatively little variation in the wholesale price of potash salts during the pre-war period. These changes in the wholesale price were not closely associated with changes in the retail price.

Owing to the scarcity of potash during the war period, wholesale prices were unusually high and potash salts disappeared from the retail markets.

Although there are wide variations in the analysis and the wholesale price of the potash salts, there are no significant differences in the margin between the wholesale and the retail price, or the cost of distributing the various salts. Consequently, the cost of distribution was only 11 per cent of the retail price of sulfate of potash, a high-grade salt, as compared with 47 per cent for kainit, a low-grade salt. With the high cost of distribution during the post-deflation period, the margin between the wholesale and the retail price widened, and was 15 per cent of the retail price for sulfate of potash and 67 per cent for kainit. When the cost of distribution increases, low-grade goods are affected the most, because the cost of distribution is a larger part of the retail price of low-grade goods than of high-grade goods.

In the pre-war period the retail price of potash in kainit, a low-grade salt, was 19 per cent greater than in muriate, a high-grade salt, as compared with 56 per cent greater in the post-war period, even though the relationship between the wholesale prices of the two salts was about the same as during the pre-war period.

The wholesale price of kainit for the five years 1924 to 1928 averaged 8 per cent less than the pre-war price, but the retail price to farmers averaged 39 per cent more than the pre-war figure.

High costs of distribution were not confined to any particular fertilizer material or geographic area. Costs of distribution are high for all fertilizer materials in New York, Connecticut, Pennsylvania, Indiana, and Texas.

During the early development of the fertilizer industry, bones were an important source of plant food; but with relatively low prices of mineral and synthetic plant-food carriers, bone products are now of only minor importance. Although the variations in the retail price of the various grades of bone manures are less than the variations in the chemical analysis, the retail price varies with the analysis. While bones contain both phosphoric acid and nitrogen, there was a tendency for the retail price to be more closely associated with the nitrogen than with the phosphoric-acid content.

In the post-war period the index number of the retail price of bones has been higher than that of any of the other fertilizer materials.

Although farmers buy fertilizer materials, the bulk of the fertilizer tonnage in the United States is mixed fertilizer, containing nitrogen, phosphoric acid, and potash. Almost every possible combination of these three plant foods has been made and sold to farmers. In the past thirty

years, more than 900 different combinations have been reported for sale by fertilizer inspectors in one State. Owing to the high cost of manufacture and distribution, and to a greater knowledge of the uses of fertilizers, the number of mixtures has decreased.

There is a high degree of relationship between the plant-food content of complete fertilizers and the retail price. For the five years 1924 to 1928, approximately 74 per cent of the variations in the retail price of the complete fertilizers were associated with the variations in the analysis.

Variations in the ammonia content of the fertilizers accounted for 62 per cent of the variability in the retail price; the phosphoric-acid and the potash content were of only minor importance, accounting for 5 and 7 per cent, respectively, of the variability in the retail price. While the relationship between the retail price and the analysis varied among the States, the relative importance of the three plant foods was much the same in New York, New Hampshire, Connecticut, Pennsylvania, and Texas. During the twenty-year period ending in 1920, there was a tendency for the retail price to become more closely associated with the plant-food content. During the deflation period, the relation between price and analysis has tended to decline. High distribution costs, increased competition, and price cutting, have disturbed the relationship between the retail price and the plant-food content.

In New York, Pennsylvania, New Hampshire, and Connecticut, the variation in the retail price of complete fertilizers per unit variation in potash content tended to fluctuate around the wholesale price of potash. That is, the difference in price between fertilizers of low and of high potash content tended to be equal to the difference in the cost of the potash at wholesale prices.

In New York, Connecticut, New Hampshire, and Pennsylvania, during the post-war period, the difference in retail price between complete fertilizers with high and with low phosphoric-acid content was approximately equal to the wholesale price of the phosphoric acid. In Pennsylvania, during the pre-war period, the difference in retail price of complete fertilizers per unit variation in phosphoric-acid content tended to be consistently lower than the wholesale price of phosphoric acid; there was a tendency, however, for the difference to become more nearly equal to the wholesale price.

Thus it appears that the difference between the retail price of fertilizers of high and of low phosphoric-acid content tends to equal the difference in the wholesale cost of the phosphoric acid which they contain. This is the normal relationship.

Because of the wide variety of nitrogen carriers used, and the difference in their prices, it is difficult to determine the normal relationship between the retail prices of complete fertilizers of high and of low nitrogen content. From the retail price of complete fertilizers of high and of low nitrogen content in Connecticut, it appears that the difference in the retail price is equal to the difference in the wholesale cost of the nitrogen. In Pennsylvania, during the pre-war period the change in the retail price of fertilizers per unit change in the nitrogen content was greater than the wholesale price of the nitrogen; during the post-war period it has been low in relation to the wholesale price of organic ammonia, but high

in relation to that of mineral ammonia. It is probable that the normal difference in retail price of low- and of high-analysis nitrogen fertilizers is also the difference in the wholesale cost of the nitrogen which they contain.

The retail price of mixed fertilizers tends to be the wholesale cost of materials plus a uniform amount per ton to cover the cost of manufacture and distribution. Consequently, the difference in the retail price of low- and of high-grade fertilizers tends to be merely the difference in the wholesale cost of the raw materials. Therefore the retail price tends to be much less variable than the analysis, and the farmer who uses mixed fertilizers finds it cheaper to purchase additional plant food by obtaining fertilizers of higher analysis than by getting additional material in unmixed form. By buying higher-analysis fertilizer the farmer pays only wholesale prices for the additional plant food. If the additional plant food is purchased in unmixed material, the farmer pays the wholesale price plus the cost of distribution.

The cost of manufacture and distribution of mixed fertilizers during the post-war period has been about 75 per cent greater than the pre-war cost. This marked change has increased the difference in the retail price of plant food per unit in high- and in low-grade fertilizers. Because of this difference, there has been a marked increase in the use of high-analysis fertilizers. Increasing the number of units of plant food per ton is a method of economizing on the cost of manufacture and distribution per unit of plant food.

There is a high degree of correlation between the guaranteed and the actual analysis of mixed fertilizers. With the improvement in methods of manufacture and chemical analysis, there has been a tendency for the overrun of each plant food to decline. The overrun for phosphoric acid is the greatest and that for nitrogen is the least. The overrun tends to be lowest for the most expensive plant food, and highest for the cheapest.

The nitrogen content of the fertilizers was the most important factor associated with variations in the retail price. Considering separately each of the three different forms of nitrogen—organic, nitrate, and ammonia—did not change the degree of relationship between the retail price and the total nitrogen content. Similarly, the separation of the phosphoric acid and the potash into their constituents did not increase the degree of relationship between the analysis and the price.

The total plant-food content of fertilizers, rather than the carrier, is the important factor affecting the retail price.

For many crops the application of unmixed materials in addition to the regular applications of complete fertilizers has often been recommended. This is not the cheapest method of buying the additional plant food. If the additional plant food is obtained by purchasing higher-analysis mixed fertilizers, the added cost would tend to be the wholesale cost of the additional plant food. If the plant food is purchased in unmixed form, the added cost is the wholesale price plus the cost of distribution. If the supplementary application of the unmixed material is considerably more efficient than the application of additional food in



the mixed fertilizers, it might pay to follow this method even though the cost of plant food per unit is somewhat higher.

With the high cost of distribution, retail prices of plant food in low analysis materials and in low-analysis complete fertilizers are unusual high.

During the post-war period, the retail price of mixed fertilizers per ton has been high because of the increase in concentration of plant food and because of high distribution costs. The high distribution costs have reduced the manufacturer's proportion of the farmer's dollar spent for fertilizers. This increase in distribution costs has affected the fertilizer industry in much the same way as the high distribution charges have affected agriculture.

The decline in the general price level since the war has had a disastrous effect on the fertilizer industry.

### SOURCES OF DATA

The fertilizer laws of most States require the collection and analysis of samples of fertilizers sold in the respective States. The fertilizer reports of the various States contain primarily the guaranteed analysis and the actual analysis as determined by the state chemist, of the sample of fertilizers collected by the state fertilizer inspectors. The fertilizer reports for Connecticut, Indiana, New Hampshire, New York, Pennsylvania, and Texas contained the retail price of the fertilizers which were sampled, as well as the analysis. The retail prices of fertilizer materials and of mixed fertilizers used in this study were tabulated from the fertilizer reports for Connecticut, Indiana, New Hampshire, New York, Pennsylvania, and Texas.

The wholesale prices of fertilizer materials for the period from 1890 to 1927 were taken from *Prices of Fertilizer Materials, and Factors Affecting the Fertilizer Tonnage*, by E. E. Vial (Cornell Univ. Agr. Expt. Sta., Memoir 119, 1928). Wholesale prices for the years 1928 and 1929 were taken from *Fertilizer Economics* (N. V. Potash Export Co., No. 1 to 9, October, 1928, to June, 1929). Wholesale prices for the period from 1881 to 1897 were tabulated from the Connecticut fertilizer reports as listed in the following paragraph.

The data for Connecticut for the years 1881 to 1906 and 1911 to 1916 were tabulated from the fertilizer sections of the annual reports of the Connecticut Agricultural Experiment Station; for the years 1907 to 1910 from the fertilizer sections of the biennial reports of the Connecticut Agricultural Experiment Station; for the years 1917 to 1928 from the annual fertilizer reports of the Connecticut Agricultural Experiment Station (Bulletins 204, 209, 217, 223, 233, 241, 250, 261, 270, 282, 290, and 296).

For the years 1881 to 1909 the fertilizer reports contained data on "nitrogenous superphosphates" and also on "special fertilizers or special manures." The fertilizers reported in each of these groups contained nitrogen, phosphoric acid, and potash. Both groups were used in studying the analysis and the price of complete fertilizers.

The data for Indiana were tabulated from the bulletins of the Purdue University Agricultural Experiment Station entitled *Commercial Fer*

izers (Bulletins 112, 121, 125, 133, 148, 151, 156, 166, 174, 180, 186, 199, 215, 229, 241, 253, 262, 269, 280, 292, and 301, and Circulars 146, 155, and 163).

The data for New Hampshire were tabulated from the bulletins of the New Hampshire Agricultural Experiment Station entitled *Inspection of Commercial Fertilizers* (Bulletins 196, 201, 206, 210, 214, 219, 225, 231, 237, and 248).

The data for New York were tabulated from the following bulletins of the New York (Geneva) Agricultural Experiment Station: Bulletins 99, 511, 539, and 548, entitled *Composition and Prices of Commercial Fertilizers in New York*; Bulletin 525, entitled *Changes in the Composition and Cost of Fertilizers in New York from 1914 to 1924*; and Bulletin 557, entitled *Commercial Fertilizers*. L. L. Van Slyke was the author of all of these bulletins.

The data for Pennsylvania were tabulated from the fertilizer reports of the Pennsylvania Department of Agriculture (Bulletins 51, 54, 72, 83, 89, 109, 114, 119, 126, 132, 138, 142, 149, 153, 159, 163, 171, 173, 185, 189, 199, 203, 212, 218, 230, 242, 244, 255, 259, 269, 277, 282, 288, 301, 308, 318, 328, 333, 347, 352, 358, 364, 370, 372, 377, 378, 387, 402, 425, 444, 463, and 479).

The data for Texas were tabulated from the bulletins of the Texas Agricultural Experiment Station entitled *Commercial Fertilizers* (Bulletins 217, 233, 248, 265, 280, 298, 312, 322, 335, 346, 368, 387, and 403).