



# Consumption of Fertilizer Materials and Grades in Oklahoma

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Fertilizer consumption in Oklahoma is far below the tonnage which will eventually be needed to maintain or increase crop yields. In eastern Oklahoma, where the average annual rainfall is higher than in the central and western part of the state, many farmers have discovered that it is profitable to use fertilizer to increase crop production on soils which possess a favorable physical structure for the storage of moisture and root development. After the productive capacity of a virgin soil which has not been too severely damaged by soil erosion has declined to a point where one or more plant nutrients must be applied or low crop yields will be obtained, the use of fertilizer will become an important part of the business of farming. Data obtained from field and laboratory tests indicate that crop yields are limited on more than 60 percent of the cultivated soils in eastern Oklahoma by low soil fertility.\*

A study of the tables presented in this report will show that a large number of different fertilizer grades have been used on Oklahoma farms during the past fourteen years for which records are available. A lack of experimental information and practical farm experience which could be used as a guide for fertilizer use on different crops has been partly responsible for this condition. Although soil tests have indicated the need for phosphate fertilization on many farms and field experiments have shown that profitable increases in yield were obtained from fertilizer applied to many crops, land owners and tenants do not change their farming procedure rapidly. Many of them do not realize that part of the farm income must be spent to maintain or improve the fertility of the soil. A better knowledge of crop and soil requirements and a more efficient use of the fertilizer applied will be important factors affecting the increased consumption of commercial materials for soil improvement in many localities.

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\* Recommendations concerning the need for commercial fertilizers in Oklahoma, proper use, and methods of applying them, are being prepared for publication as a separate experiment station bulletin.

## FERTILIZER CONSUMPTION BY YEARS, 1920 TO 1943

Data on fertilizer consumption in Oklahoma during the 24-year period from 1920 to 1943, inclusive, are given in Table I. Information for the years 1920 to 1923 are estimates obtained from the best sources available. The tonnage from 1924-43 was calculated from the sale of fertilizer tags, which, according to Oklahoma law, must be placed on each sack of fertilizer sold in the state. The estimated average annual consumption of fertilizer in Oklahoma was 1500 tons from 1910 to 1914 and 3000 from 1915 to 1919, according to a report prepared by the National Fertilizer Association.\*

TABLE I.—Quantity of Commercial Fertilizer Consumed in Oklahoma During the 24-year Period from 1920 to 1943, Inclusive.\*

Year**	Tons	Year**	Tons	Year**	Tons
1920	4000**	1928	8308	1936	5985
1921	2000**	1929	9377	1937	6185
1922	2500**	1930	9492	1938	8505
1923	3600**	1931	7139	1939	7512
1924	3290	1932	3223	1940	6871
1925	3709	1933	1985	1941	10790
1926	7344	1934	4730	1942	11385
1927	4417	1935	5932	1943	16494

\* Calculated from sale of fertilizer tags, except 1920 to 1923, inclusive, which are estimated.

\*\* From July 1 of the previous year to June 30 of year indicated.

The data in Table I show that the sale of fertilizer tags from 1924 to 1943 has been quite variable, a minimum quantity of fertilizer being used in 1932 and 1933 when the value of farm products was low.

Crop value has not had as much influence on the quantity of fertilizer used in Oklahoma as in other areas where larger applications per acre will normally produce an additional increase in crop yield. The price of cotton and Irish potatoes during the preceding season or a few months prior to the planting of these crops should have some influence on fertilizer consumption if there is any opportunity for profit. However, in Oklahoma the rate of fertilizer application per acre is low because of a wide variation in seasonal rainfall. Under such conditions a farmer will apply about the same amount of fertilizer per acre unless there is some indication that the value of the crop produced will be very low. No relation between the

\* Herbert Willett, Fertilizer Prices and Price Indexes, May 1937 p. 41. National Fertilizer Association, Washington, D. C.

quantity of fertilizer sold and the January price of Irish potatoes or the March price of cotton for the six-year period, 1938 to 1943, was obtained.

### Fertilizer Materials

Data on the tonnage of fertilizer materials sold in Oklahoma during the 14-year period from July 1, 1929 to June 20, 1943 are given in Table II. The information presented in this table was obtained from invoices received from fertilizer companies at the time fertilizer shipments were made to Oklahoma dealers or directly to consumer.\*

Fertilizer materials differ from fertilizer grades in that they are not physical mixtures. Some fertilizer materials are obtained from natural sources such as nitrate of soda, muriate of potash and ground phosphate rock. Other fertilizer materials are produced by various chemical reactions. Superphosphate, for example, is prepared by mixing finely ground rock phosphate with sulfuric acid; and ammonium sulfate is obtained in the manufacture of coke by passing the ammonia liberated from the heated coal into sulfuric acid.

Ammonium phosphate contains nitrogen and phosphorus in one chemical compound. The percentage of nitrogen and phosphorus in this compound can be shown as 11-48-0; however, it is classified as a material since it is not a physical mixture.

If the nitrogen in a fertilizer is obtained from ammonium sulfate and phosphorus is obtained from superphosphate, the product would be classified as a fertilizer grade because the plant nutrients were obtained from different sources and were combined to produce a physical mixture of guaranteed composition.

Fertilizer materials sold in Oklahoma include different kinds of phosphate fertilizers, potash fertilizers and nitrogen fertilizers. The nitrogen fertilizers were divided into two groups in Table II since the nitrogen may be present in organic or inorganic forms.

### Phosphate Fertilizers

A study of Table II will show that superphosphate containing only 16 percent of available phosphoric acid\*\* was sold in larger quantities than "18 or 20 percent" superphosphate from 1929 to 1930. At the present time 16 percent superphosphate

\* The extent to which fertilizer tonnage as calculated from shipping invoices agrees with tonnage as calculated from tax sales is discussed in Appendix II, p. 00.

\*\* Fertilizers do not contain phosphorus acid but available phosphorus equivalent to a certain percentage of phosphorus pentoxide ( $P_2O_5$ ) which is improperly called phosphoric acid.

TABLE II.—Fertilizer Materials Sold in Oklahoma During the 14-year Period from July 1, 1929, to June 30, 1943.\*  
(Tons)

Fertilizer Materials	1929-30	1930-31	1931-32	1932-33	1933-34	1934-35	1935-36
<b>A. Phosphate fertilizers</b>							
1. Bone meal (raw and steamed)	1.90	7.40	25.30	3.00	4.15	65.25	49.50
2. Rock phosphate		384.00	40.00		40.00		130.55
3. Superphosphate, 16% P <sub>2</sub> O <sub>5</sub>	613.10	326.20	78.50	17.50	.75		5.00
4. Superphosphate, 18% P <sub>2</sub> O <sub>5</sub>	507.50	456.40	261.05	103.45	240.32	232.86	201.12
5. Superphosphate, 20% P <sub>2</sub> O <sub>5</sub>	239.50	266.90	72.05	90.50	177.85	206.95	181.35
6. Superphosphate, 32% P <sub>2</sub> O <sub>5</sub>							
7. Superphosphate, 45% P <sub>2</sub> O <sub>5</sub>			2.15			9.25	.75
<b>B. Potash fertilizers</b>							
1. Kainit	.30	8.25	1.30	.05			
2. Muriate of potash	3.40	21.40	21.20	7.05	7.20	3.70	7.95
3. Sulfate of potash				1.00	.50	.15	
<b>C. Nitrogen fertilizers, inorganic materials</b>							
1. Ammonium sulfate	2.45	75.85	53.80	30.70	40.10	48.60	37.10
2. Nitrate of lime							
3. Nitrate of soda	30.80	19.60	26.80	8.95	19.30	33.50	54.70
<b>D. Nitrogen fertilizers, organic materials</b>							
1. Animal manure (dried)	1.00	5.50	1.25	1.00		2.50	4.50
2. Blood meal							
3. Calcium cyanamide							
<b>E. Miscellaneous</b>							
1. Ammonium phosphate				3.00			
2. Lawn, garden, and golf courses	.42					2.00	.70
<b>A. Phosphate fertilizers</b>							
1. Bone meal (raw and steamed)	35.13	23.35	46.75	20.90	23.26	17.00	24.46
2. Rock phosphate	647.00	450.00	255.00	333.05	623.60		
3. Superphosphate, 16% P <sub>2</sub> O <sub>5</sub>	5.50						
4. Superphosphate, 18% P <sub>2</sub> O <sub>5</sub>	190.45	191.50	210.25	45.00	126.95	69.15	251.00
5. Superphosphate, 20% P <sub>2</sub> O <sub>5</sub>	346.85	540.21	301.20	301.45	671.38	492.50	1002.55
6. Superphosphate, 32% P <sub>2</sub> O <sub>5</sub>	20.00						
7. Superphosphate, 45% P <sub>2</sub> O <sub>5</sub>		.10	2.70	1.00	12.10	20.50	6.00
<b>B. Potash fertilizers</b>							
1. Kainit							1.00
2. Muriate of potash		3.95	8.35	7.55	3.05	10.25	1.50
3. Sulfate of potash			.05	.40			



*TABLE II.—(Continued.)*

Fertilizer Materials	1936-37	1937-38	1938-39	1939-40	1940-41	1941-42	1942-43
<b>A. Phosphate fertilizers</b>							
1. Bone meal (raw and teamed)	35.13	23.35	46.75	20.90	23.26	17.00	24.46
2. Rock phosphate	647.00	450.00	255.00	333.05	623.60		
3. Sperphosphate, 16% P <sub>2</sub> O <sub>5</sub>	5.50						
4. Superphosphate, 18% P <sub>2</sub> O <sub>5</sub>	190.45	191.50	210.25	45.00	126.95	69.15	251.00
5. Superphosphate, 20% P <sub>2</sub> O <sub>5</sub>	346.85	540.21	301.20	301.45	671.38	492.50	1002.55
6. Superphosphate, 32% P <sub>2</sub> O <sub>5</sub>	20.00						
7. Superphosphate, 45% P <sub>2</sub> O <sub>5</sub>		.10	2.70	1.00	12.10	20.50	6.00
<b>B. Potash fertilizers</b>							
1. Kainit							1.00
2. Muriate of potash		3.95	8.35	7.55	3.05	10.25	1.50
3. Sulfate of potash			.05	.40			

TABLE II.—(Continued.)

Fertilizer Materials	1935-37	1937-38	1938-39	1939-40	1940-41	1941-42	1942-43
C. Nitrogen fertilizers, inorganic materials							
1. Ammonium sulfate	90.15	161.55	103.02	127.19	176.85	136.83	64.99
2. Nitrate of lime	.50						
3. Nitrate of soda	30.20	29.70	22.80	13.10	108.25	10.45	137.95
D. Nitrogen fertilizers organic materials							
1. Animal manure (dried)	20.25	14.70	12.00	9.30	58.75	10.67	32.22
2. Blood meal				.10			
3. Calcium cyanamide			3.00		.30		
E. Miscellaneous							
1. Ammonium phosphate				.20	.25	1.25	.50
2. Lawn, garden and golf courses	12.12	19.40	21.55	221.34	262.52	153.34	

\* Data based on invoices received from fertilizer companies.

is not approved for sale in Oklahoma because superphosphate manufactured from high grade rock phosphate by mixing this material with sulfuric acid contains more than 16 percent of available phosphoric acid. It is necessary to reduce the phosphorus content of the superphosphate as it is manufactured so that it will analyze approximately 16 percent of available phosphoric acid. This is usually accomplished by the addition of sand. A high percentage of the superphosphate shipments into Oklahoma in 1940-41 contained 20 percent of available phosphoric acid. Superphosphate containing more than 20 percent of available phosphoric acid is obtained by greatly reducing or eliminating the gypsum which remains in ordinary superphosphate in the manufacturing process. Since the cost per unit\*\* of phosphoric acid in the 32 percent and 45 percent material is very similar to a lower analysis product, the chief advantage to the consumer would be a lower labor requirement in handling and applying these materials to the soil. Only a very small quantity of ammonium phosphate has been used in Oklahoma. Some bone meal has been sold but this material will never become an important phosphate fertilizer because it is worth more money when used in mineral mixtures for livestock and poultry. Basic slag is another phosphate fertilizer produced by a by-product in the manufacture of steel from ore containing rather large quantities of phosphorus. The total and available phosphorus content of basic slag is low, consequently it cannot be used extensively in this area because of

\*\* One unit is 20 pounds, which is equal to one percent per ton.

a higher transportation cost per unit of phosphoric acid as compared with other phosphate fertilizers.

The tonnage of finely ground rock phosphate was slightly lower than the combined tonnage of the different superphosphates during the five-year period from 1937-1941. No shipping invoices on rock phosphate were received in 1942 and 1943. This fertilizer is used most extensively to increase the production of legume crops such as alfalfa, sweet clover, and hairy vetch which should be grown in a rotation with row crops or small grain to increase the nitrogen content of the soil.

The Agricultural Adjustment Agency of the U. S. D. A. has distributed superphosphate to farmers cooperating with their crop adjustment program since 1938. During the first three years of this period, superphosphate containing phosphorus equivalent to 48 percent phosphoric acid ( $P_2O_5$ ) and produced by the Tennessee Valley Authority was shipped to Oklahoma from Muscle Shoals, Alabama. In 1941 and 1942, superphosphate containing phosphorus equivalent to 20 percent of phosphoric acid ( $P_2O_5$ ) was purchased and distributed in 45 Oklahoma counties to be used on legume crops or pasture land. The quantity of superphosphate used in different counties in Oklahoma during the five-year period from 1938 to 1942 is given in Table III. In 1942, according to compliance records, only 3,500 tons of superphosphate were applied, the remainder being carried over for use in connection with the 1943 farm program.

The tonnage of superphosphate shipped into Oklahoma counties in 1942 by the Agricultural Adjustment Agency of the U. S. D. A. was more than five times the average quantity of both super and rock phosphate purchased annually by Oklahoma farmers since 1936. The use of phosphate fertilizer and agricultural limestone to increase the yield of legume crops which add nitrogen to the soil is a very desirable method of soil improvement on many farms.

### Potash Fertilizers

Very little potash fertilizer has been sold in Oklahoma except as it occurs in fertilizer grades. Sandy soils in the southeastern part of the state are more deficient in available potash than soil types occurring in other areas. These soils usually have a yellow sandy clay subsoil and are also normally deficient in phosphorus; consequently, it has been more convenient for the average farmer to apply phosphorus and potash in a mixed fertilizer than to purchase and apply these plant nutrients separately or as home-mixed materials. More potash should be applied for the production of legume crops, such as alfalfa,

TABLE III.—Quantity of Superphosphate Distributed in Oklahoma by the Agricultural Adjustment Agency of the U. S. D. A. during the Five-year Period from 1938 to 1942.  
(Year, and quantity in pounds.)

County	1938*	1939*	1940*	1941	1942**
Adair					507,000
Atoka					220,000
Bryan					348,300
Carter					640,000
Cherokee					269,900
Choctaw					260,000
Coal					220,000
Craig			1,600		240,000
Creek					422,600
Delaware					168,000
Garvin					80,000
Haskell					60,000
Hughes	122,000	57,200	100,400	144,000	444,300
Johnston		97,200	106,800		120,000
Kay					280,000
Latimer					230,000
LeFlore					680,000
Lincoln					239,550
Logan					240,000
Love					260,000
McClain					80,000
McCurtain			58,200	144,000	140,000
McIntosh					465,000
Marshall					40,000
Mayes					253,710
Murray					80,000
Muskogee			43,000	96,000	179,582
Nowata					240,000
Okfuskee					404,300
Oklahoma			43,400		160,000
Okmulgee					289,700
Osage					200,000
Ottawa					199,785
Pawnee					300,000
Payne					320,000
Pittsburg		1,890	16,000		250,000
Pontotoc		100,000	229,000		160,000
Pottawatomie					420,000
Pushmataha					179,900
Rogers					359,500
Seminole					240,000
Sequoyah			43,200		180,000
Tulsa					217,240
Wagoner					500,000
Washington					319,700
<b>TOTAL</b>	<b>122,000</b>	<b>256,290</b>	<b>641,600</b>	<b>384,000</b>	<b>11,928,467</b>

\* Superphosphate contained 48% P<sub>2</sub>O<sub>5</sub>. In 1941 and 1942, 20% superphosphate was distributed.

\*\* Quantity distributed from January 1, to November 24, 1942.

which are harvested and removed from the land, than to crops such as corn or other row crops where the leaves and stalks are usually left on the soil and supply potassium and other essential elements for the use of succeeding crops. In some states potash fertilizers are applied alone or with nitrogen as a side dressing for row crops. Experimental evidence does not indicate that this procedure will increase potash consumption materially in this area where climatic conditions during the growing season are frequently a limiting factor in plant development.

### Nitrogen Fertilizers

**INORGANIC NITROGEN.**—Ammonium sulfate and nitrate of soda are the two most important commercial forms of inorganic nitrogen used in Oklahoma at the present time. The tonnage of ammonium sulfate has exceeded the quantity of sodium nitrate sold in eleven of the fourteen years. As the quantity of nitrogen used for direct application to winter and spring vegetable crops increases, the tonnage of nitrate fertilizer should increase. The major portion of the sodium nitrate is used to increase the production of spinach.

Ammonium nitrate is a synthetic source of nitrogen that is sold under several trade names. The pure salt contains about 35 percent of total nitrogen. It absorbs moisture rapidly when exposed to a humid atmosphere, consequently the particles must be coated or mixed with some material such as limestone, gypsum, ammonium sulfate or siliceous earth and must be kept in moisture-proof bags until it is used. This fertilizer should be one of the important future sources of inorganic nitrogen and it is being used in large quantities at the present time with liquid ammonia to increase the nitrogen content of ammoniated superphosphate. Calnitro is a mixture of ammonium nitrate and calcium carbonate and contains from 16 to 20 percent of total nitrogen.

**ORGANIC NITROGEN.**—Dried animal manure and cottonseed meal are the most important organic nitrogen fertilizers sold in Oklahoma at the present time. Since cottonseed meal is registered as a feed, no information is available on the quantity of this material used as a fertilizer during the past 14 years. Cottonseed meal is usually mixed with superphosphate before it is applied to the soil.

Calcium cyanamide and urea are the two most important sources of organic nitrogen produced by industrial processes. Organic materials of plant or animal origin are used principally in fertilizer mixtures and are not sold extensively for direct application to the soil. Powdered cyanamide contains 22

percent of total nitrogen. Granular cyanamide contains 21 percent of total nitrogen. Urea contains 46 percent of total nitrogen but is mixed with a drying agent to prevent the absorption of excessive quantities of moisture from the air. This material contains 42 percent of total nitrogen and is sold under the trade name of Uramon.

### Fertilizer Grades

Sixty-two grades of commercial fertilizer have been distributed in Oklahoma during the 14-year period from 1929 to 1943. The different grades and the quantity sold each year during this period are given in Table IV.

The present Oklahoma Fertilizer Law\* requires that a fertilizer grade contain at least 16 units of plant food. This value is determined by adding the percentages of nitrogen, phosphoric acid and potash in a fertilizer grade. Most of the fertilizer grades occurring in Table IV would comply with the fertilizer law, but such a large number of fertilizers are not required in Oklahoma. In some instances only small quantities of certain grades have been used. Since a limited amount of experimental information concerning the kinds of fertilizer which should be used on different soils and crops grown in Oklahoma was available prior to 1930, each fertilizer company was permitted to send as much as 15 tons of one fertilizer not on the approved list into the state to be used for demonstration purposes by the fertilizer control officials of the State Department of Agriculture. This regulation was discontinued in 1939.

For many years fertilizer manufacturers have realized that a reduction in the number of fertilizer grades would reduce manufacturing costs; but as long as one company continued to manufacture a fertilizer grade, competition for business required all other companies operating in that trade area to manufacture a similar product. Several meetings have been held in Shreveport, Louisiana, since 1931 for the purpose of limiting the number of fertilizer grades which would be offered for sale in Oklahoma, Arkansas, Texas and Louisiana. These meetings were sponsored by the Soil Improvement Committee of the National Fertilizer Association. Earlier meetings had been held for the purpose of reducing the number of fertilizer grades in Texas and Louisiana. Representatives from fertilizer companies and state experiment stations, state fertilizer

\* The Oklahoma Fertilizer Law and rules and regulations pertaining to it are published in "State of Oklahoma: Seed Law, Commercial Feed Law, Fertilizer Law, Orchard and Nursery Law, and Their Rules and Regulations," Part II, pp. 46-50. Copies are available from the State Department of Agriculture, Oklahoma City, Okla. The text of the law also appears in *Compiled Oklahoma Statutes*, 1941, Title 2, ch. 10, Sections 460 to 470, inclusive.

TABLE IV.—Fertilizer Grades Sold in Oklahoma During the 14-year Period from July 1, 1929 to June 30, 1943.\*

Fertilizer Grades	1929-30	1930-31	1931-32	1932-33	1933-34	1934-35	1935-36	1936-37	1937-38	1938-39	1939-40	1940-41	1941-42	1942-43
0-12-4												4.25		
0-12-12									5.00					2.00
0-14-7														768.60
2-10-2			1.00		5.50	.80	.60							
2-12-2	368.20	162.10	54.95	61.65	117.10	190.95	159.95	270.25	323.20	194.20	72.00	204.45	115.25	
2-12-0									.65					
2-12-4	11.45	32.65	48.10	30.75	2.15	10.00	30.45	140.00	154.30	.90				
2-12-6	91.55	76.40	69.00	114.25	63.20	87.80	95.20	148.90	83.30	222.65	131.80	481.80	611.65	23.90
2-12-12						.25								
2-12-24							5.00							
2-14-2												5.00		
2-14-4												8.00		
2-16-2												15.00		
2-18-0						.50								
3-8-7														2.40
3-10-3	133.50	26.80	14.50	8.50	41.00	26.20	39.95	29.50	43.55	38.25	28.75	13.00	1.00	1.50
3-10-5	19.50	17.50	2.00											
3-12-6														5289.55
3-12-9														37.25
3-14-6	117.15	104.60		3.50										
4-8-2									15.00					
4-8-4	79.05	104.25	66.10	46.40	229.00	144.90	164.22	200.05	222.50	145.00	162.50	281.95	519.00	
4-8-5									5.00					
4-8-6	1338.60	1652.30	1159.00	660.15	2042.98	2602.98	2180.98	1548.30	1767.10	2025.10	1928.25	3093.60	2261.45	25.00
4-6-10												1.50		

TABLE IV—(Continued.)

4-8-10	174.50	751.20	508.25	135.75	248.90	267.32	122.89	112.45	149.40	135.45	126.40	131.55	82.00	
4-8-12												.50		10.00
4-9-6								4.35						
4-10-2	15.00													
4-10-4	2.00	2.00												
4-10-7									.15					333.00
4-10-10		.50												
4-12-0	3.00					8.00								
4-12-4	1006.99	399.85	182.80	166.59	398.55	618.12	358.32	402.78	300.22	364.98	269.85	571.20	1195.93	1494.44
4-12-6							1.00			10.25		10.00		
4-12-12						30.00								
4-16-4			.25		7.00									
5-8-6		.62												
5-9-3			1.00											
5-9-6	4.84	2.61												
5-10-3	1.50	.05		2.50										
5-10-5	89.50	30.15	9.50	21.75	5.35	64.50	21.50							
5-10-10			4.50					5.50	1.90			1.00		
5-11-2							25.60					5.10		
5-15-5	4.00	40.20	10.00	.50	2.00	4.05	10.50	1.75	3.85	.10				
6-8-4								2.00	7.55	.50	1.60	1.50		
6-8-6										18.65	268.15	255.50	279.95	428.55
6-8-8											30.00	10.00		
6-8-12										15.05	11.15	10.00		
6-10-7	25.00	34.25				21.05	.65			.10				
6-12-4								3.70	2.00	7.50	16.25	59.65	30.00	



TABLE IV—(Continued.)

Fertilizer Grades	1929-30	1930-31	1931-32	1932-33	1933-34	1934-35	1935-36	1936-37	1937-38	1938-39	1939-40	1940-41	1941-42	1942-43
6-12-6	3.50	40.25	20.75	1.00	31.50	75.15	53.05		1.00	5.00	13.00	47.15	2.25	
6-18-6	11.30	5.65						60.75	43.75	72.90	77.75	81.90	81.50	
8-5-3			.25											
8-0-8												6.00		
8-8-0							1.10	.05	.40					
8-8-4									2.50					
8-8-6		8.50	2.75	2.00	4.00									
8-16-16	.10													
8-24-8													.10	
9-18-18		30.10												
9-27-9		14.40												
10-0-10												.30		
10-6-4		.15												
10-8-6		1.00												
10-20-10	.50													
10-24-12		15.00												

° Data based on invoices received from fertilizer companies.

control officials and other individuals interested in this problem attended these meetings. A gradual reduction in the number of low-grade fertilizers which contain considerable quantities of inert material has occurred and competitive types of fertilizers have been eliminated to a great extent from the lists of fertilizer grades offered for sale in these states.

It would be a difficult job to recommend the most desirable fertilizer for every soil type and every crop in Oklahoma. However, this is an important problem which must be determined on different farms where fertilizers are used. Too often price per ton rather than quality of the material or crop need has determined the kind of fertilizer which is used. The object of a fertilizer grade reduction program should not be to limit the number of grades but to provide fertilizers which have distinct differences in composition. This is frequently expressed as the ratio between nitrogen, phosphoric acid and potash in the fertilizer. Many soils contain a good supply of nitrogen and, except for those crops which grow during a short period of time, very little nitrogen is needed in the fertilizer mixture. If a soil contains a good supply of available potash, a farmer may need a fertilizer containing only nitrogen and phosphorus. What may be the most profitable grade or material at the present time may need to be varied over a long period of time because of changing soil conditions. It is quite probable that a farmer who has used one fertilizer for several years may need to change to another grade to provide a more favorable nutrient balance for plant development. Superphosphate is usually the first limiting factor in crop production on dark colored soils in the humid region. As the nitrogen content of a soil declines from the continued use of superphosphate, a fertilizer containing nitrogen and phosphorus may be needed. Crops grown without any potash in the fertilizer will eventually exhaust the potash in the soil, and as a result a complete fertilizer containing nitrogen, phosphorus and potassium will be required to produce optimum yields.

A ratio of one part nitrogen, two parts of phosphoric acid and one part potash is a very good ratio for many crops grown on light-colored sandy soils. On fine-textured soil, a ratio of one part nitrogen, three parts of phosphoric acid and one part of potash should be used because soils containing a higher percentage of silt and clay fix more of the phosphorus than sandy soils. Since the average Oklahoma farmer will not apply fertilizer at such high rates per acre as are frequently used in the more humid sections of the country where drought is not such an important limiting factor in crop production, there is very

little need for a large number of fertilizer grades having a narrow range in the percentage of nitrogen, or phosphoric acid, or potash in the fertilizer mixture.

### War Conditions Limit Nitrogen Supplies

Fertilizer grades which were approved for sale in 1943 were quite different from those that had previously been sold in Oklahoma. This change was due to War Production Order M231, issued on December 4, 1942. A diversion to war industries of chemical forms of nitrogen which had previously been available for the manufacture of fertilizers resulted in a nitrogen shortage. In order that a sufficient quantity of fertilizer nitrogen would be available for food production in different areas, the use of high nitrogen fertilizers was restricted to those crops which were considered most important in connection with the war effort. The number of grades approved for distribution in Oklahoma was reduced from 12 to 6. The use of fertilizer containing four percent of nitrogen was restricted to commercial vegetable production and certain oil or fiber producing crops. An increase in the quantity of nitrogen which could be released by the War Production Board for the manufacture of fertilizer occurred during the summer of 1943, consequently nitrogen, which is an important limiting factor in crop production on many soil types, was increased in many fertilizer grades to prewar percentages.

This information was published in an order from the War Food Administration issued on July 3, 1943, concerning fertilizer materials and grades which could be sold in Oklahoma in 1943-44. A comparison of fertilizer grades approved for 1943 and 1943-44 is given in Table V. Although six fertilizer grades may not be entirely adequate for Oklahoma soil and crop requirements, this is not a serious matter where fertilizer mate-

TABLE V.—A Comparison of Fertilizer Grades Approved for Use in Oklahoma by the War Production Board on Dec. 4, 1942 and the War Food Administration on July 3, 1943.

Grades for 1943. Approved Dec 4, 1942	Grades for 1943-44. Approved July 3, 1943
0-14-7	0-14-7
3-12-6	2-12-6
3-12-9	4-12-0
4-10-7	4-12-4
4-12-4	4-12-6
3- 8-7*	5-10-5**

\* Victory garden fertilizer.

\*\* Victory garden fertilizer but not limited to such use.

TABLE VI.—Annual Fertilizer Shipments into Oklahoma Counties During the 14-Year Period from July 1, 1929, to June 30, 1943.

	1929-30	1930-31	1931-32	1932-33	1933-34	1934-35	1935-36	1936-37	1937-38	1938-39	1939-40	1940-41	1941-42	1942-43
<b>Eastern Oklahoma Counties</b>														
Adair	200.00	120.00	51.00	114.00	145.40	158.60	65.50	60.30	65.15	35.00	28.25	84.50	315.10	307.25
Atoka	1.05	31.50		15.00	20.00		15.00	11.00	19.00	13.05	29.00	45.25	69.00	124.50
Bryan	79.00	45.00	30.00		40.00	20.18	44.40	84.25	52.00	104.80	151.30	164.68	289.50	39.55
Carter	1.93	103.98	29.70	25.08	18.13	1.35	23.08	8.92	27.39	16.00	13.87	20.15	3.83	8.64
Cherokee	20.25	48.38		30.15	4.00	25.75		23.25	7.60	3.50	15.65	40.00	35.00	15.00
Choctaw	225.50	279.65	85.13	104.65	291.28	203.55	176.24	183.25	240.85	256.50	245.18	282.10	341.75	403.25
Cleveland						16.60		97.65	25.50	8.90	1.36	10.05	.60	150.69
Coal		15.00			15.00		14.50	32.25	8.90	5.00				
Craig	73.44	60.35	15.40			.18	.18	2.05	22.95	52.20	4.00	25.08	25.25	3.23
Creek	20.77	16.24	1.00	15.00		6.25	1.83	1.45	27.05	2.45	.04	6.85	.38	1.18
Delaware								16.60	5.15	16.65		57.10		
Garvin		40.00	15.10				5.00	.40	.90	2.00		55.00	45.00	30.00
Haskell	462.36	538.50	147.10	24.50	214.45	204.05	144.30	187.10	76.50	89.00	13.35	165.95	67.00	444.15
Hughes	380.67	17.21	95.45	45.90	170.35	190.15	169.78	226.31	327.50	299.95	162.68	210.75	465.20	593.45
Johnston		2.65			15.00					.50				
Kay	16.13	11.53	1.02			6.95	.33	2.70	14.83	.60	11.11	82.61	62.88	35.23
Latimer					5.00		9.85	10.10	30.35	1.25	10.50	16.50	8.00	8.35
LeFlore	554.05	648.75	766.90	272.15	861.56	1435.81	901.00	500.05	596.30	724.30	642.25	1199.83	696.30	1726.25
Lincoln	131.85	85.30	15.05		41.50	15.50	30.40	18.65	71.15	56.75	130.45	173.00	175.50	437.25
Logan	7.00	13.55	13.60	1.00	16.75	19.63	59.75	18.55	4.85	65.15	1.05	8.60	6.10	4.33
Love										2.00				
Marshall							.25							
Mayes	22.50	118.91	40.25	17.00	35.55	55.00	46.75	196.20	166.90	126.25	27.00		78.70	
McClain							.05	.15	.85			4.15		

TABLE VI.—(Continued.)

	1929-30	1930-31	1931-32	1932-33	1933-34	1934-35	1935-36	1936-37	1937-38	1938-39	1939-40	1940-41	1941-42	1942-43
<b>Eastern Oklahoma Counties</b>														
McCurtain	628.82	508.40	213.50	127.00	343.06	258.00	300.40	443.75	436.50	414.00	497.75	455.50	459.90	688.50
McIntosh	199.06	248.65	182.85	55.00	165.15	174.30	91.40	41.40	108.25	57.00	61.00	124.21	146.50	228.35
Murray	3.50	106.00	.05			.15	40.00	1.00		1.20	1.53	.20	.38	
Muskogee	363.85	425.25	202.80	100.00	278.40	349.65	235.40	114.20	94.51	149.19	127.47	345.51	249.51	539.08
Noble	20.00			20.00		.02				.25			.28	.38
Nowata	20.00	15.00		2.00			20.00		8.05					
Okmulgee	209.25	69.00	62.80		106.61	17.55	112.83	21.85	67.80	63.45	34.50	85.75	52.25	81.80
Oklahoma	49.15	211.23	164.45	133.48	206.73	233.05	200.64	351.56	339.80	315.52	286.70	337.94	473.20	442.36
Okmulgee	146.65	154.28	41.00	32.00	18.10	77.90	67.59	111.09	54.80	39.05	30.63	89.20	45.22	71.32
Osage	18.15	15.60		20.00				27.25	55.80	25.35		15.04	.10	24.42
Ottawa	113.86	182.68	135.25	48.50	62.26	209.99	262.55	495.75	467.40	335.45	309.20	777.85	353.27	367.30
Pawnee	20.00	20.00	19.50					20.30	18.05	1.00		15.00	16.00	
Payne	68.80	30.75		24.12	61.00	18.75	5.10	33.30	43.00	25.60	13.00	61.11	2.42	39.95
Pittsburg	265.29	105.21	95.30	61.00	137.10	272.50	230.16	143.05	202.10	322.35	206.61	545.97	391.27	690.72
Pontotoc	15.00	32.00	2.00	15.00	40.00	16.43	68.36	48.80	67.78	29.70	38.06	51.53	73.14	79.35
Pott'wamie	65.93	65.00	22.05	21.55	16.21	51.22	39.11	24.48	64.28	44.10	80.63	106.48	203.52	218.65
Pushma'ha	52.45	65.00	20.15	40.00	17.85	50.75	68.95	73.55	72.25	85.00	131.60	119.25	147.00	313.50
Rogers	1.40	18.30	15.00	20.00	15.25	15.30	19.25	67.35	35.85	3.50	15.50	161.05	39.30	35.46
Seminole	40.40	81.47			39.75	5.60	23.25	44.60	21.00	161.90	16.29	87.30	35.33	160.23
Sequoyah	91.00	91.10	148.85	30.50	89.75	79.90	52.85	30.00	8.55	15.00	47.50	171.45	115.52	287.70
Tulsa	153.98	190.15	108.65	95.36	159.05	219.10	246.40	339.42	392.71	359.22	632.12	907.15	394.09	564.58
Wagoner	67.00	49.25	14.00		21.33	45.75	68.50	82.50	23.55	45.00	15.00	183.75	285.50	165.00
Washington	5.35	15.00	.85	11.20		4.57	46.50	55.45	25.72	65.04	56.07	16.22	35.52	32.94

TABLE VI.—(Continued.)

	1929-30	1930-31	1931-32	1932-33	1933-34	1934-35	1935-36	1936-37	1937-38	1938-39	1939-40	1940-41	1941-42	1942-43
<b>Western Oklahoma Counties</b>														
Alfalfa												5.00		
Beaver											.45	.60		.15
Beckham	.10	.45				8.50	.05		.05					
Blaine							8.05	1.70	.10					
Caddo	64.25			.10	.40		.60	3.90	1.05					35.00
Canadian	15.48	20.00					16.25	3.85	2.60	1.95		3.09	.05	.60
Cimarron						.10								
Comanche			.70		.28	.32	.21	1.35	.50	.15	5.41	.61	3.17	11.00
Cotton								1.50						
Custer	.13								1.00	1.40			.10	
Dewey								.30						
Ellis											1.00	.15		
Harper							5.54					.05		
Garfield	5.10	.55	.25			.75		4.50	4.85	3.58	7.51	27.52	18.39	59.71
Grady		42.02	.10		15.00	.07		51.25	21.00	15.05	15.09	55.09	17.05	33.00
Grant							.15							
Greer											.05			
Jackson										.10	.20	.09	.10	.33
Jefferson			6.00			.10								
Kingfisher					.15		3.50							
Kiowa		20.00		.25			.10					.10	.25	
Major									.15					
Stephens		67.74			40.00		2.65		152.10		50.00	.55	.12	.48
Texas	.10		.30								.15	1.30	3.00	
Tillman														
Woods						5.00						.05	.15	
Woodward	.55				1.00			.70	.96	6.00	1.32	1.05	16.68	.86
Not classified						98.85			.10	16.50		16.25		
Total, State	4901.10	5199.58	2763.10	1521.49	3728.40	4726.72	3944.53	4330.58	4584.18	4484.40	4169.43	7421.06	6263.62	9506.37

NOTE:—No invoices of fertilizer shipments into Harmon, Roger Mills, or Washita counties were received during this period.

rials are also available. Fertilizer grades of varying composition can be made for local soil conditions by adding nitrogen, phosphorus, or potash to a standard fertilizer grade by home mixing when experiments or field tests indicate that the ratio of plant nutrients in the fertilizer commonly used should be changed to provide more favorable conditions for maximum crop production.

### Fertilizer Consumption by Counties, 1929 to 1943

Information concerning annual fertilizer shipments into Oklahoma counties during the 14-year period from July 1, 1929, to June 30, 1943, is given in Table VI. Eastern Oklahoma counties were separated from western Oklahoma counties in preparing this table, since a major portion of the fertilizer is used in the eastern half of the state. In the eastern counties, rainfall is more favorable for crop production and a higher percentage of the cultivated land contained a limited supply of available plant nutrients under virgin conditions.

The six counties using more than 500 tons of fertilizer in 1942-43 were as follows: LeFlore, Pittsburg, McCurtain, Hughes, Tulsa, and Muskogee. Where fertilizer practices are well established, the quantity of fertilizer used is gradually increasing. Fertilizer dealers should be able to increase their business in the eastern half of the state by knowing what grade of fertilizer or fertilizer material should be used on different crops and soils to make the farmer the greatest profit. More than sixty percent of the soils tested in the eastern part of Oklahoma are low to very low in available inorganic phosphorus. If fertilizer could be applied to all of these soils it would have an important effect on farm labor income and indirectly improve the opportunity for a higher standard of living in many communities.

### Estimated Fertilizer Consumption by Crops, 1943

An accurate record of fertilizer consumption is not easy to obtain where statistical data are not available and only a small percentage of the farmers in an area use fertilizer to increase crop production. Estimates on the percentage of fertilizer used on different crops were obtained from fertilizer manufacturers, fertilizer dealers and county agents in all counties in Oklahoma where more than 100 tons of fertilizer were used in 1943. The percentage of the fertilizer tonnage used on different crops was calculated from these reports and this information is presented in Table VII.

TABLE VII.—Estimated percentage distribution of fertilizer used on Oklahoma crops in 1943.\*

Crop	Percent of total fertilizer applied
Corn	9.6
Cotton	21.1
Irish potatoes	33.2
Peanuts	7.8
Small grain	6.3
Vegetables	20.4
Miscellaneous	1.6

\* The above data do not include superphosphate supplied by the Agricultural Adjustment agent for application to legume crops and pastures.



## SUMMARY

Fertilizer consumption in Oklahoma gradually increased from 2000 tons in 1921 to more than 9,000 tons in 1929, declined to less than 2000 tons in 1933, and increased again to more than 16,000 tons in 1943. The average annual consumption based on the sale of fertilizer tags for the 20-year period from 1924 to 1943 has been 7,133 tons.

The quantity of different fertilizer grades and materials consumed from 1929 to 1943, calculated from shipping invoices, represents about 60 percent of the total quantity of fertilizer which was sold in the state based on the sale of fertilizer tags.

The most important fertilizer materials in order of abundance were superphosphate, rock phosphate, ammonium sulfate, and nitrate of soda. The tonnage of superphosphate shipped into Oklahoma in 1942 by the Agricultural Adjustment Administration of the U. S. Department of Agriculture was more than five times the average quantity of both rock and superphosphate purchased annually by Oklahoma farmers since 1936.

Although 62 fertilizer grades were sold in Oklahoma during the 14-year period from 1929 to 1943, very few grades were purchased in large quantities. The seven most important fertilizer grades calculated on a tonnage basis prior to 1942-43 were 2-12-2, 2-12-6, 4-8-4, 4-8-6, 4-8-10, 4-12-4, and 5-15-5.

A reduction in the nitrogen content and number of fertilizer grades approved for sale by the War Production Board in December 1942 was responsible for the apparent popularity in 1943 of some grades which had not previously been offered for sale in Oklahoma.

The six counties in Oklahoma which used more than 500 tons of fertilizer were LeFlore, Pittsburg, McCurtain, Hughes, Tulsa, and Muskogee.

Very little fertilizer has been sold in the western half of the state because the major portion of the soils still contain an abundant supply of available phosphorus and potassium and sufficient organic matter for maximum crop production under the climatic conditions which prevail in that region.

Oklahoma farmers use only a small percentage of the total quantity of fertilizer which should be applied to increase crop production and maintain soil fertility.

## APPENDIX I

## Fertilizer Registrations in Oklahoma

In areas where fertilizer cannot be obtained from local dealers, information concerning the nearest source of different fertilizer materials or grades may be obtained by writing to companies which manufacture or distribute these products. Usually any company distributing fertilizer materials will also be able to supply the different fertilizer grades approved for sale in this state.

Fertilizer manufacturers or distributors who have registered various fertilizer grades and materials with the Oklahoma State Board of Agriculture are:

Name of Company	Address
American Agricultural Chemical Co.	National Stock Yards, Ill.
Arkansas Fertilizer Co.	North Little Rock, Ark.
Armour Fertilizer Works	Houston, Texas
Fort Smith Cotton Oil Co.	Fort Smith, Ark.
Gate City Fertilizer Co.	North Little Rock, Ark.
International Minerals & Chem. Corp.	Texarkana, Ark.
Newhouse Chemical & Supply Co.	North Little Rock, Ark. Box 991 Tulsa, Okla.
Shannon Fertilizer Mfg. Co.	Tulsa, Okla.
Swift & Co. Fertilizer Works	Shreveport, La.
United Chemical Co.	Dallas, Texas
Virginia-Carolina Chem. Corp.	Shreveport, La.
Wilson & Company	Oklahoma City, Okla.

Companies which have registered single fertilizer materials are:

Name of Company	Address
Nitrogen Fertilizers	
American Cyanamid Co.	New York, N. Y. 30 Rockefeller Plaza
Chilean Nitrate Sales Corp.	New York, N. Y. 120 Broadway
Colorado Fuel & Iron Corp.*	Pueblo, Colo.
Ford Motor Co.*	Dearborn, Mich.
Rock Phosphate	
Ruhm Phosphate & Chem. Co.	Mt. Pleasant, Tenn.
Thomson Phosphate Company	Chicago, Illinois
Potash Fertilizer	
French Potash Co.	New York, N. Y. 30 Rockefeller Plaza
Superphosphate (45% P <sub>2</sub> O <sub>5</sub> )	
Anaconda Copper Mining Co.	Anaconda, Montana

\* Produce ammonium sulfate.

## APPENDIX II

## A Comparison of Fertilizer Tonnage Calculated from Tag Sales with Records Obtained from Shipping Invoices.

The State Department of Agriculture requires that two copies of an invoice of each fertilizer shipment into Oklahoma be sent to the office of the fertilizer inspector within three days after the shipment is made. One copy of each invoice is forwarded to the director of the Oklahoma Agricultural Experiment Station. The quantity of different fertilizer materials and grades shipped into the state and also the quantity of fertilizer used in each county is calculated from these reports. This regulation was adopted in 1929. During that year the invoices received represented slightly more than half of the total fertilizer sales based on tag tax receipts. A comparison of fertilizer tonnage calculated from tag sales with records obtained from shipping invoices are given in Appendix Table I. Although the percentage of fertilizer sales reported has been quite variable during the 14 years over which this study was conducted, not more than 60 percent of the total quantity of fertilizer sold during this period based on tag tax receipts could be accounted for from invoices received. Data presented in Tables II, IV, and V are relative because of this condition.

*TABLE I.—Quantity of fertilizer materials and grades sold in Oklahoma from July 1, 1929 to June 30, 1943.\**

Year	Report of Sales	Tonnage Based on Tag Sales	Percent of Total Reported
1929-30	4901.10	9492	51.63
1930-31	5199.58	7139	72.83
1931-32	2763.10	3223	85.73
1932-33	1521.49	1985	76.65
1933-34	3728.40	4730	78.82
1934-35	4726.72	5932	79.68
1935-36	3944.53	5985	65.91
1936-37	4330.58	6185	70.02
1937-38	4584.18	8505	53.90
1938-39	4484.40	7512	59.70
1939-40	4169.43	6871	60.68
1940-41	7421.06	10790	68.78
1941-42	6263.62	11385	55.02
1942-43	9506.37	16494	57.64

\* Records for each fiscal year in Oklahoma date from July 1 to June 30 of the following year. Data were calculated from invoices received from fertilizer companies.

