A121-1122-4000-L

TEXAS AGRICULTURAL EXPERIMENT STATION

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS
W. B. BIZZELL, President

BULLETIN NO. 302 SEPTEMBER, 1922

DIVISION OF CHEMISTRY

THE NEEDS OF THE SOILS OF BRAZOS AND JEFFERSON COUNTIES FOR SULPHUR

B. YOUNGBLOOD, DIRECTOR
COLLEGE STATION, BRAZOS COUNTY, TEXAS

STATION STAFF†

ADMINISTRATION

B. YOUNGBLOOD, M. S., Ph. D., *Director*
CHARLES A. FELKER, *Chief Clerk*
A. S. WARE, *Secretary*
A. D. JACKSON, *Executive Assistant*
CHARLES GORZYCKI, *Technical Assistant*
M. P. HOLLEMAN, JR., *Assistant Chief Clerk*
R. N. BURROWS, M. A., *Research Librarian*

VETERINARY SCIENCE

*M. FRANCIS, D. V. M., *Chief*
H. SCHMIDT, D. V. S., *Veterinarian*
V. J. BRAUNER, D. V. M., *Veterinarian*

CHEMISTRY

G. S. FRAPS, Ph. D., *Chief; State Chemist*
S. E. ASBURY, M. S., *Assistant Chemist*
S. LOMANITZ, B. S., *Assistant Chemist*
J. B. SMITH, B. S., *Assistant Chemist*
WALDO WALKER, *Assistant Chemist*

HORTICULTURE

H. NESS, M. S., *Chief*
W. S. HOTCHKISS, *Horticulturist*

ANIMAL INDUSTRY

J. M. JONES, A. M., *Chief; Sheep and Goat Investigations*
R. M. SHERWOOD, B. S., *Poultry Husbandman*
G. R. WARREN, B. S., *Animal Husbandman in Charge of Swine Investigations*
J. L. LUSH, Ph. D., *Animal Husbandman (genetics)*
L. M. MURPHY, *Wool Specialist*

ENTOMOLOGY

M. C. TANQUARY, Ph. D., *Chief; State Entomologist*
H. J. REINHARD, B. S., *Entomologist*
H. B. PARKS, B. S., *Apiculturist*
C. S. RUDE, B. S., *Entomologist*
A. H. ALEX, B. S., *Queen Breeder*
W. P. TRICE, B. S., *Assistant Entomologist*

AGRONOMY

A. B. CONNER, B. S., *Chief; Crops*
A. H. LEIDIGH, B. S., *Agronomist; Soils*
E. B. REYNOLDS, M. S., *Agronomist; Small Grains*
G. N. STROMAN, M. S., *Agronomist and Farm Superintendent*
**PEARL DRUMMOND, *Seed Analyst*

PLANT PATHOLOGY AND PHYSIOLOGY

J. J. TAUBENHAUS, Ph. D., *Chief*

COTTON BREEDING

G. F. FREEMAN, D. Sc., *Chief*

FARM AND RANCH ECONOMICS

L. P. GABBARD, M. S., *Farm and Ranch Economist*

SOIL SURVEY

**W. T. CARTER, JR., B. S., *Chief*
H. W. HAWKER, *Soil Surveyor*
H. V. GEIB, B. S., *Soil Surveyor*

FEED CONTROL SERVICE

B. YOUNGBLOOD, M. S. Ph. D., *Director*
F. D. FULLER, M. S., *Chief Inspector*
S. D. PEARCE, *Inspector*
J. H. ROGERS, *Inspector*
W. H. WOOD, *Inspector*
J. J. KELLY, *Inspector*

SUBSTATIONS

No. 1. Beeville, Bee County
I. E. COWART, M. S., *Superintendent*

No. 2. Troup, Smith County
W. S. HOTCHKISS, *Superintendent*

No. 3. Angleton, Brazoria County
V. E. HAFNER, B. S., *Superintendent*

No. 4. Beaumont, Jefferson County
A. H. PRINCE, B. S., *Superintendent*

No. 5. Temple, Bell County
D. T. KILLOUGH, B. S., *Superintendent*

No. 6. Denton, Denton County
P. B. DUNKLE, B. S., *Superintendent*

No. 7. Spur, Dickens County
R. E. DICKSON, B. S., *Superintendent*

No. 8. Lubbock, Lubbock County
R. E. KARPER, B. S., *Superintendent*

No. 9. Balmorhea, Reeves County
J. J. BAYLES, B. S., *Superintendent*

No. 10. College Station, Brazos County (Feeding and Breeding Substation)
L. J. MCCALL, *Superintendent*

No. 11. Nacogdoches, Nacogdoches County
G. T. MCNESS, *Superintendent*

****No. 12. Chillicothe, Hardeman County**
A. B. CRON, B. S., *Superintendent*

No. 14. Sonora, Sutton-Edwards Counties
E. M. PETERS, B. S., *Superintendent*
D. H. BENNETT, V. M. D., *Veterinarian*

---

†As of October 1, 1922.
*In cooperation with School of Veterinary Medicine, A. and M. College of Texas.
**In cooperation with United States Department of Agriculture.

TABLE OF CONTENTS.

[Page Blank in Bulletin]

THE NEEDS OF THE SOILS OF BRAZOS AND JEFFERSON COUNTIES FOR SULPHUR

BY

S. LOMANITZ*

While sulphur has already at the early period of chemical investigations in agriculture been found to be an element essential to plant life, it was not until comparatively recent years that the possibility of this fact having a bearing upon agricultural practice has been given serious consideration.

Figure 1.—Experiment with corn on soils 18911—18999.

In 1897 Halstead (1) reported that in his experiments on some New Jersey soils, he found that peas planted on plats receiving sulphur developed one-tenth as many root tubercles as the plants on the plats not treated. In the years following, workers in agricultural chemistry in various countries took up the study of sulphur in its relation to soils and crops. This work was given an additional impetus by the reports of a number of investigators that the amount of sulphur in the ash of plants,—the method then prevalent for the determination of this element,—usually represents only a fraction, quite often an insignificant fraction, of the total sulphur the plant originally contained.

*A thesis submitted to the Faculty of the Agricultural and Mechanical College of Texas in partial fulfilment of the requirements for the degree of Master of Science in Agriculture.

Berthelot (2), Bogdanov (3), Fraps (4), Beistle (5), Fraps and Withers (6), Hart and Peterson (7), have all drawn attention to the great loss of sulphur occurring during the burning of the plants to an ash.

In this work with sulphur, the results reported by different investigators are not always in agreement. Favorable effects of sulphur applications are reported by Boullanger (8) in the case of carrots, beans, celery, lettuce, potatoes, and onions. Bernhard (9) also reported benefit to potatoes and mangolds from the application of sulphur at the rate of about 350 pounds to the acre. Tottingham (10) found sulphur beneficial to rape and radishes. Magnien (11) noted the same results with turnips and beets.

In the case of fruits, Lierke (12) reported beneficial results from fertilizing materials containing sulphates as compared with those not having that ingredient. Vermorel (13), also Chauzit (14), found sulphur favorable to grapes, especially if applied in connection with manure.

Increased yields of alfalfa fertilized with sulphur were reported by Reimer (15). Similar results were reported by Brown (16) in Oregon; although landplaster, he adds, gave larger increases. Experimenting in southern Oregon during 1915-1918, Reimer and Tartar (17) found that the alfalfa and clover crops can be increased 50 to 1,000 per cent. by the use of fertilizers containing sulphur.

Shedd (18) found tobacco and soy beans in pot experiments to have benefiited from sulphur applications at the rate of 240 pounds per acre. Duley (19) reports sulphur beneficial to red clover on sand and silt loam. Ames and Boltz (20) also report increased yield of clover due to sulphur.

Effects of sulphur applications altogether contrary to those mentioned are reported by other workers. Gianetto (21) reports that sulphur applied to potatoes at the rate of 400 pounds per acre resulted in a net loss. Voelker (22) could find no influence of sulphur as a fertilizer with mustard, rape, or clover. Bosinelli's (23) field and pot experiments with sulphur on oats, vetch, mustard, corn, beans, and rape were not favorable to sulphur applications. Unfavorable results with sulphur on oats are reported by Pfeffer and Planck (24). Hart and Tottingham (25), while finding sulphates beneficial to Leguminosae and Cruciferae, report elementary sulphur generally harmful. Experiments on oats reported by Pfeiffer and Simmermacher (26) are also unfavorable to sulphur. The Wisconsin Station (27) reports that while elementary sulphur on oats is sometimes beneficial, it quite often exercises a poisonous effect. According to the Ohio Station (28), "additions of sulphur and sulphates have not increased the yields of corn, oats, wheat, soy beans, potatoes and clover." The Mississippi Station (29), experimenting with flowers of sulphur on cotton, found that the sulphur had a depressing effect when used by itself.

Shedd (18), who, as already mentioned, found tobacco and soy beans *to be benefited by sulphur, reported that on the same soil clover, alfalfa, and cabbage showed no benefit. Pfeiffer (30), experimenting with sul*phur on barley, reports that an application of 357 pounds of sulphur per acre in connection with barnyard manure decreased the yield of grain and straw. Fellers (31) reports that sulphur applied at the rate of more than 100 pounds per acre did not increase the yield of dry matter or seed; large amounts of sulphur proving injurious. At the Cowra (New South Wales) Experiment Station farm (32), sulphur applied to wheat showed a net financial loss, and when added with superphosphate, seemed to nullify the otherwise beneficial effects of the latter. Van Rossem (35) experimented on rice with sulphuric acid in amounts equivalent to 88, 176, and 238 pounds of ammonium sulphate, and reported no evident influence upon the yield.

And so we find on the one hand Shedd, Vogel (34), and others, advocating the inclusion of sulphur fertilization as a regular farm practice, while on the other hand we find Pfeiffer and Simmermacher (26), Bosinelli (23), Stewart (35), McCool (36), and Soderbaum (37) asserting just as definitely that the general use of sulphur as a fertilizer is not to be recommended.

This lack of agreement in the results of experiments with sulphur on crops is not confined to the matter of yield only. While Halstead, as previously cited, reported a decrease in the number of the root nodules on the plants grown on plats receiving sulphur, Pitz (38), in his experiments, records that sulphur did not affect development or number of nodules. Duley (19) even found that sulphur increased nodule production on clover. Fellers (31) also reports sulphur to have stimulated nodule formation. That size as well as number of nodules was increased with the application of sulphur fertilizers, is reported also by Reimer and Tartar (17).

Different results are similarly reported with respect to the nitrogen and sulphur content of plants receiving sulphur. Shedd (18) states that "there seems to be no consistent relation between the percentages of sulphur and protein (nitrogen X 6.25) in soy beans." Reimer and Tartar (17) found that alfalfa hay fertilized with sulphur, contained more sulphur and more protein than the hay of the check plots. Pfeiffer (30) reports that the reverse took place with barley, sulphur decreasing the nitrogen content of the plant.

The amount of sulphur removed by crops is given by Hart and Peterson (7) to be about two-thirds, expressed as SO^3, that of phosphoric acid (P^2O^5), in the case of cereals. With legumes the two substances are removed in about equal quantities. Some Cruciferae crops, such as cabbage and turnips, may remove two to three times as much sulphur trioxide as phosphoric acid. Daikahara (39), from results with pot crops, concludes that soils with even less than 0.02 per cent. sulphur have a sufficient supply to meet the requirements of the barley plant for that element.

Vityn (40) states that the sulphur carried down by atmospheric precipitation is more than sufficient for the requirements even of high yields of grain and straw. Stewart (35) is also of the opinion that the sulphur supply of the soil is automatically replenished from the atmosphere. Hart and Peterson (7), referring to conditions near Madison, Wisconsin, point out, that while the gain of sulphur from precipitation is nearly 20 pounds per acre a year, the loss from drainage amounts to 50 pounds for the same period. Lyon and Bizzel (41) found that sulphur was removed in drainage three to six times as much as in crops.

The form in which sulphur is present in plants is chiefly organic, according to Stutzer (42). He based his conclusion on the results of his examination of rye, oats, cocoanut cake, cottonseed meal, hay, and other plant material. Sulphates are reported (43) to be found in oats, crimson clover, cowpea vines, and cottonseed meal. Sulphates were not found in green millet, timothy hay, corn silage, or peanuts.

According to Dint (44), sulphur is oxidized in the soil completely to sulphuric acid within the first two months. Demolon (45) reports that when sulphur is mixed with garden soil and kept moist at 20° C., sulphuric acid, combined as calcium sulphate, was formed. Shedd (18) found that 60-80 per cent. of the sulphur applied oxidized to sulphuric acid within four months. Oxidation proceeded more rapidly in fertile than in poor soil. The organic sulphur of horse manure, he reports, oxidizes slowly. Peter (46) reports that sulphur added at the rate of 500 parts to the million of soil was nearly all converted into sulphates within a month.

Microörganisms, according to Demolon (45), intervene in the oxidation of sulphur in the soil, as he found the sulphur in unsterilized soils to oxidize more rapidly than in sterilized soil. Heinze (47) states that the action of sulphur in the soil is not entirely biological, and that the process is not well understood. Kappen and Quensell (48) assert that bacteria aid in the transformation, and that soils differ in bacterial capacity to effect the changes. Peter (46) reports that little difference was noted in the "sulphofying" power of several soils tested. McIntire and his co-workers (49) effected a non-biological oxidation of sulphur in moist contact with relatively pure quartz.

This oxidation of elementary sulphur in the soil to sulphuric acid, is reported by Ames and Boltz (20) to have increased the solubility of insoluble phosphorus compounds. Lipman and his co-workers (50) conclude from their experiments, that available phosphoric acid may be produced out of rock phosphate, by utilizing compost heaps in which sulphofication was active. Peter (46) also is of the opinion that this may be a practical means of producing acid phosphate on the farm. Ellet and Harris (51), experimenting with Virginia soils, conclude that the formation of available phosphoric acid by sulphofication is too slow to meet the needs of practical farming. Lipman et al. (52) report that inoculated sulphur is more effective in rendering phosphate rock available.

The power of making phosphorus compounds more available is considered by Tottingham and Hart (53) as probably a way in which sulphur exerts a fertilizing effect. Miege (54) calls attention to the theory that sulphur, by utilizing soil oxygen, releases nitrogen for nitrogen-fixing bacteria. Nicolas (55) reports that sulphur also favors the utilization of carbon dioxide by plants.

It is obvious that the oxidation of sulphur will introduce an acid ingredient in the soil, the resulting acidity of which will vary with the nature of the soil in question. Duley (19) reports a slight increase in acidity when sulphur was applied to a sand and to a silt loam soil. Ames and Boltz (20) also report increased acidity due to sulphur in case of pot experiments. From Demolon's (45) experiments, it appears that the sulphuric acid combines with lime to form calcium sulphate.

According to Lyon and Bizzel (56), the presence of lime in the soil will cause a greater loss of sulphur in the drainage water.

A soil rich in organic matter, Ames and Boltz (20) state, will contain more sulphur than a poorer soil, and the surface soil contains a larger amount of that element than the subsoil.

The conflicting opinions regarding the use of sulphur in farming, should lead at least to one definite conclusion, namely: that especially with this substance, it is not safe to rely upon conclusions drawn from experiments made in other places. Results obtained with sulphur applied to a crop on a certain soil may not at all be applicable to another soil even with the same crop. A number of factors may be the cause of the different results obtained by the investigators cited. Some of these factors are likely to be: differences in the sulphur content of the soils; the greater or lesser capacity of the soil to neutralize the acidity produced by the sulphur; the effect of this acidity upon the biological activities in the soil; the effect upon the physical nature of the soil; all of which is of course subject to great variations.

EXPERIMENTAL WORK

In what follows is presented a study of the sulphur-needs of the soils of Brazos county and the soils of Jefferson county.

A considerable number of soils of Brazos county were analyzed for their content of sulphur. Pot experiments were carried on with soils of the county representing the principal soil type; a few soils from other counties were included in the pot experiments. Various additions of fertilizing materials, including sulphur by itself or in combination, were made to the soils in the pots and the effects on the crops planted were noted. The crops consisted mainly of corn and sorghum, but alfalfa and some cotton were also planted. The crops were analyzed for their content in sulphur. On some crops nitrogen determinations were also made to see if any relation existed between the nitrogen and the sulphur content of the plant. The acidity of some of the soils in the pots was determined after the crops were harvested, and this acidity was compared with that of the original soil and with checks to which no sulphur was added.

In the case of Jefferson county, the sulphur content of various soils was determined, but no pot experiments were made.

Analytical Method for Sulphur in Soils and Plants. The determination of sulphur in the soils as well as in the plants was made according to the following method:

Five grams of the sample were treated with 20 c.c. concentrated nitric acid; after frothing subsided and the mixture partly evaporated, 20 c.c. of a 5 per cent. solution of calcium nitrate were added and the whole evaporated to dryness and ignited to an ash. This was treated with hydrochloric acid, heated, filtered, and the sulphates precipitated in the filtrate by means of barium chloride in the usual way. The calcium nitrate solution was made by dissolving calcium carbonate in nitric acid, the calcium carbonate having been previously washed to free it from any sulphates with which it might have been contaminated. Blanks were run on the reagents and allowance made when needed.

Details of Pot Experiments. Into an 8-inch galvanized iron pot, provided with tubes for soil ventilation, were added, first, enough washed gravel to bring up the weight of pot and gravel to 2½ kilograms; and then five kilograms of the soil, which had previously been pounded up with a wooden mallet until it would pass a 3-millimeter sieve. The trash and rocks remaining on the sieve were not used. The additions to the soil were, in the case of ammonium nitrate and potassium chloride, in the form of a solution of the salt; with the other additions, the solid substance was used. The additions, as well as cistern and condensed water, were tested for their content in sulphur. Some lots of chemicals and the cistern water had to be rejected and condensed water which was found satisfactory was used for watering the pots.

The abbreviations used for designating the various additions made to the pots, and to which reference is made in the tables, are as follows: CaS = calcium sulphate, 2 grams; KD = potassium sulphate, 1 gram;

Figure 2.—Experiment with corn on soils 1956—18910.

S = flowers of sulphur, 1 gram; K, when not in an addition containing D, is meant for potassium chloride, 1 gram; N = ammonium nitrate, 1 gram.

In the case of small seeds like alfalfa and sorghum, the same weight, 1 gram, was added to each pot. With larger seeds like corn and cotton, the same number of seeds, five, and weighing the same weight within 0.1 gram, was used. Three times a week the pots were weighed and the loss of water replaced to half the water-holding capacity of the soil.

The pot experiments extended over two seasons of two crops each, with a different set of soils for each season.

Season 1920. In this season the soils with the following laboratory numbers were used: 5954, 5956, 5957, 5966, 8839, 9038, 17442, and 17445. Soils Nos. 5954, 5957, 5966, and 9038 were planted to alfalfa; the other soils were planted to corn and sorghum. Soil No. 17442 was also planted to cotton.

The alfalfa was planted on the 6th of April and the first cut made September the 8th; a second cut was made November the 2nd. In case of soil 5966, a cut was made also on June the 7th. The corn was planted April the 6th and harvested June the 10th. The pots were then stirred up thoroughly, new additions made of ammonium nitrate and potassium chloride, and sorghum planted on June the 12th. This was harvested September the 7th. The cotton was planted April the 14th and harvested November the 2nd. The green crops were put in paper sacks, dried at a low heat, and weighed. The analyses were made on the air-dry sample.

Season 1921. The soils used this season were all from Brazos county, with the following laboratory numbers: 1956, 18910, 18911, 18999, and 19000. Corn was planted April the 4th and harvested May the 31st. The sorghum crop was planted the 13th of June, but no stand was secured with this nor with a subsequent planting, and a new planting was made the 9th of July. This crop was harvested September the 5th. Otherwise the procedure was the same as with the crops of the previous season.

SOILS USED IN THE POT EXPERIMENTS

Description

No. 5954—Depth 6"-18", clay, black, from the farm of J. H. Sandidge, 9 miles northeast of McKinney, Collin county, Texas.

No. 5956—Depth 6"-18", clay, brown, probably Crawford Silty Clay (according to Dr. G. S. Fraps), from the farm of F. G. Hollekamp, Comfort, Kendall county, Texas.

No. 5957—Depth 0"-9", black sandy loam and clay; "black land," 18 miles west of Comanche, Comanche county, Texas.

No. 5966—Depth 0"-10", black clay; "black land," Williamson county, Texas.

No. 8839—Depth 12"-24", yellowish gray, 2 miles northeast of Eagle Lake, Colorado county, Texas.

No. 9038—Depth 0"-7", chocolate sandy loam from Geo. D. Davis, 1½ miles northeast of Brownwood, Brown county, Texas.

No. 17442—Depth 0"-6", reddish brown, clay loam, from S. P. Mayes, Paint Rock, Concho county, Texas.

No. 17445—Depth 7"-18", dark brown loamy clay, from H. S. Elsnore, Eden, Concho county, Texas.

No. 1956—Lufkin Fine Sandy Loam, sand from the farm of E. J. Kyle, between College Station and Bryan, Brazos county, Texas.

No. 18910—Depth 0"-7", Lufkin Fine Sandy Loam, gray sandy loam, from the farm of C. M. Evans, between College Station and Bryan, Brazos county, Texas.

No. 18911—Depth 7"-19", clay, gray, subsoil to No. 18910.

No. 18999—Surface soil, grayish-black clay, Lufkin Fine Sandy Loam, from the experimental grounds of the Department of Horticulture, of the Agricultural and Mechanical College of Texas, College Station, Texas.

No. 19000—Subsoil to No. 18999.

The chemical composition of these soils is given in Table 1.

Table 1. Comparison of the soils used in the pot experiments.

Lab. No.	Parts per hundred: Total phosphoric acid	Nitrogen	Total potash	Lime	Magnesia	Sulphur trioxide	Parts per million, Active: Phosphoric acid	Active: Potash	Acidity
5954	0.075	0.160	0.415	24.86	0.24		30		0
5956	0.012	0.091	2.00	0.95	0.60		19	694	0
5957	0.030	0.129	0.84	1.06	0.33		30	587	0
5966	0.020	0.175	0.70	12.65	0.58		31	176	0
8839	0.040	0.045	0.145	0.23	0.27		5	45	230
9038	0.055	0.073	0.325	0.98	0.15		48	285	0
17442	0.077	0.158					60	337	0
17445	0.116	0.131					29	314	0
1956	0.037	0.033	1.34	0.33	0.06	0.05	75	106	0
18910	0.032	0.054	1.00			0.04	18	117	230
18911	0.010	0.047	0.89			0.04	10	50	0
18999	0.038	0.096	0.54			0.08	17	95	460
19000	0.033	0.078	0.80			0.05	9	110	1100

Table 2. Comparison of yield of pots with various treatment.

Season 1920—Crop Alfalfa.

Pot No.	Addition	Yield in grams: 1st cut	2nd cut	3rd cut	Total per pot	Average per pot per addition	Gain or loss with sulphur
	Soil No. 5966						
1	O	3.9	7.7	0.4	12.0		
2	O	10.3	11.8	7.0	29.1	20.5	
3	CaS	7.0	9.9	4.0	20.9		
4	CaS	3.7	6.9	2.5	13.1	17.0	—3.5
5	KD	9.2	12.5	9.6	31.3		
6	KD	11.9	13.4	5.5	30.8	31.0	
7	KDCaS	6.1	10.6	5.7	22.4		
8	KDCaS	8.9	13.7	8.7	31.3	26.8	—4.2
	Soil No. 5954						
1	O	3.6	1.0		4.6		
2	O	2.9	1.8		4.7	4.6	
3	CaS	5.9	3.7		9.6		
4	CaS	7.0	4.0		11.0	10.3	+5.7
5	KD	6.5	3.7		10.2		
6	KD	5.4	2.7		8.1	9.1	
7	KDCaS	8.4	4.5		12.9		
8	KDCaS	7.5	3.0		10.5	11.7	+2.6
	Soil No. 5957						
1	O	4.9	3.0		7.9		
2	O	3.2	1.0		4.2	6.0	
3	CaS	3.5	2.4		5.9		
4	CaS	6.9	1.4		8.3	7.1	+4.1
5	KD	7.7	3.0		10.7		
6	KD	8.9	2.6		11.5	11.1	
7	KDCaS	5.2	1.0		6.3		
8	KDCaS	6.0	1.5		7.5	6.9	—4.2
	Soil No. 9038.						
1	O	8.0	4.0		12.0		
2	O	7.9	4.5		12.4	12.2	
3	CaS	6.9	2.7		9.6		
4	CaS	5.5	3.2		8.7	9.2	—3.0
5	KD	7.1	2.2		9.3		
6	KD	6.9	3.3		10.2	9.7	
7	KdCaS	6.5	2.2		8.7		
8	KDCaS	9.1	4.0		13.1	10.9	+1.2
	Soil No. 17442–Crop cotton						
1	O	20.9			20.9		
2	O	15.0			15.0	17.9	
3	S	17.0			17.0		
4	S	18.0			18.0	17.5	—0.5

Table 2—Continued. Comparison of yields.

Crops—Corn and Sorghum.

Pot No.	Addition	Yield in grams		Total per pot	Average per pot per addition	Gain or loss with sulphur
		Corn	Sorghum			
	Soil No. 5956					
1	KN	9.8	48.5	58.3		
2	KN	15.8	48.4	64.2	61.2	
3	KNCaS	26.8	27.4	54.2		
4	KNCaS	6.8	41.4	48.2	51.2	—10.0
5	KDN	56.3	55.9	112.2		
6	KDN	44.8	54.5	99.3	105.7	
7	KD	46.1	7.2	53.3	53.3	
	Soil No. 8839					
1	KN	2.0	3.9	5.9		
2	KN	3.2	3.7	6.9	6.4	
3	KNCaS	3.2	5.2	8.4		
4	KNCaS	1.7	3.9	5.6	7.0	—0.6
5	KDN	28.7	30.9	59.6		
6	KDN	31.9	30.9	62.8		
7	KD	14.8	3.7	18.5		
	Soil No. 17442					
1	O	13.6	7.5	21.1		
2	O	13.8	8.0	21.8	21.4	
3	S	12.3	8.0	20.3		
4	S	11.4	9.5	20.9	20.6	—0.8
5	CaS	9.2	10.0	19.2		
6	CaS	13.4	9.0	22.4	20.8	—0.6
7	KD	21.2	7.7	28.9		
8	KD	23.9	7.5	31.4	30.1	
9	KDN	24.6	31.0	55.6		
10	KDN	28.3	45.9	74.2	64.9	
11	KDNS	20.8	48.0	68.8		
12	KDNS	22.8	43.0	65.8	67.3	—2.4
	Soil No. 17445					
1	O	16.9	10.2	27.1		
2	O	16.7	10.7	27.4	27.2	
3	S	20.8	9.2	30.0		
4	S	15.8	10.0	25.8	27.9	—0.7
5	CaS	21.3	8.2	29.5		
6	CaS	21.9	8.0	29.9	29.7	—2.5
7	KD	26.4	8.9	35.3	35.3	
	Soil No. 1956					
1	O	13.8	3.5	17.3		
2	O	14.7	3.3	18.0	17.6	
3	S	16.7	0.2	16.9		
4	S	14.2	4.0	18.2	17.5	—0.1
5	KN	16.5	8.5	25.0		
6	KN	21.9	21.5	43.4	34.2	
7	KNS	20.2	6.0	26.2		
8	KNS	27.3	12.6	39.9	33.0	—1.2
9	KP	16.7	2.1	18.8		
10	KP	12.5	3.5	16.0	17.4	
11	KPS	16.6	4.0	20.6		
12	KPS	16.9	3.1	20.0	20.3	+2.3
13	KPN	23.1	12.7	35.8		
14	KPN	24.3	21.0	45.3	40.5	
15	KPNS	29.1	11.5	40.6		
16	KPNS	31.7	2.0	33.7	37.1	—3.4
	Soil No. 18910					
1	O	12.0	7.1	19.1		
2	O	10.0	5.8	15.8	17.4	
3	S	12.8	(a)	12.8		
4	S	12.3	(a)	12.3	12.5	—6.4
5	KN	24.5	32.0	56.5		
6	KN	27.2	37.0	64.2	60.3	
7	KNS	25.4	22.4	47.8	47.8	—12.5
8	KP	15.8	7.4	23.2		
9	KP	15.9	7.8	23.7	23.4	
10	KPS	16.4	8.0	24.4	24.4	+1.0
11	KPN	35.7	42.1	77.8	77.8	
12	KPNS	40.2	29.5	68.7		
13	KPNS	36.4	5.6	42.0	55.8	—22.0

Table 2—Continued. Comparison of yields.

Crops—Corn and Sorghum.

Pot No.	Addition	Yield in grams		Total per pot	Average per pot per addition	Gain or loss with sulphur
		Corn	Sorghum			
	Soil No. 18911					
1	O	25.2	4.9	30.1	30.1	
2	S	4.5	3.5	8.0	8.0	
3	KN	6.2	11.5	17.7		
4	KN	27.6	29.2	56.8	37.2	
5	KNS	7.7	9.5	17.2	17.2	—20.0
6	KP	6.2	4.8	11.0		
7	KP	6.7	3.9	10.6	10.8	
8	KPS	34.7	4.6	21.0	21.0	+9.2
9	KPN	36.2	42.0	78.2	78.2	
10	KPNS	37.7	32.0	69.7		
11	KPNS	40.0	45.0	85.0	77.3	—0.9
	Soil No. 18999					
1	O	10.3	5.5	15.8	15.8	
2	S	10.2	5.7	15.9	15.9	+0.1
3	KN	12.3	8.0	20.3	20.3	
4	KNS	12.0	8.0	20.0	20.0	—0.3
5	KP	15.1	9.3	24.4		
6	KP	17.6	8.0	25.6	25.0	
7	KPS	14.5	8.0	22.5	22.5	—2.5
8	KPN	49.2	31.5	80.7	80.7	
9	KPNS	49.3	32.5	81.8		
10	KPNS	48.2	30.6	78.8	80.3	—0.4
	Soil No. 19000					
1	O	11.5	5.5	17.0		
2	O	11.5	5.7	17.2	17.1	
3	S	12.8	6.4	19.2	19.2	+2.1
4	KN	18.6	7.5	26.1		
5	KN	17.3	11.7	29.0	27.5	
6	KNS	20.0	9.4	29.4	29.4	+1.9
7	KP	16.5	8.5	25.0		
8	KP	15.0	9.5	24.5	24.7	
9	KPS	16.5	10.2	26.7	26.7	+2.0
10	KPN	49.4	36.5	85.9	85.9	
11	KPNS	54.0	37.0	91.0		
12	KPNS	48.3	38.5	86.8	88.9	+4.0

(a) Crop died shortly after coming up.

EFFECT OF SULPHUR ON YIELDS OF CROPS

The weight of the crops, on the air-dry basis, of the different soils with the corresponding additions are given in Table 2.

On examining Table 2, one sees that of the soils planted to alfalfa, soil No. 5966, which produced the largest crop, showed a loss with calcium sulphate, both as compared with no addition, and when the addition consisting of calcium sulphate and potassium phosphate is compared with the one containing potassium phosphate only. The other soils of the set in alfalfa produced in general poor yields. Soil No. 5954 showed an increase with the calcium sulphate as compared with the checks, while soil No. 5957 which showed a small gain with calcium sulphate as against no addition, showed a loss about four times as large as this gain, when the addition of calcium sulphate and potassium phosphate is compared with the addition of potassium phosphate alone. Soil No. 9038 showed a decrease with calcium sulphate over no addition. The addition consisting of potassium phosphate and calcium sulphate, showed an increase over the check, but this increase was only about one-third of the decrease in the first case.

Considering the alfalfa crop as a whole, the addition of calcium sulphate as compared with the respective checks produced a gain of 10.6 grams as against a loss of 14.9 grams or a net loss of 4.3 grams.

Soil No. 17442, planted to corn and sorghum, showed two decreases with sulphur or calcium sulphate, totaling 1.4 grams, to one increase of 2.4 grams. This soil was planted also to cotton; sulphur application resulted in a slight loss with this crop.

All the other soils were planted to corn and sorghum.

Soil No. 17445 and soil No. 19000 show a slight increase with sulphur or calcium sulphate.

Soil No. 5956 produced a good-sized crop. The addition of calcium sulphate shows a decrease as compared with the check.

Soil 8839 shows a slight increase with the addition containing calcium sulphate as compared with the check, but the yield was very poor in either case, and only the addition containing the three standard ingredients, nitrogen, potash, and phosphoric acid, produced a good crop.

Soils Nos. 1956, 18910, 18911, and 18999, all showed a loss in three cases and a gain in one case with sulphur as compared with the corresponding checks. The losses with soils Nos. 1956 and 18999 as well as the gains were very small. The losses in case of soils Nos. 18910 and 18911 were rather heavy, amounting with the first soil to a loss of 40.9 grams and a gain of 1.0 gram, and with the second soil, to a loss of 42.1 grams as against an increase of 10.1 grams.

Soil No. 19000 shows an increase with sulphur over the corresponding additions without sulphur, but the differences were small.

The results of these pot experiments lead to the conclusion that none of the soils tested can be said to have sulphur as a limiting factor in crop production; sulphur is not in this case a soil deficiency in the sense in which this term is used in discussions of soil fertility. The effect of the applications of sulphur upon the yield in the pot experiments, considered as a whole, was anything but favorable to sulphur. The gain with sulphur as compared with parallel applications without sulphur, amounted to a total of 25.6 grams, while the loss reached the figure of 93.2 grams, the ratio of loss to gain being a little over 3.5. These figures refer to elementary sulphur. With calcium sulphate applications, there were losses totaling 25.5 grams and gains totaling 13.7 grams.

Considering the pot experiments with the soils of Brazos county only, the ratio of losses to gain with sulphur is even greater still. The gains total 22.6 grams and the losses total 91.8 grams, a ratio of 4 to 1. The heavy losses with sulphur on soils Nos. 18910 and 18911, are obviously due to the fact that these soils are inclined to a condition of acidity, which was aggravated by the sulphur added.

Table 3. Sulphur, expressed as SO3, removed by the crops.

Laboratory Nos. 1st cut	2nd cut	3rd cut	Pot No. and Addition	Per Cent SO3 1st cut	2nd cut	3rd cut	Total SO3 removed grams
			Season 1920—Crop, alfalfa.				
			Soil No. 5966				
......	18611	......	1—O	......	1.05	......	......
17835	18612	18728	2—O	1.27	0.78	0.58	0.2634
17836	18613	18729	3—CaS	1.22	0.98	0.97	0.2213
......	18614	18730	4—CaS	......	1.19	1.29	......
17838	18615	18731	5—KD	0.98	0.78	0.42	0.2280
17839	18616	18732	6—KD	0.88	0.55	0.67	0.2153
17840	18617	18733	7—KDCaS	1.15	0.90	0.50	0.1941
17841	18618	18734	8—KDCaS	1.00	0.82	0.57	0.2509
			Soil No. 5954				
18595	......	......	1—O	0.70	......	......	......
18596	......	......	2—O	0.82	......	......	......
18597	......	......	3—CaS	0.74	......	......	......
18598	......	......	4—CaS	0.74	......	......	......
18599	......	......	5—KD	0.70	......	......	......
18600	......	......	6—KD	0.83	......	......	......
18601	......	......	7—KDCaS	0.76	......	......	......
18602	......	......	8—KDCaS	0.69	......	......	......
			Soil No. 5957				
18719	......	......	1—O	0.89	......	......	......
18720	......	......	2—O	0.69	......	......	......
18721	......	......	3—CaS	0.63	......	......	......
18722	......	......	4—CaS	0.87	......	......	......
18723	......	......	5—KD	0.35	......	......	......
18724	......	......	6—KD	0.48	......	......	......
18726	......	......	8—KDCaS	1.44	......	......	......
			Soil No. 9038				
18603	18735	......	1—O	0.93	0.56	......	0.0970
18604	18736	......	2—O	0.96	0.45	......	0.0961
18605	18737	......	3—CaS	1.17	0.90	......	0.1050
18606	18738	......	4—CaS	1.56	0.80	......	0.1106
18607	18739	......	5—KD	0.84	1.44	......	0.0913
18608	18740	......	6—KD	0.85	0.60	......	0.0745
			Soil No. 17442—crop, cotton.				
18743	......	......	1—O	0.56	......	......	0.1170
18744	......	......	2—O	0.80	......	......	0.1200
18745	......	......	3—S	1.08	......	......	0.1836
18746	......	......	4—S	0.98	......	......	0.1764

Table 3—Continued. Sulphur removed by the crops.

Season 1920—Crops corn and sorghum.

Laboratory Nos. Corn	Sorghum	Pot No. and Addition	Per cent SO3 Corn	Sorghum	Total SO3 removed grams
....	18588	1—KN	....	0.33	....
....	18589	2—KN	....	0.29	....
18064	18590	3—KNCaS	0.37	0.35	0.1951
18065	18591	4—KNCaS	0.48	0.37	0.1858
....	18592	5—KDN	....	0.31	....
....	18593	6—KDN	....	0.33	....
		Soil No. 17442			
18078	....	3—S	0.26	....	....
18079	....	4—S	0.20	....	....
18080	....	5—CaS	0.38	....	....
18081	....	6—CaS	0.24	....	....
18082	....	7—KD	0.19	....	....
18083	....	8—KD	0.22	....	....
18084	18584	9—KDN	0.26	0.29	0.1539
18085	18585	10—KDN	0.15	0.29	0.2039
18086	18586	11—KDNS	0.36	0.28	0.2093
18087	18587	12—KDNS	0.36	0.37	....

Table 3—Continued. Sulphur removed by the crops.

Season 1920—Crops corn and sorghum.

Laboratory Nos.		Pot No. and Addition	Per cent SO3		Total SO3 removed grams
Corn	Sorghum		Corn	Sorghum	
		Soil No. 17445			
....	18633	1—O	....	0.31	....
....	18644	2—O	....	0.25	....
....	18645	3—S	....	0.33	....
....	18646	4—S	....	0.32	....
18092	18647	5—CaS	0.25	0.32	0.0795
18093	18648	6—CaS	0.24	0.32	0.0782
18094	18649	7—KD	0.22	0.27	0.0830
		Season 1921			
		Soil No. 1956			
19138	19759	1—O	0.33	0.25	0.0571
19139	....	2—O	0.31	....	....
19140	....	3—S	0.68	....	....
....	19757	4—S	....	0.50	....
....	19753	5—KN	....	0.46	....
....	19752	6—KN	....	0.33	....
....	19751	7—KNS	....	0.49	....
....	19749	8—KNS	....	0.53	....
....	19746	10—KP	....	0.42	....
....	19754	11—KPS	....	0.37	....
....	19340	13—KPN	....	0.42	....
....	19341	14—KPN	....	0.24	....
....	19342	15—KPNS	....	0.59	....
		Soil No. 18919			
19142	....	1—O	0.23	....	....
19143	....	2—O	0.26	....	....
19144	....	3—S	0.36	....	....
19145	....	4—S	0.36	....	....
....	19967	5—KN	....	0.31	....
....	19772	7—KNS	....	0.51	....
....	19774	8—KP	....	0.41	....
....	19769	10—KPS	....	0.62	....
....	19343	11—KPN	....	0.22	....
....	19344	12—KPNS	....	0.41	....
		Soil No. 18911			
19146	19771	1—O	0.25	0.55	0.0900
....	19766	4—KN	....	0.38	....
....	19760	5—KNS	....	1.37	....
....	19750	6—KP	....	0.45	....
....	19768	8—KPS	....	0.58	....
....	19345	9—KPN	....	0.23	....
....	19346	10—KPNS	....	0.45	....
....	19347	11—KPNS	....	0.36	....
		Soil No. 1899			
19148	19765	1—O	0.26	0.78	0.0697
19149	19761	2—S	0.55	1.75	0.1559
....	19762	5—KP	....	0.47	....
....	19748	7—KPS	....	0.83	....
....	19348	8—KPN	....	0.25	....
....	19349	9—KPNS	....	0.49	....
....	19350	10—KPNS	....	0.50	....
		Soil No. 19000			
19150	19763	1—O	0.23	0.81	0.0711
19151	....	2—S	0.27	....	....
19152	19764	3—S	0.33	1.58	0.1433
....	19777	4—KN	....	0.70	....
....	19773	6—KNS	....	1.45	....
....	19747	7—KP	....	0.48	....
....	19758	9—KPS	....	0.78	....
....	19351	10—KPN	....	0.26	....
....	19352	11—KPNS	....	0.48	....
....	19353	12—KPNS	....	0.51	....

EFFECT OF ADDITIONS ON AMOUNT OF SULPHUR IN THE CROPS.

The percentage of sulphur, expressed as sulphur trioxide, in the crops of the different pots with their respective additions, is given in Table 3. Where all the cuts or crops of the same pot were analyzed for sulphur, the total sulphur trioxide removed is also given.

The alfalfa grown on soil No. 5966 shows no consistent increase in sulphur content with applications of calcium sulphate as compared with the checks. No difference is noted in sulphur content of the crop grown on soil No. 5954 between the pots receiving calcium sulphate and those not supplied with that ingredient. The crop of soil No. 5957 shows a greater content of sulphur in the plants of the pot receiving potassium phosphate and calcium sulphate as against the plants of the pots receiving potassium phosphate only. With the same soil, no appreciable difference is noticeable when the sulphur content of the plants of the pots with no addition is compared with those receiving calcium sulphate. The alfalfa of soil No. 9038 shows a greater percentage of sulphur in the plants of the pots receiving calcium sulphate as compared with the plants of the checks.

The cotton grown on soil No. 17442 shows an increase in sulphur content with the addition of sulphur.

The corn and sorghum of soils Nos. 17442, 5956, and 17445 showed no appreciable difference in sulphur content as between the pots receiving additions of calcium sulphate or sulphur and the pots not receiving these additions. The other soils show a tendency for an increased percentage of sulphur in the plants with the addition of this element.

With the soils of Brazos county, the analyses for sulphur content were made mostly on the sorghum crop, although a few samples of corn were also analyzed. There is usually a greater percentage of sulphur in these crops when supplied with that element than in the checks. This holds true of all the soils of the county used in the pot experiments.

Table 4. Comparison of sulphur and nitrogen content of crops.

Season 1921—Crop, sorghum.

Laboratory Number	Pot No. and Addition.	Sulphur trioxide per cent	Nitrogen per cent
	Soil No. 1956		
19759	1—O	0.25	0.89
19757	4—S	....	0.84
19753	5—KN	0.46	2.04
19752	6—KN	0.33	1.09
19751	7—KNS	0.49	2.09
19749	8—KNS	0.53	1.76
19755	9—KP	....	1.43
19746	10—KP	0.42	1.21
19754	11—KPS	0.37	1.25
19756	12—KPS	....	1.14
19340	13—KPN	0.42	1.83
19341	14—KPN	0.24	1.11
19342	15—KPNS	0.59	1.46
	Soil No. 18910		
19767	5—KN	0.31	0.75
19772	7—KNS	0.51	1.03
19774	8—KP	0.41	0.65
19769	10—KPS	0.52	0.65
19343	11—KPN	0.22	0.60
19344	12—KPNS	0.41	0.94

Table 4. Comparison of sulphur and nitrogen content of crops.

Season 1921—Crop, sorghum.

Laboratory Number	Pot No. and Addition.	Sulphur trioxide per cent	Nitrogen per cent
	Soil No. 18911		
19771	1—O	0.55	0.68
19766	4—KN	0.38	0.73
19760	5—KNS	1.37	1.84
19750	6—KP	0.45	0.71
19768	8—KPS	0.58	0.67
19745	9—KPN	0.23	0.62
19346	10—KPNS	0.45	0.80
19347	11—KPNS	0.36	0.57
	Soil No. 18999		
19765	1—O	0.78	0.79
19761	2—S	1.75	0.81
19762	5—KP	0.47	0.55
19748	7—KPS	0.83	0.70
19348	8—KPN	0.25	0.62
19349	9—KPNS	0.49	0.66
19350	10—KPNS	0.50	0.74
	Soil No. 19000		
19763	1—O	0.81	0.94
19764	3—S	1.58	0.87
19770	4—KN	0.70	1.71
19773	6—KNS	1.45	1.59
19747	7—KP	0.48	0.77
19758	9—KPS	0.78	0.67
19351	10—KPN	0.26	0.59
19352	11—KPNS	0.48	0.67
19353	12—KPNS	0.51	0.61

RELATION BETWEEN SULPHUR AND NITROGEN CONTENT OF CROPS

A considerable number of samples of the sorghum grown in the pots with the Brazos county soils were analyzed for nitrogen to see whether any relation existed between the sulphur and nitrogen content of the plants. As previously cited, some investigators reported an increase in the protein content of alfalfa when fertilized with sulphur. The figures for the respective percentages of nitrogen and sulphur in the sorghum analyzed are given in Table 4.

There is no consistency noticeable between the figures in the table representing nitrogen and the sulphur percentage, respectively, and no definite relation between the two constituents can be traced in this case. This is in agreement with the conclusion of Shedd (16) with respect to the sulphur and nitrogen percentages of the soy bean.

Table 5. Soil acidity as affected by additions of sulur.

Laboratory No.	Soil No.	Pot No. and Addition	Acidity after cropping	Acidity original soil	Acidity increase with sulphur
19354	1956	2—O	0	0	....
19355	....	3—S	700	....	700
19356	....	4—S	700	....	700
19357	....	16—KPNS	700	....	700
19358	18910	2—O	700	230	....
19359	....	3—S	1100	....	400
19360	....	4—S	1100	....	400
19361	....	13—KPNS	1100	....	400

ACIDITY CAUSED BY SULPHUR

Soils Nos. 1956 and 18910 were analyzed for acidity after the last crops were removed. Table 5 shows the figures obtained, and also gives the figures for the original soil. It will be seen that soil No. 1956, which showed no acidity originally nor after cropping the pot with no addition, reached a condition of acidity of 700 per million in the pots to which sulphur was added. In other words, about 2500 pounds of limestone or 1400 pounds of quicklime would have to be added to the soil per acre, in order to neutralize the acidity introduced by the addition of the sulphur. In referring to Table 2, one will notice that these pots which showed this acidity with sulphur also gave somewhat smaller yields, especially soil No. 18910. The plants in the pots marked 3-S and 4-S of this soil died a few days after they came up, and a preliminary test with litmus paper applied to the soils in the pots showed the soils to be acid. This soil had an acidity figure of 230 to begin with; this was increased to 700 in the case of the pot receiving no addition, and to 1100 for the pots receiving sulphur, an increase of 400 due to sulphur. Pot 13-KPNS of this soil, which also shows an acidity of 1100, had its yield heavily depressed as compared with the checks, as can be noted from Table 2.

Table 6. Sulphur content, expressed as sulphur trioxide, of soils of Brazos County.

Laboratory Nos.		Soil Type	SO3 Percent	
Surface	Subsoil		Surface	Subsoil
1956	....	Lufkin Fine Sandy Loam (Sand)	0.05	....
6953	6954	Tabor Fine Sandy Loam	0.05	0.06
6955	6956	Lufkin Fine Sandy Loam	0.07	0.06
8329	8330	Lufkin Clay Loam	0.06	0.20
8331	8332	Ochlockonee Silt Loam	0.08	0.17
8333	....	Pledger Clay	0.19	....
8335	8336	Crockett Fine Sandy Loam	0.18	0.17
8337	8338	Susquehanna Fine Sandy Loam	0.15	0.10
8339	8340	Wilson Fine Sandy Loam	0.08	0.16
8341	8342	Norfolk Fine Sand	0.18	0.19
....	8344	Lufkin Fine Clay Loam	....	0.20
8345	8346	Crockett Clay Loam	0.22	0.19
8347	8348	Yahola Silt	0.08	0.17
8349	8350	Miller Find Sandy Loam	0.13	0.15
8351	8352	Tabor Fine Sandy Loam	0.20	0.21
8353	8354	Ochlockonee Fine Sandy Loam	0.23	0.19
8355	8356	Wilson Clay	0.09	0.18
8357	8358	Ochlockonee Clay	0.23	0.23
8359	8360	Miller Fine Sandy Loam	0.24	0.25
8361	8362	Wilson Clay Loam	0.23	0.06
8363	8364	Norfolk Fine Sand	0.07	0.17
8365	8366	Bell Clay	0.28	0.24
8367	8368	Tabor Fine Sandy Loam	0.19	0.22
8369	8370	Miller Fine Sand	0.21	0.16
8371	8372	Miller Clay	0.17	0.27
8373	8374	Bastrop Fine Sandy Loam	0.24	0.14
8375	8376	Crockett Clay Loam	0.14	0.15
8377	8378	Tabor Fine Sandy Loam	0.05	0.11
8379	8380	Miller Clay	0.16	0.18
8381	8382	Crockett Clay	0.17	0.15
8383	8384	Bastrop Sand	0.14	0.12
8385	8386	Trinity Clay	0.16	0.15
8387	8388	Lufkin Fine Sandy Loam	0.10	0.13
8389	8390	Susquehanna Clay	0.15	0.16
8391	8392	Susquehanna Fine Sandy Loam	0.05	0.08
8393	8394	Susquehanna Gravelly Fine Sandy Loam	0.14	0.13
8395	8396	Susquehanna Fine Sandy Loam	0.12	0.06
12420	12421	Lufkin Fine Sandy Loam	0.08	0.14
12639	12640	Wilson Clay	0.08	0.06
12641	12642	Trinity Fine Sandy Loam	0.06	0.06
12643	12644	Trinity Clay	0.10	0.07
12645	12646	Pledger Clay	0.11	0.09
12647	12648	Miller Fine Sandy Loam	0.05	0.08

Table 6. Sulphur content, expressed as sulphur trioxide, of soils of Brazos County.

Laboratory Nos.		Soil Type	SO3 Percent	
Surface	Subsoil		Surface	Subsoil
12649	12650	Miller Clay	0.07	0.06
12651	12652	Yahola Silt Loam	0.07	0.08
12653	12654	Bastrop Fine Sandy Loam	0.05	0.05
12655	12656	Bastrop Sand	0.03	0.03
12657	12658	Bell Clay	0.10	0.05
12659	12660	Wilson Clay Loam	0.09	0.08
12661	12662	Tabor Fine Sandy Loam	0.04	0.06
12663	12664	Crockett Clay	0.10	0.10
12665	12666	Crockett Fine Sandy Loam	0.07	0.05
12667	12668	Crockett Loam	0.07	0.07
12669	....	Crockett Clay Loam	0.08	....
12671	12672	Susquehanna Fine Sandy Loam	0.12	0.10
12673	12674	Lufkin Fine Sandy Loam	0.09	0.07
12675	12676	Ochlockonee Fine Sandy Loam	0.09	0.07
....	12678	Lufkin Clay Loam	....	0.10
12679	12680	Wilson Fine Sandy Loam	0.13	0.06
18910	18911	Lufkin Fine Sandy Loam	0.04	0.05
18999	19000	Lufkin Fine Sandy Loam	0.08	0.05
		Average	0.12	0.12

Table 7. Average sulphur content of the soil types of Brazos County.

No. analysed	Soil Type	Average SO3 per cent	
		Surface	Subsoil
7	Lufkin Fine Sandy Loam	0.07	0.08
5	Tabor Fine Sandy Loam	0.11	0.13
3	Susquehanna Fine Sandy Loam	0.09	0.11
3	Crockett Clay Loam	0.14	0.17
3	Miller Fine Sandy Loam	0.14	0.16
3	Miller Clay	0.13	0.17

Table 8. Sulphur content of the soils of Jefferson County.

Lab. No.	Soil Type	SO3 per cent
890	Lake Charles Very Fine Sandy Loam	0.10
2409	Lake Charles Clay	0.12
2410	Lake Charles Clay, subsoil	0.10
4644	Acadia Very Fine Sandy Loam	0.10
7613	Lake Charles Clay	0.15
10606	Lake Charles Clay	0.10
10607	Lake Charles Clay, subsoil	0.20
10608	Lake Charles Silt Clay Loam	0.09
10609	Lake Charles Silt Clay Loam, subsoil	0.09
14844	Rice Soil, surface	0.18
	Average	0.12

SULPHUR CONTENT OF THE SOILS

In Table 6 is given the percentage of sulphur, expressed as SO^3, of surface and subsoils of Brazos county. In Table 7 is shown the average sulphur content of various soil types of the county. The average of all the surface soils of the county analyzed is 0.12 per cent. as SO^3, or 2400 pounds per acre. Figured to elemental sulphur, this amounts to 960 pounds per acre. This is a considerably larger figure than found by Shedd (57) in the large majority of Kentucky soils analyzed by him. And while he invariably found the phosphorus content of the soil to exceed that of sulphur, the reverse is true with the soils of Brazos county used in the pot experiments, as can be seen from Table 1. The average percentage of sulphur of the subsoils of Brazos county is the same figure as for the surface soils, which shows these soils to be well supplied with sulphur, the analysis bearing out the results of the pot experiments.

Table 8 gives the sulphur content of some of the soils of Jefferson county. The average for all the soils analyzed is 0.12 per cent., the same as in the case of the Brazos county soils. These soils, too, may therefore be considered as containing a good supply of sulphur.

SUMMARY AND CONCLUSIONS

1. Soils of Brazos county and of Jefferson county were analyzed for their content in sulphur.
2. Pot experiments to test the effect of applications of sulphur on corn, sorghum, alfalfa, and some cotton, were carried on for two years with soils of Brazos county and of some other counties.
3. The analyses and the pot experiments, both, show that these soils are not deficient in sulphur.
4. Sulphur exercised a harmful effect upon some of the soils of Brazos county tested, reducing the yield and causing the plants in some pots to die very young.
5. The acidity of some Brazos county soils was increased by the addition of sulphur.
6. No relation was found between the percentage of nitrogen and that of sulphur in the sorghum grown in the pots.
7. The plants showed a tendency to take up more sulphur with an increased supply of this substance.
8. The soils of Brazos county tested, contain more sulphur than phosphoric acid.

LITERATURE CITED

1. B. D. Halstead, Proc. Soc. Prom. Agr. Sci. (1897), pp. 77-81.
2. M. Berthelot, Comp. Rend. Acad. Sci., 128 (1899), No. 1.
3. S. Bogdanov, Bul. Soc. Chem. Paris (1899), p. 965.
4. G. S. Fraps, Jour. Amer. Chem. Soc. (1901), p. 199.
5. C. P. Beistle, Jour. Am. Chem. Soc. (1902), No. 11.
6. G. S. Fraps and W. A. Withers, Exp. Sta. Rec. XIV, p. 1043.
7. E. B. Hart and W. H. Peterson, Jour. Am. Chem. Soc. (1911), No. 4.
8. E. Boullanger, Comp. Rend. Acad. Sci. Paris (1912), No. 6.
9. Bernhard, Deut. Landw. Press (1912), No. 6.
10. W. E. Tottingham, Wisc. Sta. Bulletin No. 288.
11. A. Magnien, Jour. Soc. Nat. France (1913), 4.
12. E. Lierke, Deut. Obstbau Ztg. (1913), No. 4.
13. V. Vermorel, Exp. Sta. Rec., XXIX, p. 822.
14. J. Chauzit, Rev. Vit. Fr. (1914), 41.
15. F. C. Reimer, Pacific Rural Press (1914), No. 26.
16. G. G. Brown, Oregon Sta. Bull. No. 141.
17. F. C. Reimer and H. V. Tartar, Ore. Sta. Bull. No. 163.
18. O. M. Shedd, Ky. Sta. Bull. No. 188.

19. L. Duley, Jour. Am. Soc. Agr. (1916), No. 3.
20. J. W. Ames and G. E. Boltz, Ohio Sta. Bull. No. 292.
21. F. Gianetto, Bol. Soc. Agr. Ital. (1912), No. 14.
22. J. A. Voelker, Jour. Royal Agr. Soc. (1913), No. 74.
23. G. Bosinelli, Staz. Sper. Agr. Ital. (1915), 83, No. 58.
24. T. Pfeffer and E. Planck, Landw. Versuchst. (1914), No. 5.
25. E. B. Hart and W. E. Tottingham, Jour. Agr. Research (1915), No. 6.
26. T. Pfeffer and W. Simmermacher, Fruhling's Landw. Ztg. (1915), Nos. 9-10.
27. Wisconsin Sta. Bull. No. 268.
28. Ohio Sta. Annual Rprt. *1919-1920, p. XXIII.*
29. Miss. Sta. 34th Annual Rprt., 1921.
30. Pfeiffer, Fruhling's Landw. Ztg. (1917), Nos. 7-8.
31. C. R. Fellers, Soil Science (1918), No. 6.
32. Agr. Gaz. New S. Wales (1920), No. 7.
33. Exp. Sta. Rec. XXXV (1921), p. 622.
34. J. Vogel, Central. Bakt. (1914), 1-8.
35. R. Stewart, Ill. Sta. Bull. No. 227 (1920).
36. M. M. McCool, Mich. Sta. Quart. Bull. 3 (1920), No. 1.
37. H. G. Soderbaum, Exp. Sta. Rec. XXXIV (1921), p. 129.
38. W. Pitz, Jour. Agr. Research (1916), No. 16.
39. G. Daikahara, Bull. Imp. Cent. Agr. Exp. Sta. Japan, 1 (1907), No. 2.
40. I. A. Vityn, Exp. Sta. Rec. XXV, p. 317.
41. T. L. Lyon and J. Bizzel, Cornell Sta. Mem. (1918), 12.
42. A. Stutzer, Biochem. Ztschr. 7 (1908).
43. Exp. Sta. Rec. XIV, p. 114.
44. H. C. Dint, Jour. Ind. and Eng. Chem. (1914), No. 9.
45. A. Demolon, Comp. Rend. Acad. Sci. (1913), No. 9.
46. A. M. Peter, Ky. Sta. Rprt. (1918), p. 389.
47. B. Heinze, Naturwissenschaften, 1 (1913), p. 111.
48. H. Kappen and E. Quensell, Landw. Versuchst. (1915), p. 1.
49. W. H. McIntire et al., Jour. Ind. and Eng. Chem. (1921), No. 4, p. 310.
50. J. G. Lipman et al., Exp. Sta. Rec. XXXIV, p. 26.
51. W. B. Ellet and W. G. Harris, Soil Science, No. 10 (1920), p. 315.
52. J. G. Lipman et al., Soil Sci., 11 (1921), No. 2, p. 87.
53. W. E. Tottingham and E. B. Hart, Soil Science, 11 (1921), No. 1, p. 49.
54. E. Miege, Rev. Sci., Paris, 1914, I.
55. G. Nicolas, Comp. Rend. Acad. Sci., 172 (1921), p. 85.
56. T. L. Lyon and J. Bizzel, Jour. Amer. Soc. Agr. (1916), No. 2.
57. O. M. Shedd, Mo. Sta. Bull. No. 174.

ACKNOWLEDGMENT

The thanks of the writer are due to Dr. G. S. Fraps, Chief of the Division of Chemistry, of the Texas Agricultural Experiment Station, for his stimulating guidance throughout the work here presented.