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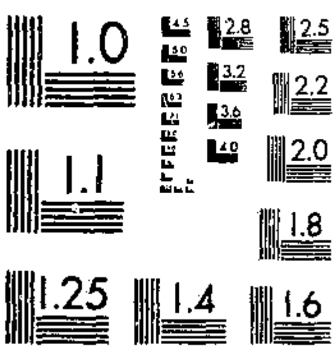

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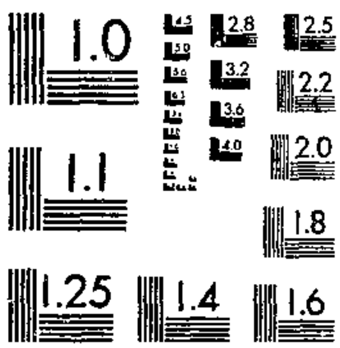

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NATIONAL BUREAU OF STANDARDS-1963-A

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Chemical Composition of Sugarcane Juice as Affected by Fertilizers[1]

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INTRODUCTION

Extensive experimentation (*29, 31, 40, 41, 42, 44, 45, 46, 49, 50, 60, 65*)[4] has demonstrated that the use of fertilizer is a profitable practice in the sugarcane district of Louisiana. The results show that maximum sucrose content and maximum tonnage are seldom obtained by the use of the same fertilizer combination; hence materials are usually recommended that combine the properties of growth stimulation and sucrose formation in such a ratio that the maximum amount of sucrose per acre is produced on the different soil types. Two or more fertilizer combinations frequently appear to have only slight differences in their effect on productivity. In such cases, it is desirable to have additional bases of comparison in order to make a proper selection. One important consideration in selecting from several apparently satisfactory fertilizers is their effect on the composition of

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[4] Italic numbers in parentheses refer to Literature Cited, p. 61.

the juice, as not only the sucrose content but also the kind and amount of nonsucrose substances present have a pronounced effect on the manufacturing quality of the juice. A fertilizer that improves the working quality of the juice by decreasing the quantity of interfering nonsucrose substances, or that enhances certain properties essential for clarification or any other phase of the manufacturing process, is to be preferred to one that yields a similar tonnage and sucrose content but that renders the juice more difficult to handle in the factory. This aspect of sugarcane fertilization has received but slight attention (*1*, *18*). It is, however, well known that juice composition is materially affected by fertilization and that a high ash content and particularly an unfavorable glucose-ash ratio of sirups and massecuites (*35*) reduce sugar recoveries. It has also been shown (*25*, *66*) that juices of similar apparent purity may differ considerably in their workability, owing to differences in their nonsugar composition. Hence the sugar per acre estimated from observed tonnage and apparent-purity calculations may not always exactly parallel the amount of recoverable sugar per acre if material differences in nonsugar composition result from use of fertilizers of different types. Knowledge of the nonsucrose composition of the juice is of assistance in selecting between fertilizer and other treatments that yield crops having similar sucrose and purity analyses but that produce different effects in processing because of other constituents present in the juice.

The general influence of nitrogen, phosphate, and potash fertilizers on the composition of sugarcane and sugarcane juice has been studied in various cane-producing countries (*12*, *14*, *16*, *19*, *20*, *33*, *37*, *52*), but the greater part of this work has been conducted under conditions different from those found in the Louisiana sugarcane district. Agronomic experiments with fertilizers, conducted by the Division of Soil Fertility Investigations, at the United States Sugar Plant Field Station, Houma, La., provided an opportunity to study the effect of a wide variety of fertilizers on the composition of the juice of millable sugarcane under conditions that were as nearly as possible typical of plantation practices. The work reported in this bulletin was started in 1931 and continued through the 1933 harvest, and had two objectives, namely, (1) to determine the influence of fertilizers on the composition of the juice over a representative range of the soil types devoted to sugarcane culture in Louisiana, and (2) to determine the influence of the three common plant foods when used singly and in mixtures.

MATERIALS AND EXPERIMENTAL PROCEDURE

The sugarcane used in these experiments was grown by representatives of the United States Department of Agriculture, in cooperation with plantation operators, in replicated plot tests on commercial plantations. The location of the test fields and other pertinent data concerning the sources of material used are given in table 1. The detailed discussion of the soils and the plot technique and agronomic procedures used has been presented by those responsible for those phases of the work (*31*, *40*, *41*, *42*, *43*, *44*, *45*, *46*), but a brief description of the methods used is included here to indicate the quality of the material on which this investigation was based. The test fields were selected to represent the dominant soil type of the vicinity in

TABLE 1.—*Location and type of soils of experimental fields, and varieties and fertilization data of sugarcane experiments in Louisiana, 1931–33*

Plantation	Nearest town	Soil series and type	Sugarcane			
			Variety	Age	Date fertilized	Date harvested
					1931	
Belle Terre	Donaldsonville	Yazoo very fine sandy loam	P. O. J. 213	Second ratoon	Apr. 9	Nov. 11
Bubenzer	Bunkie	Yahola very fine sandy loam	P. O. J. 36	First ratoon	Apr. 16	Dec. 11
Mandalay	Houma	Yazoo very fine sandy loam	P. O. J. 213	Second ratoon	Apr. 20	Nov. 17
Roy	Lafayette	Lintonia silt loam	P. O. J. 36	First ratoon	Apr. 15	Nov. 24
Sterling	Franklin	Franklin silt loam	P. O. J. 213	do	Apr. 2	Nov. 27
Upper Ten	Raceland	Yazoo very fine sandy loam	Co. 281	do	Apr. 7	Nov. 5
					1932	
Bubenzer	Bunkie	Yahola very fine sandy loam	P. O. J. 36	do	Apr. 19	Nov. 30
Mandalay	Houma	Sharkey silty clay	C. P. 807	Plant	Apr. 15	Nov. 24
Roy	Lafayette	Lintonia silt loam	P. O. J. 36	First ratoon	Apr. 12	Nov. 21
Sterling	Franklin	Franklin silt loam	P. O. J. 213	Second ratoon	Apr. 11	Oct. 31
Upper Ten	Raceland	Yazoo very fine sandy loam	do	Plant	Apr. 14	Dec. 5
					1933	
Albania	Jeanerette	Iberia silt loam	Co. 290	do	Apr. 19	Nov. 27
Bubenzer	Bunkie	Yahola very fine sandy loam	P. O. J. 36	Second ratoon	May 10	Oct. 31
Mandalay	Houma	Sharkey silty clay	C. P. 807	First ratoon	Apr. 20	Nov. 13
Upper Ten	Raceland	Yazoo very fine sandy loam	P. O. J. 213	do	Mar. 28	Nov. 20

which each field experiment was conducted, and the area to be used was first studied in detail to determine its suitability for experimental work; the requirements to be met included known and uniform agronomic treatment for several years preceding the experiment; uniformity of soil type, drainage, and exposure of the field; and adaptation of the sugarcane variety to the region.

The fertilizer used was mixed and applied by hand to the replicated plots, and the harvesting operations were closely supervised by the Government representatives. All cultivation and harvesting operations were the same as those used on commercial fields. At harvest, samples of commercial mill-length cane were collected from each plot by a standardized procedure of random collection (*43*). The accuracy of this method of sampling has been indicated by Arceneaux (*7*), and the relative agreement in analysis of the commercial and experimental juices thus obtained has been reported (*54, table 3*). The samples of sugarcane were brought to the Houma laboratory by truck and were crushed, within 24 hours after harvesting, in a hydraulically equipped, three-roller sugarcane mill designed to reproduce commercial grinding operations on a small scale (*54*). Equal quantities of the crusher juice [5] from the samples of cane of each replication were composited; this composite sample, representing the juice from about 200 to 300 pounds of cane, was immediately freed of adventitious substances and analyzed by procedures which have been described elsewhere (*27, 36*).

In general, analytical results from individual fields will not be presented, but only averages of several composite samples. Thus the influence of samples of abnormal composition is minimized, and comparatively minor trends can be observed and their significance determined by appropriate statistical treatment. The limits of significance indicated in the tables are generalized values for the data as a whole, computed according to the method described by Arceneaux (*6, 7*). The statistical figures are stated as indicative of a moderate and high level of significance, according to the *t* values published by Snedecor (*61, table 35*) to convert the standard deviations to significant differences. They have been used as a basis for discussion of the observed trends. Statistically significant differences due to fertilization have been found for nearly every constituent of the juice included in the study where applications of single-element fertilizers have been compared; and, within the limits set by these extreme differences in fertilization, trends of varying degrees of significance resulted from the use of different combinations of the three plant foods investigated. These were generally found to form a graded series intermediate between the values observed for the extremes.

The data obtained reflect not only the effects of the fertilizer but also the effects of weather, soil, variety, and other factors, which were uniform within each experimental field though differing from year to year and at the various locations. For the latter reasons, unfertilized check plots were included at each location, and the effects ascribed to fertilization are the differences observed between the composition of the juice from fertilized and unfertilized sugarcane. The discussion and particularly the graphical representations of the data

[5] Comparative studies (27) of crusher and whole mill juices have indicated that both sources of material were equally adapted to the purposes of this investigation. Because of the comparative simplicity of the crushing operation, crusher juice was therefore adopted as the standard material for analysis.

deal with these differences and not with absolute values. In this way, the other effects are minimized or eliminated and attention is directed primarily to the effect of fertilization.

The different types of soil appeared to influence the effects of fertilization on juice composition, the extent of which will be shown for several of the more important constituents. These soil-type effects were, in most cases, either an accentuation or a decrease in the effects noted for the average data of the district as a whole. Therefore the discussion of fertilizer effects deals first with the general trends for the district and then with the deviations from this general trend resulting from the influence of the several soil types. This "soil" effect doubtless includes the climatic influences on the crop of the area in which the soils occur, but, as these are inseparable for the purposes of practical sugarcane culture, they are considered as one factor. The time of cutting and the age of the cane influence the effects of fertilization on the crusher juice (*13*), but are probably not sufficiently large to materially alter the relationships developed in the present studies. Seasonal conditions affect maturity and thus probably influence the effects of fertilizer on juice composition, as noted by Phelan (*47*), Richardson (*48*), and others. Such an effect was noted in the course of the present investigation. In general, the effects of fertilizer on juice composition were relatively large in 1931, relatively small in 1932, and intermediate in 1933, although in each case the trends were similar. The magnitudes of the fertilizer effects thus corresponded closely with the reported (*8*, *9*, *10*) weather conditions for those 3 years, which resulted in crops relatively immature, unusually mature, and of about average maturity, respectively.

EFFECT OF FERTILIZER RATIO ON COMPOSITION OF JUICE

The method of fertilizer research originated by Schreiner and Skinner in connection with plant-culture studies (*55*, *56*) and recommended by them for field experiments (*39*, *57*) has proved of outstanding value for initial investigations on the response of plants to fertilization. Through its use, the effect of fertilizers on a crop can be investigated systematically and the separate and combined effects of the three common plant foods can be determined. The relationship between the fertilizer combinations used follows a definite pattern which can be best represented as points of a triangle, hence the system has become known as the triangle method of fertilizer investigation. In a triangle diagram, the three common plant foods—nitrogen, phosphorus, and potassium—are represented as the apices of a triangle. Various mixtures of any two of these plant foods are obtained by systematic decrease of one element and a corresponding increase of the other. The relative proportions used can be represented diagrammatically along a side of the triangle. The central portion of the figure thus developed can be used to represent various mixtures of all three plant foods, in which one element is maintained constant and the other two are varied, as represented by lines parallel to the sides. The essential characteristic of this system is constancy of the total amount of plant food used. Obviously, any quantity of plant food can be selected as a basis for a triangle experiment, and the number of "points," or fertilizer combinations, to be used is determined by the amount of change desired in the fertilizer ratios to be investigated.

These studies were based on a 21-point triangle and a plant-food application of 60 pounds per acre, nitrogen being calculated as N, phosphorus as P_2O_5, and potassium as K_2O. The materials used as fertilizers were sodium nitrate, superphosphate, and muriate of potash. The fertilizer ratios used and their interrelationships are shown graphically in figure 1. The percentage composition in each fertilizer

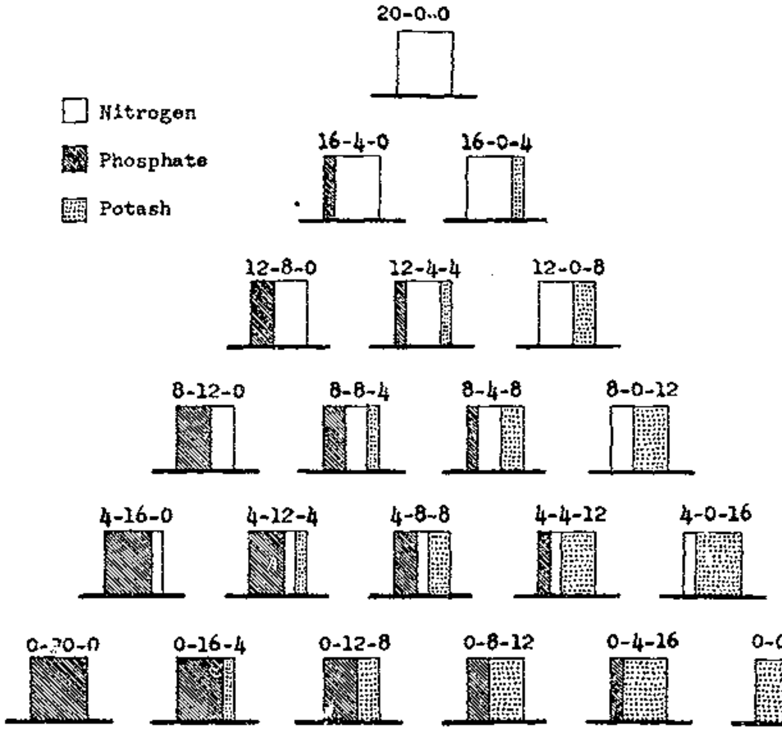

FIGURE 1.—Fertilizer ratios used and their interrelationships in the triangle system of fertilization.

ratio is indicated by the width of the shaded areas. Starting from the top of the figure, the fertilizer consisting of nitrogen alone (20-0-0) is represented at the upper apex. Each succeeding lower horizontal row of figures represents a ratio containing 4 percent less nitrogen than the row above it; the remainder of the plant-food application consists in systematically increasing quantities of phosphate, from right to left in the figure, or of potash, from left to right in the figure. Similarly, the phosphorus applications are represented as progressively decreasing in 4-percent steps in the fertilizer formula from phosphate alone (0-20-0), at the lower left apex, to phosphate-free mixtures along the right side of the triangle; potash alone (0-0-20) appears at the lower right apex and progressively decreases toward the left side of the triangle.

By plotting the experimental results on similar diagrams, systematic trends may be determined, extreme or questionable data from any fertilizer mixture become apparent, and experimental work may usually be interpreted with considerable certainty. The results of this investigation are therefore illustrated by triangle figures.

Brix and Total Solids

Fertilization at the rate of 60 pounds of plant food per acre affected the solids content of the juice by a small but measurable amount. The averaged results from the triangle fertilizer experiments conducted at various places in the sugarcane district during the 1931, 1932, and 1933 crop years are shown in table 2, column 2. Sodium nitrate used alone and with superphosphate as a 16-4-0 mixture decreased the

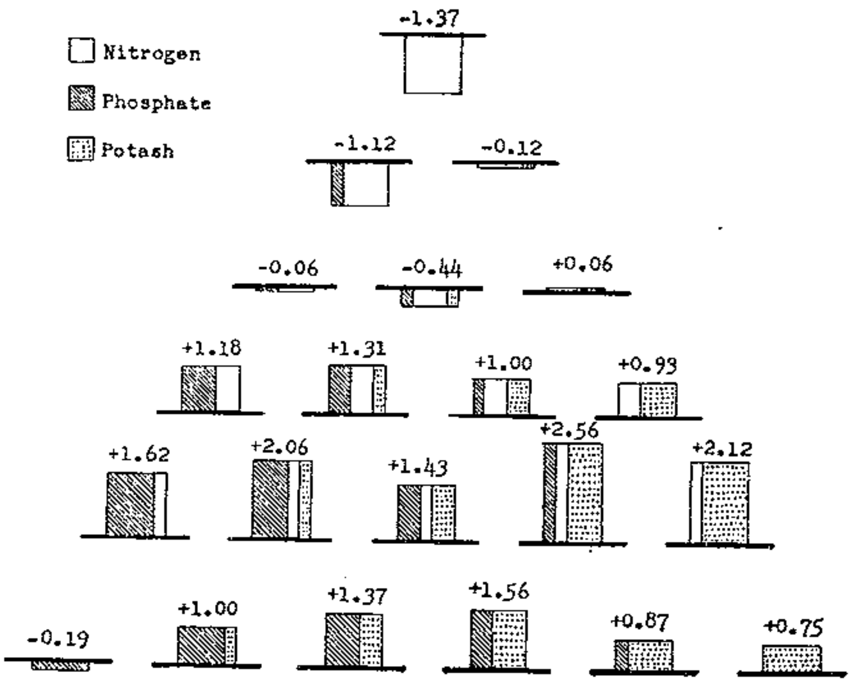

Figure 2.—Influence of fertilizer on Brix solids of crusher juice from certain varieties of sugarcane grown in Louisiana. Differences from unfertilized samples expressed as percentage changes of constituents. Average of 15 experiments.

Brix solids value considerably below that found in the juice of unfertilized sugarcane. Neither superphosphate nor potash used alone seemed to have significant effect on the Brix solids of the juice.

The effect of the various fertilizer mixtures is shown in figure 2, in which the observed value for the Brix of unfertilized cane is taken as the base line, and changes from this value caused by the indicated fertilizer mixtures are shown proportional to the height of the column above or below this base line for increases and decreases, respectively. The numbers express the change on a constituent basis, that is, the percentage of change from the unfertilized sample resulting from fertilization. It is apparent that only those mixtures in the lower half of the figure, representing fertilizers containing 8 percent of nitrogen or less, produced cane with as high solids content in the juice as was found in unfertilized sugarcane, also that most of the highest Brix values seemed to be associated with mixtures containing 4 percent of nitrogen. The bottom line of the figure shows that mixtures containing about equal parts of phosphate and potash and no nitrogen increased the apparent solids in the juice more than fertilizers consisting largely or wholly of phosphate or potash.

TABLE 2.—*Effect of different fertilizers on solids, sucrose, purity, and reducing sugars in crusher juice from certain varieties of sugarcane grown in Louisiana, 1931–33*

Fertilizer ratio N–P_2O_5–K_2O (300 pounds per acre)	Brix solids [1]	Calculated true solids [1]	Brix solids minus true solids	Apparent sucrose [1]	Apparent purity [1]	Calculated true purity [1]	Nonsucrose solids [1]	Reducing sugars [1]		Glucose ratio [1] [2]
	°	*Percent* [3]		*Percent* [3]			*Percent* [4]	*Percent* [3]	*Percent* [5]	
20-0-0	−0.22	−0.14	−0.42	−0.37	−1.16	−1.61	+1.61	+0.15	+0.98	+1.24
16-4-0	−.18	−.15	−.47	−.35	−1.18	−1.43	+1.43	+.16	+1.03	+1.31
16-0-4	−.02	+.03	−.45	−.09	−.41	−.75	+.75	+.08	+.50	+.60
12-8-0	−.01	+.01	−.48	−.11	−.61	−.76	+.76	+.11	+.67	+.86
12-4-4	−.07	−.01	−.44	−.14	−.39	−.85	+.85	+.04	+.30	+.37
12-0-8	+.01	+.05	−.46	−.07	−.05	−.73	+.73	−.05	−.36	−.46
8-12-0	+.10	+.25	−.44	+.13	−.20	−.56	+.56	−.04	−.33	−.41
8-8-4	+.21	+.21	−.50	+.26	+.61	+.49	−.49	+.01	.00	−.01
8-4-8	+.16	+.17	−.49	+.15	+.30	+.01	−.01	−.02	−.28	−.37
8-0-12	+.15	+.12	−.53	+.20	+.02	+.61	−.61	−.09	−.65	−.82
4-16-0	+.26	+.23	−.53	+.22	+.10	+.12	−.12	.00	−.13	−.15
4-12-4	+.33	+.20	−.54	+.27	+.07	+.11	−.11	−.11	−.84	−1.03
4-8-8	+.23	+.21	−.52	+.28	+.64	+.61	−.61	−.09	−.63	−.75
4-4-12	+.41	+.37	−.54	+.48	+.66	+.90	−.99	−.17	−1.15	−1.48
4-0-16	+.34	+.34	−.50	+.41	+.90	+.71	−.71	−.14	−.97	−1.17
0-20-0	−.03	−.06	−.53	−.00	−.26	−.24	+.24	−.01	−.01	+.02
0-16-4	+.16	+.10	−.56	+.09	−.16	+.02	−.02	−.03	−.24	−.19
0-12-8	+.22	+.19	−.53	+.25	+.45	+.53	−.53	−.07	−.60	−.75
0-8-12	+.25	+.19	−.66	+.26	+.39	+.60	−.60	−.09	−.67	−.79
0-4-16	+.14	+.06	−.58	+.17	+.46	+.75	−.75	−.12	−.78	−.91
0-0-20	+.12	+.05	−.57	+.24	+.96	+1.26	−1.26	−.16	−1.00	−1.26
0-0-0 (check)	16.04	15.54	−.50	13.26	82.51	87.26	12.74	.00	5.00	6.82
Difference required for significance:										
P=0.05	±.15	±.16	...	±.20	±.61	...	...	±.11	±.70	...
P=.01	±.21	±.21	...	±.26	±.80	...	...	±.15	±.93	...

[1] Values for fertilized plots represent differences from values for unfertilized plot (check).
[2] Grams of reducing sugars per 100 gm. of calculated "true" sucrose.
[3] Juice basis.
[4] Calculated true-solids basis.
[5] Brix solids basis.

If the data are averaged according to soil types, correlations between fertilizer and solids content of the juice are found to depend somewhat upon the soil in which the cane was grown (table 3). Fertilizer applied to the Lintonia silt loam appeared to have a marked effect on the apparent solids. Applications of nitrogen as sodium nitrate at the rate of 24 to 60 pounds of nitrogen per acre, alone or in combination with other elements, decreased the solids of the sugarcane juice to values definitely below that of unfertilized cane, the change being for the most part proportional to the quantity of nitrogen applied. Sixty pounds of plant food per acre, containing 12 pounds or less of nitrogen, the remainder consisting of varying quantities of phosphate or potash, increased the apparent solids of the juice to values greater than those obtained with unfertilized cane. Experiments on the Yahola very fine sandy loam showed relationships somewhat similar to those of the Lintonia soil, but the effects from fertilizer were less pronounced. The effects of fertilizer on the apparent solids in the sugarcane juice from the experiments on the Yazoo very fine sandy loam appeared to be similar to those of the Yahola very fine sandy loam, except for the effects of potash, which were less. Fertilizers applied to the Franklin silt loam appeared to produce different effects on the juice solids of the cane from the effects observed in the case of the other soil types. On this soil type nitrogen as sodium nitrate, used alone or as the predominating element in mixtures, appeared to increase the solids in the juice. Phosphate alone or mixtures of potash and phosphate fertilizers containing no nitrogen seemed to decrease the juice solids. Two test fields on Sharkey silty clay near Houma, La., gave results somewhat similar to those obtained on the Franklin silt loam. All fertilizers except superphosphate used alone, produced cane having higher apparent solids in the juice than did unfertilized cane. Nitrogen or potash used alone produced cane with somewhat lower apparent solids in the juice than cane fertilized with many of the complete mixtures. The single test with Co. 290 plant cane, conducted near Jeanerette, La., on the Iberia silt loam, gave evidence that all but three mixtures applied to cane grown on this soil type decreased the apparent solids content in the juice. These three exceptions are not considered significant.

TABLE 3. *Effect of different fertilizers on solids, sucrose, purity, and reducing sugars in crusher juice from certain varieties of sugarcane grown on various soil types in Louisiana, 1931–33* [1]

Fertilizer ratio $N-P_2O_5-K_2O$ (300 pounds per acre)	Brix	Calculated true solids	Apparent sucrose	Apparent purity	Calculated true purity	Nonsucrose solids	Reducing sugars
LINTONIA SILT LOAM							
	°	*Percent* [2]	*Percent* [2]			*Percent* [3]	*Percent* [4]
20-0-0	−0.73	−0.65	−1.01	−2.50	−2.90	+2.90	+3.08
0-20-0	+.15	+.12	+.29	+.90	+1.15	−1.15	+.54
0-0-20	+.42	+.31	+.74	+2.32	+2.87	−2.87	−2.02
0-0-0 (check)	16.50	16.13	13.62	82.55	80.30	13.04	7.54
YAHOLA VERY FINE SANDY LOAM							
20-0-0	−0.34	−0.29	−0.51	−1.33	−1.74	+1.74	+1.76
0-20-0	+.07	+.02	+.11	+.34	+.60	−.60	−.43
0-0-20	+.07	.00	+.25	+1.21	+1.61	−1.61	−.91
0-0-0 (check)	15.99	15.52	12.76	79.80	84.21	15.79	9.04
YAZOO VERY FINE SANDY LOAM							
20-0-0	−0.33	−0.24	−0.57	−1.90	−2.37	+2.37	+1.43
0-20-0	−.04	−.09	−.22	−1.18	−.92	+.92	+.50
0-0-20	+.05	−.05	+.11	+.43	+1.01	−1.01	−.59
0-0-0 (check)	15.90	15.36	13.23	83.21	88.15	11.85	4.66
FRANKLIN SILT LOAM							
20-0-0	+0.32	+0.45	+0.51	+1.45	+0.89	−0.89	....
0-20-0	−.12	−.15	−.05	+.32	+.55	−.55	....
0-0-20	+.14	+.06	+.37	+1.54	+2.02	−2.02	....
0-0-0 (check)	16.10	15.57	13.67	84.01	89.79	10.21	....

[1] Values for fertilized plots represent differences from values for unfertilized plots (checks).
[2] Juice basis.
[3] Calculated true-solids basis.
[4] Brix-solids basis.

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TABLE 3.—*Effect of different fertilizers on solids, sucrose, purity, and reducing sugars in crusher juice from certain varieties of sugarcane grown on various soil types in Louisiana, 1931–33*—Continued

SHARKEY SILTY CLAY

Fertilizer ratio $N-P_2O_5-K_2O$ (300 pounds per acre)	Brix	Calculated true solids	Apparent sucrose	Apparent purity	Calculated true purity	Nonsucrose solids	Reducing sugars
	°	Percent	Percent			Percent	Percent
20-0-0	+0.28	+0.26	+0.32	+0.60	+0.61	−0.04	−0.56
0-20-0	−.10	−.21	−.22	−.93	−.26	+.28	−.33
0-0-20	+.24	+.15	+.40	+1.34	+1.86	−1.86	−1.61
0-0-0 (check)	15.03	14.38	12.24	81.44	87.27	12.73	5.96

IBERIA SILT LOAM

Fertilizer ratio $N-P_2O_5-K_2O$ (300 pounds per acre)	Brix	Calculated true solids	Apparent sucrose	Apparent purity	Calculated true purity	Nonsucrose solids	Reducing sugars
20-0-0	−0.55	−0.46	−0.85	−2.17	−2.50	+2.50	+1.86
0-20-0	−.45	−.60	−.66	−1.56	−1.23	+1.23	+.25
0-0-20	−.43	−.57	−.61	−1.54	−.75	+.75	−.82
0-0-0 (check)	18.01	17.46	15.41	85.56	90.03	9.97	4.68

The foregoing data and discussion are based on Brix values, which were determined by a specific gravity method (*62*). This method was used because the large number of samples prevented use of the slower and more elaborate gravimetric method. The determination of juice solids by spindling, however, is known to give values greater than the true values as determined by drying, owing to the influence on juice density of the inorganic substances in solution. It will be shown later that fertilization influenced the quantity of inorganic material dissolved in the juice; hence it was important to determine whether the differences in solids content of the juice reported above as Brix values were actually due to the fertilizer treatment of the cane, or whether the effect was only apparent. It has recently been shown (*26*) that the apparent solids of Louisiana sugarcane juices, as determined by spindling, can be recalculated by means of an ash correction factor to give data that closely approximate the true solids content of the juice as determined by the official gravimetric method (*11*). This procedure was tested for a representative group of the experiments discussed in this bulletin. Table 4 shows that the calculated and determined true solids agreed closely for a representative group of the fertilizer ratios used, whereas the solids as determined by the two different methods are widely divergent. The Brix data were recalculated to determine whether the apparent differences previously ascribed to fertilization actually exist. The calculated "true" values for total solids thus obtained (tables 2 and 3) show that fertilization affected the solids content of the juice in the manner previously discussed, within the limits of significance of the data, although the differences due to treatment were usually less than the Brix determinations indicated except in the case of the samples grown on the Franklin silt loam, where the unusual effect of nitrogen was somewhat accentuated. The differences between the Brix and calculated true solids were not constant, but depended upon fertilizer treatment (table 2, column 4), because of the effect of fertilizer on the ash content of the juice.

TABLE 4.—*Total solids of crusher juice as determined by two different methods and as calculated by means of ash correction factor*[1]

Fertilizer ratio N-P_2O_5-K_2O (300 pounds per acre)	By spindling	By drying[2]	Difference	Carbonate ash	Calculated solids	Difference from solids by drying
	° Brix	*Percent*		*Percent*[3]	*Percent*	
20-0-0	15.39	14.93	−0.46	2.201	14.98	+0.05
12-4-4	15.71	15.30	−.41	2.228	15.29	−.01
0-20-0	15.89	15.35	−.54	2.344	15.35	.00
0-0-20	16.00	15.49	−.51	2.368	15.45	−.04
0-0-0 (check)	16.00	15.52	−.48	2.307	15.50	−.02
Average difference			−.48			−.004

[1] Average of 4 determinations for each fertilizer ratio.
[2] Determined by C. A. Fort, Carbohydrate Research Division, Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture.
[3] Brix-solids basis.

SUCROSE

As sucrose is the principal solid constituent of sugarcane juice, it would seem that the relationships previously discussed for total solids would be similar to and, to a certain extent, dependent upon the variations in the sucrose content of the juice resulting from fertilizer treatment. The apparent-sucrose data of the juices discussed in the previous paragraphs show that the influence of fertilizer on apparent sucrose closely follows that of total solids, but in general the sucrose relationships are somewhat more marked. The average minimum sucrose content was associated with application of nitrogen alone (table 2, column 5). A similar decrease in sucrose following applications of nitrogen fertilizer has been noted by Das (*21*), Kerr (*32*, *33*), Saito (*53*), and others. For the district as a whole the change in apparent-sucrose content due to use of superphosphate alone was slight and statistically insignificant. The use of 60 pounds per acre of potash increased the average apparent-sucrose content of the juice 0.24 percent. In general, the apparent sucrose increased as nitrogen in the mixed fertilizers was decreased and either phosphate or potash increased, the change being greater with potash-nitrogen mixtures than with phosphate-nitrogen mixtures (fig. 3).

Figure 3 shows the extent to which the six high-nitrogen fertilizers, and superphosphate when used alone, depressed the average apparent sucrose of the juice. Mixtures of phosphoric acid and potash containing an excess of the latter plant food increased the sucrose in the juice above that found in the juice of unfertilized sugarcane. Five of the six mixtures containing all three plant foods increased the apparent-sucrose values, the exception being the 12-4-4 ratio, where the influence of nitrogen was probably dominant, causing a decrease in sucrose. The favorable influence of potash on sucrose formation has been reported by various investigators (*3*, *28*, *30*, *33*). The maximum increase in apparent sucrose was not associated with the maximum potash application of 60 pounds of K_2O per acre in any of the 15 experiments studied. These sucrose relationships and the closely related total-solids and reducing-sugar values were the only constituents affected by fertilization in which maximum values were not associated with use of a single-component fertilizer. No fertilizer ratio consistently produced sugarcane of the highest juice sucrose, although in 12 of the 15 trials the highest values on the different fields were associated with mixtures containing 8 percent or more of potash. The average results show that the 4–4–12 mixture was best in promoting sucrose formation in the juice. However, as this mixture is not very effective in growth stimulation, others of higher nitrogen content produced more sugar per acre (*31, 40, 41, 42, 44, 45, 46*).

It has been reported (*26*) that apparent-sucrose values of Louisiana crusher juices as determined by single polarization methods are somewhat lower than those determined by the double-polarization tech-

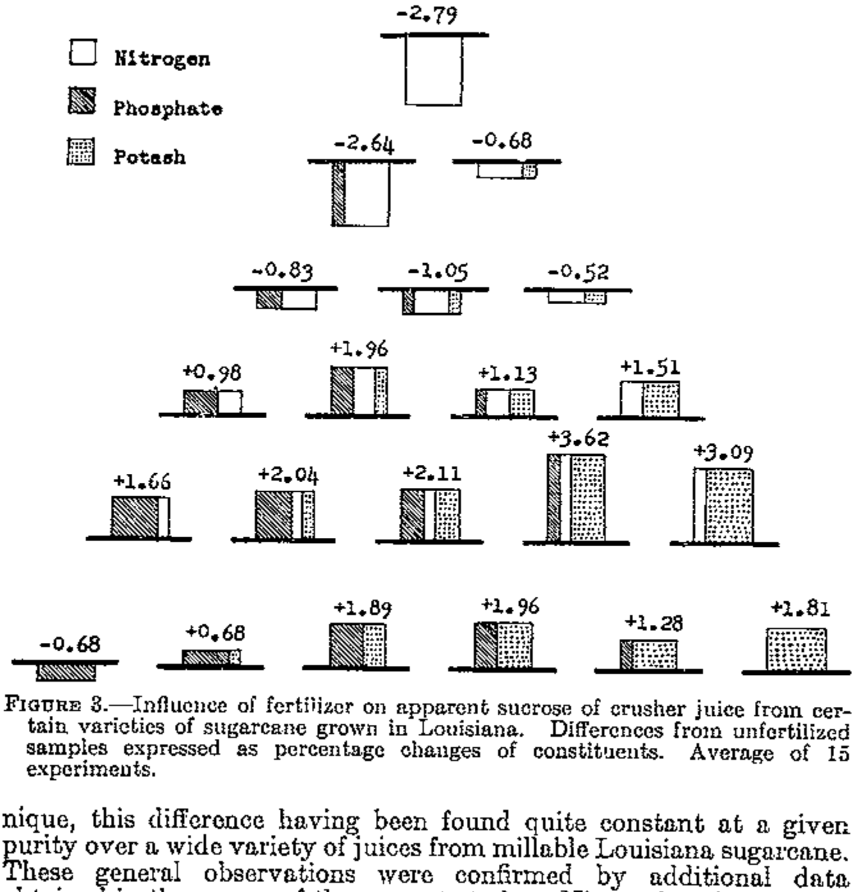

FIGURE 3.—Influence of fertilizer on apparent sucrose of crusher juice from certain varieties of sugarcane grown in Louisiana. Differences from unfertilized samples expressed as percentage changes of constituents. Average of 15 experiments.

nique, this difference having been found quite constant at a given purity over a wide variety of juices from millable Louisiana sugarcane. These general observations were confirmed by additional data obtained in the course of the present study. Ninety-four juices from different fertilizer mixtures representative of those used in this investigation gave an average true-sucrose reading 0.31 percent greater than the apparent values. No significant differences due to treatment were observed, although more detailed study might show that the relationships between apparent and true sucrose are affected by changes in the kind or quantity of nitrogen compounds present as a result of fertilization with nitrogen. Such a possibility is indicated by studies conducted by Zerban and Gamble (*67*). It is therefore concluded that the effects of fertilizer on the apparent-sucrose relationships, indicated above, represent the relative variations in the actual sucrose content of the juice caused by the fertilizers used.

The soil on which the cane was grown influenced the fertilizer-sucrose relationships (table 3). The two experiments on Lintonia silt loam gave minimum sucrose values following use of nitrogen alone, this plant food reducing the sucrose content more than 1 percent below that of unfertilized cane. Superphosphate used alone seemed to have little significant influence on the sucrose content of the juice. The greatest increase in apparent sucrose was produced by the 0–8–12 fertilizer on the Lintonia silt loam although seven other mixtures differed by less than 0.25 percent from this maximum, which is within experimental error. All eight of these high-sucrose-producing mixtures contained 4 percent of nitrogen or less, and six contained 8 percent or more of potash. The relationship of apparent sucrose to fertilizer on the Yahola very fine sandy loam was similar but less pronounced than on the Lintonia soil, fertilizers of high nitrogen content producing sugarcane of low sucrose content all 3 years and high sucrose values being associated with the 4–4–12, 4–0–16, 4–8–8, and 8–8–4 mixtures, respectively. Applications of either nitrogen or phosphoric acid to cane grown on the Yazoo very fine sandy loam depressed the sucrose content of the juice below that of unfertilized cane in four of the five experiments, the depression due to nitrogen being greater than that due to phosphoric acid. Sucrose maxima in juice from cane grown on the Yazoo soil were scattered, but the highest values were observed where high potash ratios were used. The effects of fertilizer on the apparent sucrose of cane grown on the Franklin silt loam and Sharkey silty clay were somewhat similar to each other but different from the other soil types in that the minimum values for these soils occurred where superphosphate alone was used. The other mixtures produced higher sucrose than was found in the juice from unfertilized sugarcane. The high sucrose values were associated with mixtures relatively rich in nitrogen, in contrast to the other soils. The results of a single experiment on Iberia silt loam indicated that, in general, fertilization reduced the sucrose and that the higher nitrogen ratios caused the greatest reduction.

Purity and Nonsucrose Solids

It has been shown in the preceding paragraphs that both the total solids and the apparent sucrose were changed as a result of the use of different fertilizer materials and that the changes were generally similar in direction. Therefore, purity changes were not so greatly affected by fertilization as they would have been if only the sucrose or the total solids were affected. The data of table 2 show that the various fertilizer mixtures influenced the apparent purity of the juice to a slight extent and in the same general manner as was the case for total solids and sucrose, confirming the statement previously made that the sucrose was affected by fertilization in a similar manner but to a greater extent than the total solids. Nitrogen, used singly or as the major ingredient of a fertilizer, reduced to a slight extent the apparent purity of the samples below that of unfertilized cane, the average for the 3-year period being 1.16 percent in the case of the 20–0–0 and 1.18 in the case of the 16–4–0 fertilizers. In general, the influence of phosphate used singly or in combination at the rates indicated is apparently negligible under the conditions of these experiments. Potash fertilizers improved the purity to a slight extent, as the highest average purity values are associated either with the 0–0–20 fertilizer or those mixtures relatively rich in potash.

The trends obtained by use of mixed fertilizer are clearly defined in figure 4. The high-phosphate mixtures, which form the lower left

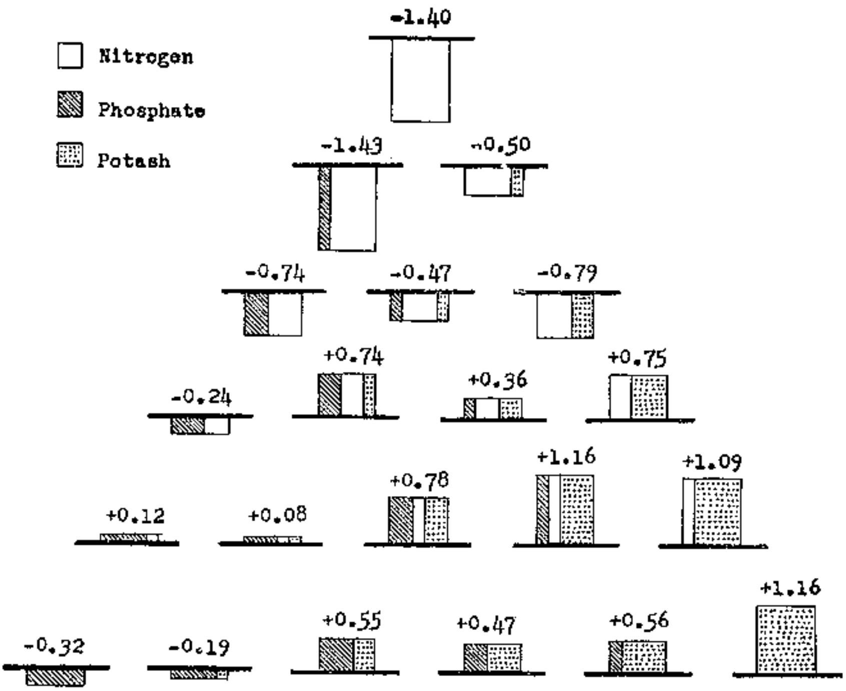

FIGURE 4.—Influence of fertilizer on apparent purity of crusher juice from certain varieties of sugarcane grown in Louisiana. Differences from unfertilized samples expressed as percentage changes of constituents. Average of 15 experiments.

portion of the figure, were without pronounced effect in changing the purity of the juice from that of unfertilized cane. The high-nitrogen ratios, which form a group at the top of the figure, depressed the average purity. The high-potash mixtures, which form the group at the lower right of the figure, increased the average purity of the juice to a measurable extent above that of unfertilized cane. The gradual change in purity caused by systematically increasing one plant food with corresponding decrease in one or more of the others is obvious. The figure clearly shows that the effects of the three principal plant foods on the purity of Louisiana cane juice was additive within the limits of significance of the data and that, unlike the total solids and sucrose relationships, maximum effects were obtained with single-component fertilizers rather than with mixtures. Because of the ash relationships, the apparent purity of samples from the 4–4–12 and the 0–0–20 plots were the same, but the true purity of the 0–0–20 samples was greater than that of samples from sugarcane fertilized with the 4–4–12 mixture.

The influence of fertilizer on the juice purity was modified by the soil on which the cane was grown (table 3). The juice from sugarcane fertilized with potash alone had higher purity in every case than that which had been fertilized with either nitrogen or superphosphate, but the relative effects of these plant foods with respect to unfertilized samples were different on the various soils. Nitrogen applied as sodium nitrate decreased the purity in the samples from the Lintonia, Yahola, Yazoo, and Iberia soils, but increased it in the case of the Franklin and Sharkey samples. Superphosphate decreased the purity of juices from sugarcane grown on the Yazoo, Sharkey, and Iberia soils, but increased it in the samples from the other soils. Compared with unfertilized samples, potassium chloride increased the purity of the juice of sugarcane grown on all the soil types except the Iberia silt loam.

The difference between the purity value and 100 is the percentage of nonsucrose solids. This class includes the reducing sugars, mineral constituents, nitrogenous compounds, gums, waxes, acids, and other substances. The total amount of this material can be calculated easily when the true purity of the juice is known, but not without serious error from apparent-purity data unless the relationship between true and apparent purity is known. Because the data of table 4 indicate that the average value for total solids of the juices used in this study can be estimated accurately and that the true sucrose content of the juices can be closely approximated from the apparent values, as indicated on page 12, it was possible to estimate the true purity and then approximate the total quantity of nonsucrose substances present in the juice.

Table 2 shows the average calculated values for the nonsucrose solids of the crusher juice for the 15 experiments previously discussed. Reference to this table and to figure 5 indicates that nitrogen fertilizers appreciably increased the nonsucrose solids of the juice, the change apparently being proportionally related to the nitrogen content of the fertilizer used in the six high-nitrogen formulas. The average nonsucrose solids of the juice of sugarcane fertilized with nitrogen alone was estimated as 14.35 percent of the calculated true solids compared with 12.74 percent for the juice of corresponding unfertilized cane. This represents an increase of 1.61 percent calculated on the calculated true solids basis, or more than 12 percent on a constituent basis, of this undesirable class of material present as a result of nitrogen fertilization. Potash decreased the nonsucrose solids almost as much as nitrogen increased them, the amount of change calculated on a constituent basis being nearly 10 percent. Superphosphate used alone did not increase the nonsucrose solids significantly. When mixtures of two or more plant foods were used, the changes in total nonsucrose solids appeared to be due primarily to the potash or nitrogen, phosphate apparently having little, if any, effect on the total of these substances as a class. As will be shown later, this is due to an increased quantity of certain nonsugars approximately equalizing a decrease in others.

Reducing Sugars

Preliminary data obtained [6] during the 1931 harvest season from a limited number of fertilizer mixtures showed that fertilization influenced the concentration of reducing sugars in the juice. These results were confirmed in 1933 when the reducing-sugar content of all available samples was determined (table 2). When the data were

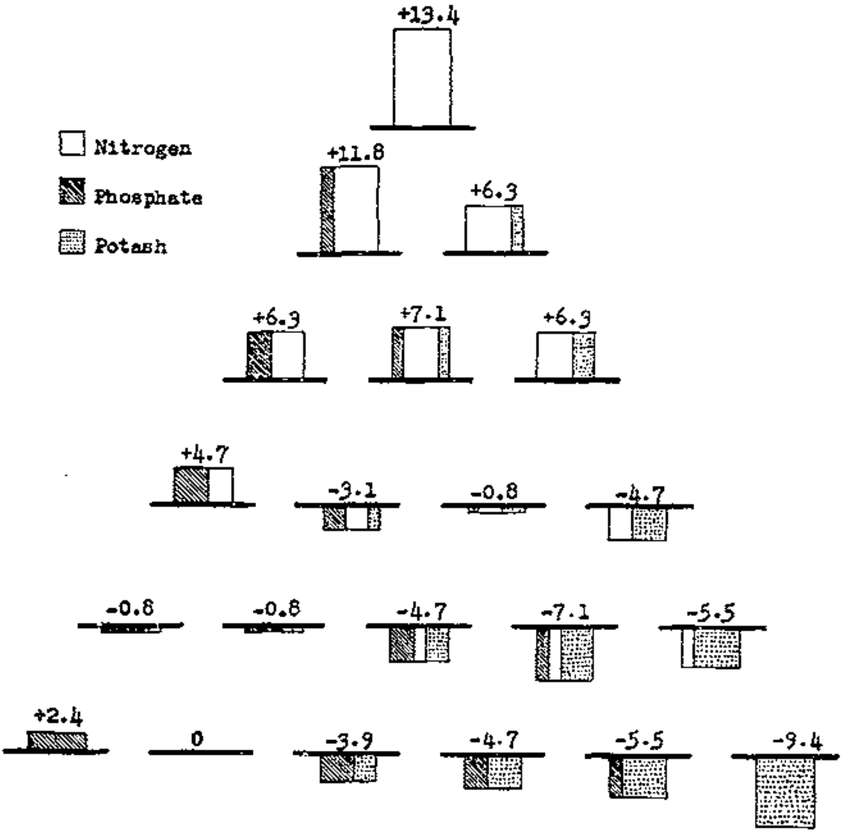

Figure 5.—Influence of fertilizer on nonsucrose solids of crusher juice from certain varieties of sugarcane grown in Louisiana. Differences from unfertilized samples expressed as percentage changes of constituents. Average of 15 experiments.

calculated on a solids basis, the use of nitrogen alone as fertilizer was found to increase the reducing sugars nearly 1 percent above the quantity found in the juice of unfertilized sugarcane. A similar application of potash decreased them by practically the same amount. Phosphate fertilization was without marked effect. The influence of systematic variation of fertilizer is clearly shown in figure 6, where the data are recalculated to show the percentage change of the constituents resulting from the use of the 21 fertilizers. Progressive

[6] By C. A. Fort, Carbohydrate Research Division, Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture.

decrease in the nitrogen and corresponding increase of potash in mixtures of these two plant foods showed a systematic decrease in the reducing sugars in the juice. Similarly, progressive change from nitrogen alone to phosphate alone, through the four different mixtures of these two plant foods, indicated a progressive decrease in reducing-sugar content. The various combinations of phosphate and potash showed a decrease in reducing-sugar content of the juice, which was closely proportional to the increase of potash in the mixture. The

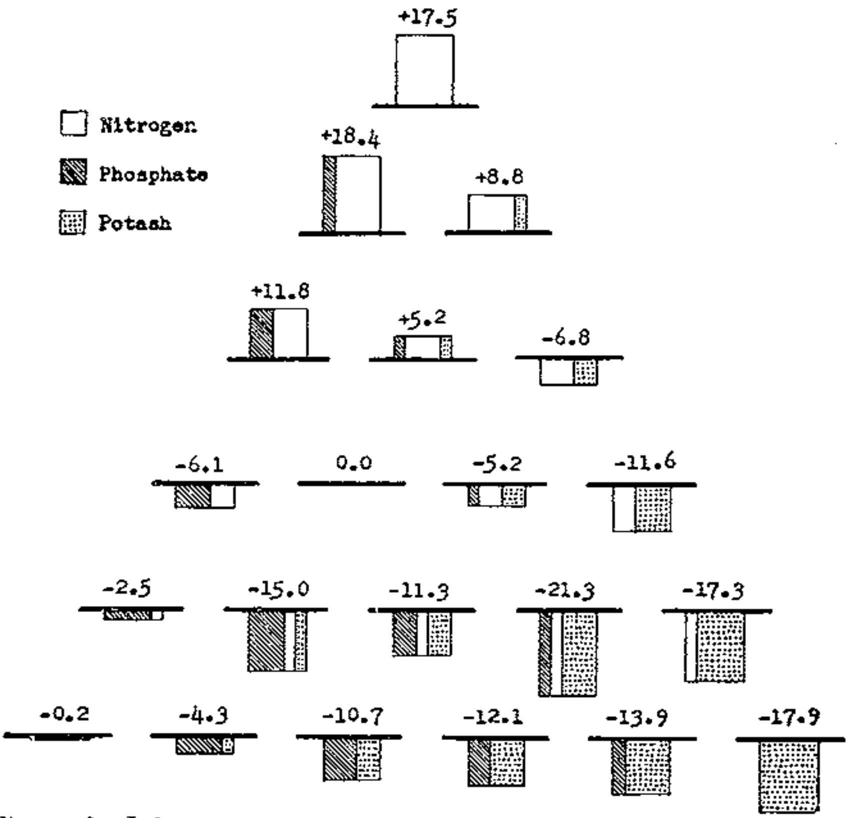

FIGURE 6.—Influence of fertilizer on reducing sugars of crusher juice from certain varieties of sugarcane grown in Louisiana. Differences from unfertilized samples expressed as percentage changes of constituents. Average of four experiments.

analyses of juice from cane fertilized with each of the six three-component fertilizers form a less conclusive series, although the trends in general indicate that the combined influence of each fertilizer component is roughly in proportion to the quantity used and that the 4–4–12 mixture produces cane having a minimum content of reducing sugars in the crusher juice. This fertilizer ratio also formed the highest average amount of sucrose. The foregoing relationships are essentially the same when the reducing sugars are considered as a ratio of glucose to sucrose, as is customary in certain tropical countries.

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Nitrogen increased the reducing sugars in the juice solids of sugarcane grown on all the soil types for which data are available, except the Sharkey soil, where a decrease was noted, compared with the values for unfertilized samples. Superphosphate slightly increased the reducing sugars in samples from the Lintonia, Yazoo, and Iberia soils and slightly decreased them in samples from the Yahola and Sharkey soils. These changes may not be significant. Potash decreased the reducing sugars more than the other plant foods and caused lower values for this constituent than were found for unfertilized samples from any soil type.

Das and Cornelison (*22*) found that the use of large quantities of nitrogen fertilizer reduced the total solids and sucrose and increased the glucose in the juice of Hawaiian sugarcane. They suggested that nitrogen caused this by increasing the succulence of the plant and promoting storage of sugar as reducing sugars rather than as sucrose. However, this suggestion failed to account for the opposite action of potash on these constituents. It seems simpler to assume that the increased succulence, lower sucrose and solids, and higher glucose, at least under Louisiana conditions, are all associated with delayed maturity resulting from the use of larger quantities of nitrogenous fertilizer. This view is also held by Batham and Nigam (*15*), who compared sugarcane maturity on rich and poor soils.

Acidity and Hydrogen-Ion Concentration

Some preliminary data [7] obtained in 1931 showed that fertilization influenced the acidity of crusher juice to a slight but measurable extent. The phenolphthalein method was not sufficiently sensitive to measure accurately the small differences involved, so a potentiometric titration method (*27, 36*) was used in 1932 and 1933. As the titration curves showed no points of inflection, the value of pH 7.74 was arbitrarily selected in 1932 as the end point of the titration. This was the mean of several samples titrated colorimetrically by an experienced sugar chemist in calculating the lime requirement of juices. The quantity of alkali required to bring the samples to true neutrality (pH 7.0) was also noted. As shown in table 5, the average difference between the two end points was about 0.35 cc. of 0.1 N alkali per 10 cc. of juice, although juice from cane fertilized with potash alone and with the higher nitrogen ratios generally had differences less than this average, and juice from cane fertilized with superphosphate and with the high-potash and phosphate ratios had differences greater than the average. This effect was probably due to greater buffering capacity of the increased amount of ash present in potash and phosphate-fertilized sugarcane. Where potash alone was used and the ash contained a relatively large amount of potassium chloride, there was apparently less buffer action. The influence of fertilizers on the buffer capacity of the crusher juice analyzed is thus indicated.

[7] Determinations by C. A. Fort, Carbohydrate Research Division, Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture.

TABLE 5.—*Effect of fertilization on buffer capacity, acidity, and hydrogen-ion concentration of crusher juice from certain varieties of sugarcane grown in Louisiana*

Fertilizer ratio $N-P_2O_5-K_2O$ (300 pounds per acre)	Total acidity to pH 7.0 [1]	Total acidity to pH 7.74 [1]	Difference [1]	Total acidity [2,3]	Hydrogen-ion concentration [1,2] $\times 10^{-6}$	Effective acidity [1]
	Ml.[4]	*Ml.*[4]	*Ml.*[4]	*Ml.*[4]		*pH*
20-0-0	1.17	1.49	0.32	−0.10	−0.38	5.46
16-4-0	1.14	1.46	.32	−.12	−.19	5.44
16-0-4	1.18	1.52	.34	−.06	−.22	5.44
12-8-0	1.19	1.52	.33	−.07	−.13	5.43
12-4-4	1.17	1.50	.33	−.10	+.02	5.42
12-0-8	1.18	1.53	.35	−.10	+.13	5.40
8-12-0	1.15	1.48	.33	−.11	.00	5.42
8-8-4	1.18	1.52	.34	−.01	−.03	5.42
8-4-8	1.21	1.59	.35	+.01	−.03	5.42
8-0-12	1.19	1.55	.36	−.03	−.10	5.43
4-16-0	1.20	1.55	.35	−.06	+.09	5.41
4-12-4	1.22	1.58	.36	−.06	+.06	5.41
4-8-8	1.26	1.61	.35	−.03	+.20	5.39
4-4-12	1.26	1.63	.37	−.02	+.19	5.40
4-0-16	1.27	1.64	.37	−.01	+.11	5.41
0-20-0	1.19	1.57	.38	−.07	+.06	5.41
0-16-4	1.21	1.50	.38	−.05	+.08	5.41
0-12-8	1.20	1.58	.38	−.09	+.02	5.42
0-8-12	1.21	1.59	.38	−.07	+.07	5.41
0-4-16	1.23	1.59	.36	−.08	+.12	5.40
0-0-20	1.24	1.57	.33	−.03	+.18	5.40
0-0-0 (check)	1.26	1.62	.36	1.43	3.83	5.42
Difference required for significance:						
P=0.05				±.05	±.25	
P= .01				±.06	±.36	

[1] Average of 5 experiments.
[2] Values for fertilized plots represent differences from values for unfertilized plots (checks).
[3] Titrated to pH 7.0. Average of 8 experiments in 1932 and 1933.
[4] Expressed as milliliters of 0.1 N sodium hydroxide (NaOH) per 10 ml. of juice.

As similar results in regard to the general influence of fertilizer on the acidity of the juice were obtained by titration to either end point, titrations in 1933 were made only to the neutral point (pH 7.0). The influence of fertilizer was similar each year, within the limits of significance of the data (table 5). In all but one case (this exception being nonsignificant) the juice of fertilized sugarcane was found to be less acid than that of unfertilized sugarcane. Although the differences were slight and there were some exceptions due to random variations in the samples, the general trend was for the complete mixtures and the potash-nitrogen mixtures relatively rich in the former substance to produce cane having a juice with acidity values only slightly below those observed for unfertilized cane; whereas mixtures high in nitrogen or phosphate or the phosphate-potash mixtures produced sugarcane of lower acidity.

The effect of fertilization on the pH value of the juice appeared to be somewhat different from that on the total acidity. Compared with the juice from unfertilized cane, sodium nitrate applied to the crop at the rate of 60 pounds of nitrogen per acre decreased the hydrogen-ion concentration of the juice somewhat; superphosphate applied at the same rate increased the hydrogen-ion by an insignificant amount; and potash apparently increased it to a slightly greater extent. The general effect of the 21 fertilizers studied is shown in figure 7.

Progressive substitution of nitrogen by either phosphate or potash or both appeared to increase the hydrogen-ion concentration of the juice. This effect seemed to be more pronounced with potash than with phosphate. The highest average hydrogen-ion concentration was noted in the 4–8–8 mixture, but this maximum may not be significantly associated with this mixture. From the available data it appears, however, that mixtures containing 8 percent or less of nitrogen produce

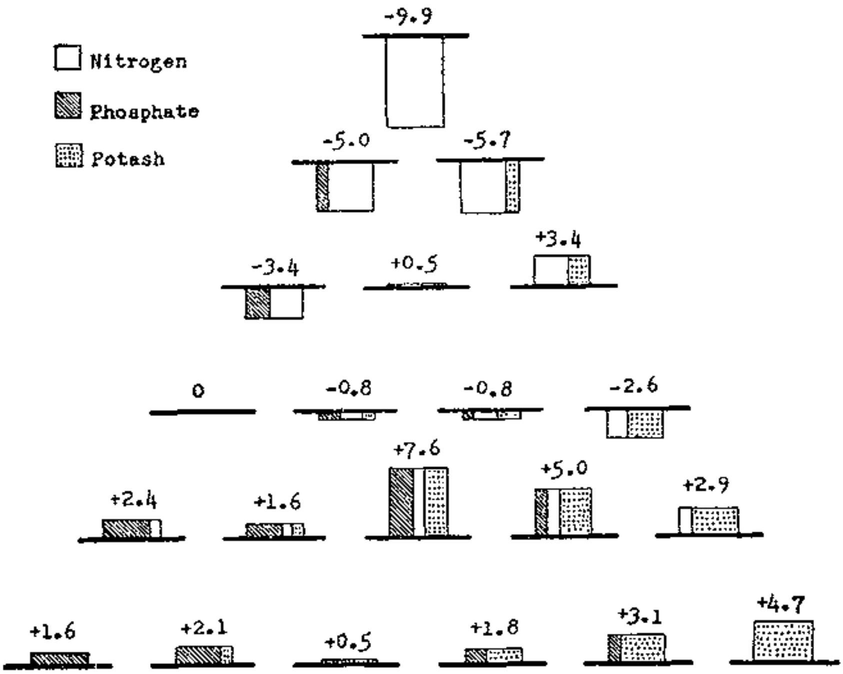

FIGURE 7.—Influence of fertilizer on hydrogen-ion concentration of crusher juice from certain varieties of sugarcane grown in Louisiana. Differences from unfertilized samples expressed as percentage changes of constituents. Average of five experiments.

cane with juice of significantly lower pH values than nitrogen alone, under the conditions of these experiments.

ASH

Fertilizer had a definite and pronounced effect on the ash of the crusher juices from 14 of the 15 experiments. The average ash content of the Brix solids from cane fertilized with sodium nitrate was 2.34 percent compared with 2.68 percent for the corresponding unfertilized material (table 6). Both superphosphate and potash increased the ash content in every experiment, the average increases being 0.043 and 0.076 percent of the Brix solids, respectively. The change in ash content of the juice solids caused by the different fertilizer ratios is shown in figure 8, where the data are expressed as changes in the percentage of the ash, using the ash content of the juice solids of unfertilized sugarcane as a basis.

Figure 8 shows, within the limits of significance of the data, a perfect correlation between the various fertilizers and their effect on the ash content of the juice solids. The systematic change from nitrogen to superphosphate through mixtures of the two was correlated with a graded series of changes in ash content ranging from −12.7 percent on a constituent basis in the former to +10.4 percent in the latter. This series forms the left side of the figure. A similar series occurred in each of the lines parallel to the nitrogen-phosphate side of the triangle, which represent variation of nitrogen-phosphate ratios modified by

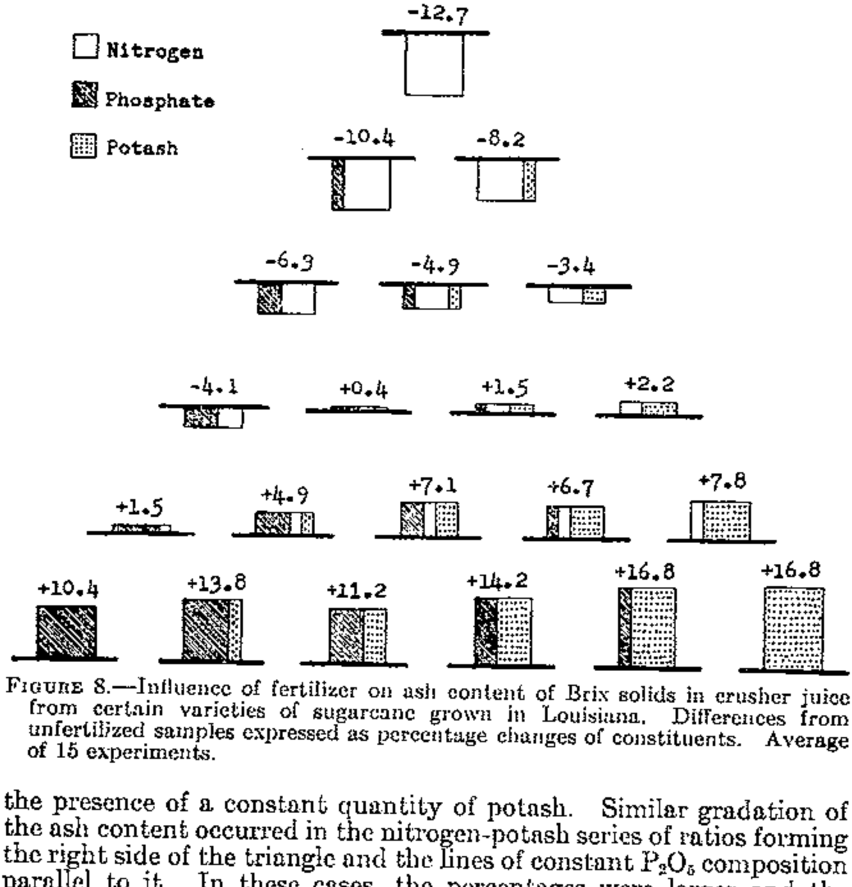

FIGURE 8.—Influence of fertilizer on ash content of Brix solids in crusher juice from certain varieties of sugarcane grown in Louisiana. Differences from unfertilized samples expressed as percentage changes of constituents. Average of 15 experiments.

the presence of a constant quantity of potash. Similar gradation of the ash content occurred in the nitrogen-potash series of ratios forming the right side of the triangle and the lines of constant P_2O_5 composition parallel to it. In these cases, the percentages were larger and the transition from negative to positive values occurred at higher nitrogen ratios, indicating that potash alone or in combination with the other plant foods increased the ash content more than equivalent quantities of phosphate. The bottom line of the figure, which represents the phosphate-potash mixtures, also shows that potash generally increased the ash of the juice solids more than equivalent quantities of superphosphate. The changes caused by progressive change from phosphate to potash in mixtures of these two plant foods are repeated along each horizontal row where the ratios varied in the presence of a fixed quantity of nitrogen. It is shown by figure 8, therefore, that the influence of each of the three principal plant foods—nitrogen, phosphorus, and potassium—was algebraically additive in changing the ash content of the crusher juices analyzed. As the effect of fertilizer on the total solids is smaller than on the ash, the above relationships apply when the data are calculated on the juice basis.

TABLE 6.—*Effect of fertilizer on mineral constituents of crusher juice from certain varieties of sugarcane grown in Louisiana, 1931-38* [1]

JUICE BASIS

Fertilizer ratio N-P_2O_5-K_2O (300 pounds per acre)	Ash [2]	Silica [2] as SiO_2	Phosphate [3] as P_2O_5	Sulfate [4] as SO_4	Chloride [5] as Cl	Potassium [6] as K_2O	Sodium [7] as Na_2O	Calcium [7] as CaO	Magnesium [6] as MgO	Manganese [8] as MnO
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
20-0-0	−0.060	+0.0001	−0.0127	−0.0252	−0.0069	−0.0324	−0.0011	+0.0028	+0.0012	0.00017
16-4-0	−.040	−.0005	−.0136	−.0100	−.0059	−.0284	.0055	+.0010	−.0012	−.00006
16-0-4	−.036	+.0001	−.0129	−.0190	+.0011	−.0220	.0054	+.0010	−.0013	−.00020
12-8-0	−.020	−.0007	−.0092	−.0065	−.0051	−.0185	.0014	+.0014	−.0015	−.00017
12-4-4	−.015	−.0020	−.0080	−.0074	+.0031	−.0102	.0012	+.0011	.0007	.00006
12-0-8	−.014	−.0005	−.0083	−.0153	+.0135	−.0056	.0053	+.0012	−.0017	−.00014
8-12-0	−.013	+.0008	−.0075	+.0020	−.0016	−.0124	−.0018	+.0011	−.0012	.00002
8-8-4	+.007	−.0003	−.0054	+.0015	+.0021	−.0051	−.0019	+.0007	−.0019	+.00002
8-4-8	+.011	−.0002	−.0035	−.0034	+.0093	−.0010	−.0039	.0000	−.0020	−.00015
8-0-12	+.014	.0000	−.0005	−.0107	+.0169	+.0068	−.0016	+.0007	−.0015	−.00008
4-16-0	+.013	−.0001	−.0022	+.0145	+.0001	.0078	.0017	+.0007	+.0005	+.00013
4-12-4	+.030	+.0011	−.0019	+.0139	+.0072	+.0091	−.0055	+.0006	−.0007	+.00015
4-8-8	+.037	+.0005	.0014	+.0073	+.0105	+.0112	−.0058	+.0007	−.0006	+.00000
4-4-12	+.041	+.0005	+.0015	+.0054	+.0177	+.0178	−.0059	.0003	−.0014	+.00009
4-0-16	+.043	−.0012	+.0005	−.0074	+.0215	+.0271	.0057	.0012	−.0023	+.00013
0-20-0	+.043	+.0007	+.0019	+.0159	+.0098	+.0159	.0047	.0010	+.0002	+.00022
0-16-4	+.004	−.0004	+.0028	+.0215	+.0069	+.0178	−.0054	−.0008	+.0001	+.00017
0-12-8	+.055	.0000	+.0031	+.0153	+.0114	+.0219	−.0018	−.0005	.0000	+.00008
0-8-12	+.068	.0000	+.0035	+.0131	+.0166	+.0315	−.0056	−.0006	.0080	+.00028
0-4-16	+.070	−.0005	+.0044	+.0086	+.0249	+.0323	−.0044	−.0012	−.0011	+.00010
0-0-20	+.076	+.0007	+.0051	+.0033	+.0311	+.0465	.0028	−.0007	+.0033	+.00023
0-0-0 (check)	.430	.0151	.0706	.0537	.0336	.2043	.0120	.0172	.0289	.00155
Difference required for significance:										
$P=0.05$	±.013	±.0013	±.0024	±.0055	±.0040	±.0095	±.0019	±.0011	±.0013	±.00012
$P=.01$	±.018	±.0018	±.0032	±.0073	±.0053	±.0126	±.0025	±.0016	±.0016	±.00016

BRIX-SOLIDS BASIS

Fertilizer ratio N-P_2O_5-K_2O (300 pounds per acre)	Ash	Silica as SiO_2	Phosphate as P_2O_5	Sulfate as SO_4	Chloride as Cl	Potassium as K_2O	Sodium as Na_2O	Calcium as CaO	Magnesium as MgO	Manganese as MnO
20-0-0	−0.34	+0.002	−0.073	−0.156	−0.042	−0.183	−0.026	+0.020	+0.011	−0.0011
16-4-0	−.28	−.002	−.080	−.061	−.036	−.161	−.035	+.008	−.005	−.0005
16-0-4	−.22	+.001	−.070	−.123	+.009	−.132	−.034	+.007	−.007	−.0013
12-8-0	−.17	−.004	−.056	−.040	−.032	−.112	−.028	+.009	−.009	−.0012
12-4-4	−.13	−.012	−.048	−.046	+.022	−.057	−.027	+.009	−.003	−.0004
12-0-8	−.09	−.003	−.050	−.097	+.088	−.029	−.033	+.008	−.007	−.0009
8-12-0	−.11	+.004	−.050	+.008	−.011	−.088	−.031	+.006	−.009	−.0003
8-8-4	+.01	−.003	−.030	+.004	+.010	−.018	−.031	+.003	−.011	.0000
8-4-8	+.04	−.002	−.023	−.024	+.054	−.010	−.025	.000	−.013	−.0010
8-0-12	+.06	−.001	−.043	−.006	+.106	+.035	−.028	+.004	−.010	−.0005
4-16-0	+.04	−.002	−.010	+.087	−.002	−.063	−.030	+.003	+.001	+.0005
4-12-4	+.13	+.005	−.018	+.081	+.045	+.035	−.035	+.002	−.007	+.0007
4-8-8	+.19	+.002	−.014	+.039	+.059	+.054	−.037	+.001	−.006	+.0003
4-4-12	+.18	+.001	.000	+.023	+.099	+.070	−.038	+.006	−.012	+.0002
4-0-16	+.21	−.000	−.003	−.054	+.124	+.143	−.037	−.000	−.017	+.0001
0-20-0	+.28	+.005	+.012	+.100	+.064	+.099	−.030	−.004	+.001	+.0012
0-16-4	+.37	−.003	+.014	+.133	+.039	+.098	−.032	−.005	−.001	+.0010
0-12-8	+.30	−.001	+.016	+.094	+.067	+.127	−.031	−.004	−.001	+.0003
0-8-12	+.38	−.001	+.016	+.075	+.085	+.177	−.038	−.005	−.002	+.0014
0-4-16	+.45	−.004	+.024	+.050	+.151	+.253	−.029	−.009	−.010	+.0003
0-0-20	+.45	+.004	+.027	+.014	+.187	+.274	−.019	−.004	.000	+.0012
0-0-0 (check)	2.68	.004	.440	.334	.210	1.273	.070	.107	.180	.0098
Difference required for significance:										
$P=.05$	±.08	±.008	±.015	±.034	±.025	±.059	±.012	±.007	±.008	±.0008
$P=.01$	±.11	±.011	±.020	±.046	±.034	±.078	±.015	±.010	±.010	±.0010

[1] Values for fertilized plots represent differences from values for unfertilized plots (checks).
[2] Average of 15 experiments.
[3] Average of 11 experiments.
[4] Average of 5 experiments.
[5] Average of 4 experiments.
[6] Average of 3 experiments.
[7] Average of 10 experiments.
[8] Average of 2 experiments.

TABLE 6.—*Effect of fertilizer on mineral constituents of crusher juice from certain varieties of sugarcane grown in Louisiana, 1931–33*—Continued

ASH BASIS

Fertilizer ratio $N-P_2O_5-K_2O$ (300 pounds per acre)	Ash	Silica as SiO_2	Phosphate as P_2O_5	Sulfate as SO_4	Chloride as Cl	Potassium as K_2O	Sodium as Na_2O	Calcium as CaO	Magnesium as MgO	Manganese as MnO
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
20-0-0	------	+0.81	−0.52	−5.29	−0.79	−0.92	−1.18	+1.78	+2.08	+0.044
16-4-0	------	+.48	−1.42	−.87	−.55	−1.50	−1.20	+1.18	+1.04	+.077
16-0-4	------	+.45	−1.41	−3.82	+1.41	−.61	−1.43	+.82	+.65	+.011
12-8-0	------	+.18	−.95	−.53	−.63	−1.67	−1.06	+.37	+.28	+.001
12-4-4	------	−.22	−1.07	−.79	+1.13	+.41	−1.14	+.68	+.39	+.035
12-0-8	------	+.09	−1.24	−3.56	+3.88	+.65	−1.56	+.51	+.01	−.058
8-12-0	------	+.33	−1.08	+1.24	+.07	−1.02	−1.33	+.39	−.05	+.002
8-8-4	------	−.06	−1.27	+.30	+.45	−1.53	−1.43	+.14	−.48	−.004
8-4-8	------	−.16	−.95	−.97	+2.31	−.44	−1.13	+.03	−.49	−.032
8-0-12	------	−.05	−1.89	−2.95	+3.99	+.70	−1.07	+.19	−.40	−.018
4-16-0	------	−.03	−.68	+3.33	−.06	−1.94	−1.36	+.14	+.10	+.034
4-12-4	------	+.04	−1.40	+2.38	+.25	−.89	−1.65	−.10	−.62	+.001
4-8-8	------	−.17	−1.51	+.27	+1.62	−.98	−1.78	−.33	−.75	−.053
4-4-12	------	−.18	−.81	+.13	+3.35	+.20	−1.70	−.02	−.86	−.021
4-0-16	------	−.64	−1.40	−2.04	+4.23	+1.26	−1.73	−.76	−1.23	+.005
0-20-0	------	−.17	−1.16	+3.10	−.06	−1.33	−1.41	−.62	−.56	+.035
0-16-4	------	−.55	−1.26	+3.78	+.65	−1.66	−1.55	−.74	−.76	−.017
0-12-8	------	−.43	−1.20	+2.32	+2.02	−.77	−1.40	−.60	−.79	−.037
0-8-12	------	−.40	−1.52	+1.55	+3.12	+.16	−1.72	−.72	−.96	+.013
0-4-16	------	−.67	−1.68	+.24	+4.27	+1.29	−1.44	−1.03	−1.50	−.055
0-0-20	------	−.45	−1.61	−.75	+5.95	+2.33	−1.01	−.83	−1.17	−.015
0-0-0 (check)	------	3.67	16.96	13.04	8.37	49.54	3.26	4.39	7.31	.442
Difference required for significance:										
$P=0.05$	------	±.30	±.70	±1.11	±1.02	±1.48	±.51	±.47	±.54	±.039
$P=.01$	------	±.40	±.93	±1.46	±1.35	±1.96	±.68	±.62	±.72	±.052

The general effects of fertilizer on the ash content of the juice are influenced more or less by the soil on which the cane is grown. Nitrogen applied to Lintonia silt loam decreased the ash content of the juice solids; phosphate increased it slightly; and potash increased it appreciably (table 7). Phosphate fertilization appeared to have a greater influence on the ash of juice from cane grown on the Yahola very fine sandy loam than on the Lintonia silt loam, and potash and nitrogen somewhat less effect. Sodium nitrate decreased and superphosphate and potash increased the ash content of the juice solids from cane grown on the Yazoo very fine sandy loam somewhat more than in the Lintonia or Yahola samples. Although fertilization of sugarcane grown on the Franklin silt loam had comparatively small influence on the total solids, sucrose, and purity of the crusher juice, the effect on the ash was marked. Increases due to superphosphate and potash were comparable to those on the Yahola soil. Sodium nitrate reduced the ash in the juice solids 0.70 percent below that of unfertilized cane, equivalent to 26 percent when calculated on a constituent basis, or more than for any other soil type. Experiments on Sharkey silty clay gave results that differed from those of the other soils studied. Sodium nitrate appeared to have no significant effect on the ash of juice from cane grown on this soil type, slightly increasing it in 1932 and slightly decreasing it in 1933. Potash increased the ash in a manner similar to the Lintonia and Yazoo samples and superphosphate increased it more than potash, a result not observed on any other soil type. It is not known whether this latter effect was due to the nature of the soil or to the variety of cane used, as it has been shown (*27*) that the juice of C. P. 807 is characteristically high in phosphate and magnesium and this varietal trait may indicate an unusual tendency to absorb these ions from the soil. The juice ash of cane grown on Iberia silt loam was affected by nitrogen and phosphate fertilization in the same way and to practically the same extent as the general average of all samples studied, but the effect of potash was greater than that observed on any other soil type.

TABLE 7.—*Effect of different fertilizers on mineral constituents of crusher juice from certain varieties of sugarcane grown on various soil types in Louisiana, 1931–33* [1]

Fertilizer ratio $N-P_2O_5-K_2O$ (300 pounds per acre)	Ash	Phosphate as P_2O_5	Sulfate as SO_4	Chloride as Cl	Potassium as K_2O	Sodium as Na_2O	Calcium as CaO	Magnesium as MgO
LINTONIA SILT LOAM								
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
20-0-0	−0.33	−0.053	−0.111	−0.060	−0.252	−0.050	+0.119	+0.047
0-20-0	+.10	+.008	+.101	+.053	−.040	−.035	−.011	+.015
0-0-20	+.44	+.012	+.012	+.215	+.205	−.016	−.021	−.006
0-0-0 (check)	1.88	.251	.196	.160	.911	.081	.132	.184
YAHOLA VERY FINE SANDY LOAM								
20-0-0	−0.21	−0.081	−0.125	−0.004	−0.084	−0.007	+0.017	+0.012
0-20-0	+.22	+.023	+.066	+.039	+.139	−.016	+.003	−.004
0-0-20	+.35	+.007	+.005	+.156	+.327	−.010	+.011	.000
0-0-0 (check)	2.43	.357	.291	.076	1.158	.040	.129	.198
YAZOO VERY FINE SANDY LOAM								
20-0-0	−0.44	−0.052	−0.158	−0.053	−0.234	------	+0.031	+0.001
0-20-0	+.28	+.012	+.215	−.039	+.093	------	+.001	−.005
0-0-20	+.50	+.045	+.053	+.188	+.209	------	.000	−.008
0-0-0 (check)	2.81	.505	.344	.298	1.388	------	.090	.108
FRANKLIN SILT LOAM								
20-0-0	−0.70	−0.081	−0.289	------	−0.240	------	−0.010	+0.001
0-20-0	+.19	−.001	+.016	------	+.101	------	−.014	+.003
0-0-20	+.36	+.019	−.006	------	+.264	------	−.005	+.001
0-0-0 (check)	2.72	.423	.520	------	1.297	------	.081	.163
SHARKEY SILTY CLAY								
20-0-0	+0.05	−0.053	−0.053	+0.163	+0.071	−0.021	+0.019	−0.003
0-20-0	+.65	+.026	+.169	+.085	+.325	−.039	+.007	+.004
0-0-20	+.46	+.031	+.009	+.276	+.225	−.033	−.010	+.023
0-0-0 (check)	3.57	.702	.248	.226	1.720	.105	.095	.181
IBERIA SILT LOAM								
20-0-0	−0.34		------	------	------	------	------	------
0-20-0	+.30		------	------	------	------	------	------
0-0-20	+.73		------	------	------	------	------	------
0-0-0 (check)	2.52		------	------	------	------	------	------

[1] Values for fertilized plots represent differences from values for unfertilized plots (checks) expressed on Brix-solids basis.

McCleery (*35*), reporting some investigations by Layton, has shown that sucrose recoveries are increased by increasing the glucose-ash ratio of massecuites of a given purity. If this is true for Louisiana juices, the high glucose and low ash usually associated with use of sodium nitrate and certain other nitrogen fertilizers (pp. 49, 50) might act as an offsetting influence to the decreased sucrose content caused by their use, provided this favorable ratio carried through from the juice to the massecuites. The glucose-ash ratio of the crusher juice was calculated for four experiments for which data were available, representing the Yahola, Yazoo, Sharkey, and Iberia soils. It was found that the effect of fertilizer on the ratio was greater than its effect on either the glucose (reducing sugars) or the ash, because the action is in the opposite direction on these two constituents. In each

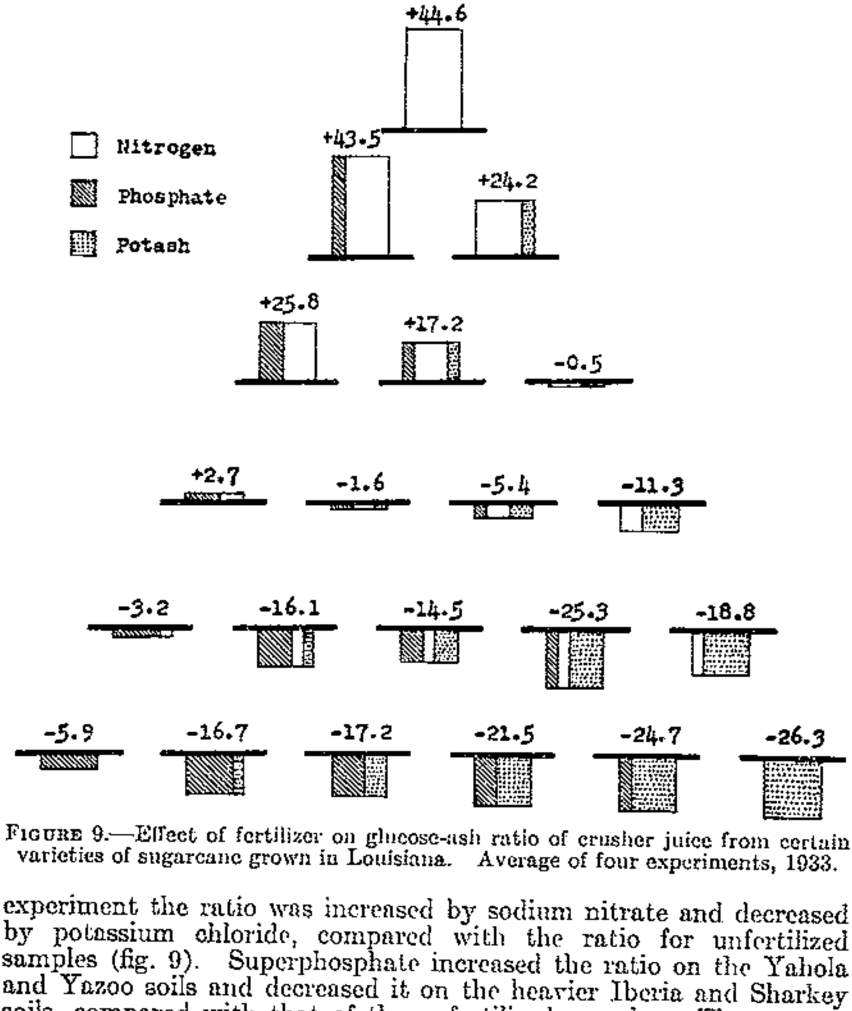

FIGURE 9.—Effect of fertilizer on glucose-ash ratio of crusher juice from certain varieties of sugarcane grown in Louisiana. Average of four experiments, 1933.

experiment the ratio was increased by sodium nitrate and decreased by potassium chloride, compared with the ratio for unfertilized samples (fig. 9). Superphosphate increased the ratio on the Yahola and Yazoo soils and decreased it on the heavier Iberia and Sharkey soils, compared with that of the unfertilized samples. The average changes resulting from use of the various fertilizer ratios show that the characteristic effects of the single plant foods were algebraically additive when mixed fertilizers were used. These crusher-juice ratios give evidence that the exhaustibility of massecuites may be considerably influenced by the fertilizer that the crop received, and that those fertilizers that produce the largest crops and juices of lowest solids content may also produce juices capable of increased sucrose recovery.

Composition of Ash

As fertilization was found to affect the ash content of the juice, it seemed desirable to determine whether the observed changes were merely a matter of variation in the total quantity of inorganic material present or whether the relative proportions of inorganic substances were affected by the plant foods applied to the crop. A systematic investigation of the inorganic constituents was undertaken to determine the effect of fertilization on these components of the juice.

SILICA

The results of silica determinations from all available samples showed no correlation indicative of fertilizer influence for the data as a whole or for any of the soil types studied (table 6). In the general average, the deviations from the silica content of the juice and juice solids were within the generalized limits of significance of the data in all but two cases, and these apparent exceptions were found upon closer analysis to be without significance. Significant differences were found when the data were calculated to the ash basis because of the effect of fertilizer on the total ash and not on the silica content of the juice or juice solids. From the available data, it is concluded that use of normal quantities of fertilizer had no in-influence on the concentration of this undesirable constituent in Louisiana crusher juices. Silica was one of two of the substances investigated that was not definitely influenced by fertilization, the other being magnesium (see p. 36).

PHOSPHATE

Sodium nitrate depressed the percentage of phosphate in the juice and juice solids below the corresponding values for unfertilized cane in every experiment (table 6). Fertilization with superphosphate appeared to have no significant effect in changing the phosphate content of the juice. This unexpected result has also been reported by Dymond, Viger, and Odendaal (*24*), who analyzed the juice of Uba cane in South Africa and by Saint (*52*), who studied the effect of fertilizer on the juice of three varieties of sugarcane in Barbados. However, Carrero reported a good correlation between phosphate fertilization and the P_2O_5 content of Puerto Rican sugarcane (*18*). The use of potash appeared to increase the quantity of phosphate in the juice and juice solids a small but significant amount.

These three plant foods had the same specific effects when used singly as when used in mixtures (fig. 10). Mixtures of sodium nitrate and superphosphate applied to the cane changed the phosphate content of the juice solids in proportion to the nitrogen content of the fertilizer. High nitrogen-low phosphate mixtures produced sugarcane juices lower in phosphate than the juices from unfertilized sugarcane. The differences became smaller as the ratio of phosphate increased and that of nitrogen decreased. This series, which forms the left side of figure 10, is repeated, within the limits of significance of the data, in each parallel line, but the numerical values are modified by the potash included in the fertilizer. A similar series occurs in the nitrogen-potash mixtures. The essential difference between the two series is that the positive effect shown for potash alone is evident in its mixtures approximately in proportion to the amount used. Similarly, each horizontal line in the figure shows that potash, either in the absence or in the presence of constant quantities of nitrogen, had more effect than superphosphate in increasing the phosphate content of the juice. Figure 10 indicates that all fertilizer combinations that

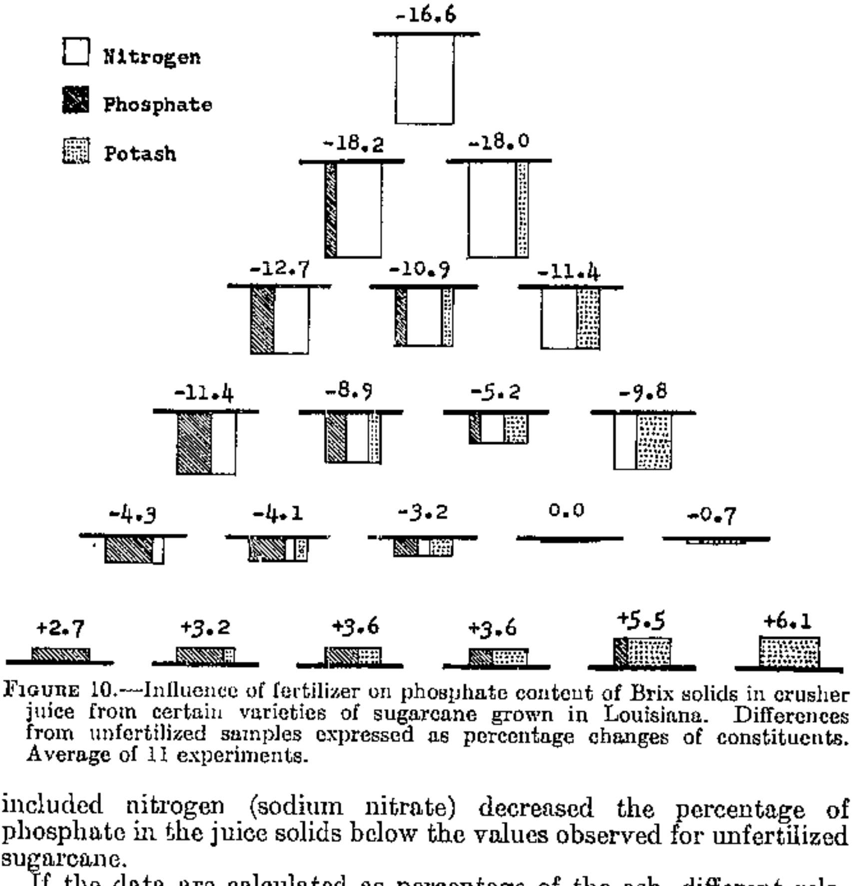

FIGURE 10.—Influence of fertilizer on phosphate content of Brix solids in crusher juice from certain varieties of sugarcane grown in Louisiana. Differences from unfertilized samples expressed as percentage changes of constituents. Average of 11 experiments.

included nitrogen (sodium nitrate) decreased the percentage of phosphate in the juice solids below the values observed for unfertilized sugarcane.

If the data are calculated as percentage of the ash, different relationships appear because of the effect of fertilization on the composition of the ash as a whole (fig. 11). Every fertilizer ratio decreased the amount of phosphate in the ash below that observed for the ash from juice of unfertilized cane. From this it follows that other constituents of the ash were influenced by fertilization to a greater extent than was phosphate.

These general effects of fertilization on the phosphate content of the juice appeared to apply with only minor exceptions to the data from each of the soil types. Sodium nitrate, either alone or as the predominating component of a mixture, depressed the phosphate content of the juice solids on each of the five soil types studied (table 7). No significant trends resulted from application of superphosphate to sugarcane grown on Lintonia silt loam, Yazoo very fine sandy loam, or Franklin silt loam. Superphosphate caused a small increase in the phosphate content of the juice solids of sugarcane grown on Yahola very fine sandy loam and Sharkey silty clay. Potash increased the phosphate content of the juice solids of sugarcane grown on each soil type. This effect was least in the experiments on the Yahola very fine sandy loam and greatest on those conducted on the Yazoo

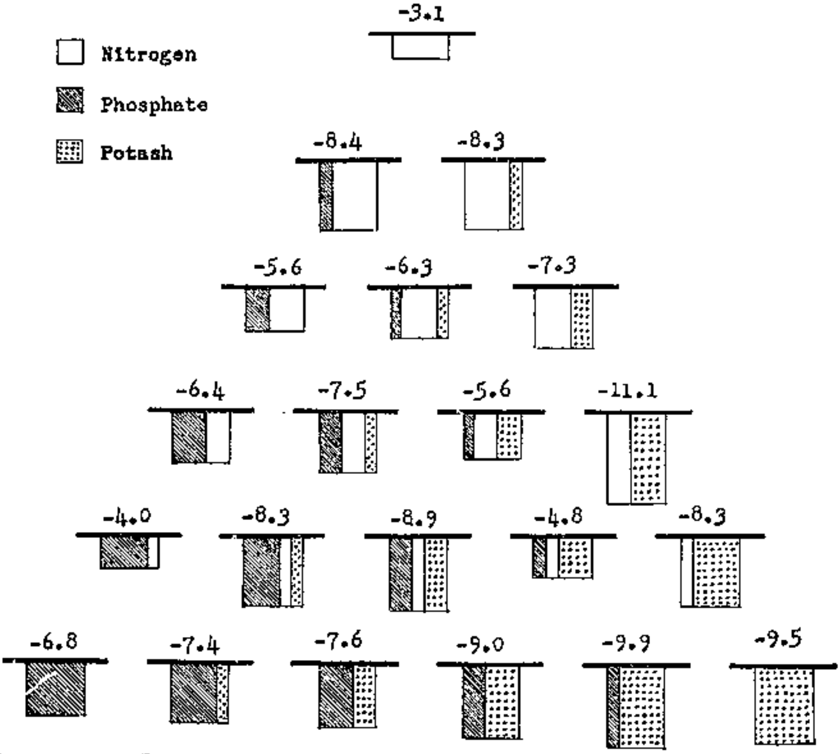

FIGURE 11.—Influence of fertilizer on phosphate content of carbonate ash in crusher juice from certain varieties of sugarcane grown in Louisiana. Differences from unfertilized samples expressed as percentage changes of constituents. Average of 11 experiments.

very fine sandy loam and the Sharkey silty clay. The phosphate content of the ash was decreased by application of superphosphate and potash to the crop on all soil types and by sodium nitrate on all soil types except the Yazoo very fine sandy loam, where an increase of doubtful significance was noted, and on the Franklin silt loam, where the unusually large effect of sodium nitrate in decreasing the total ash content probably contributed to the increased proportion of phosphate.

SULFATE

Commercial superphosphate contains calcium sulfate, which is slightly soluble; therefore the sulfate ion is available for absorption by plants. The sulfate from superphosphate applied to Louisiana soils seemed to be readily absorbed by sugarcane. Superphosphate increased the average sulfate content of the solids by 0.1 percent and that of the ash by 3.1 percent (table 6). Use of potassium chloride caused only a negligible increase in the sulfate content of the juice or juice solids. The juice, juice solids, or juice ash of sugarcane fertilized with sodium nitrate contained approximately half as much sulfate as was found in unfertilized cane, and roughly one-third as much as from sugarcane fertilized with an equivalent quantity of superphos-

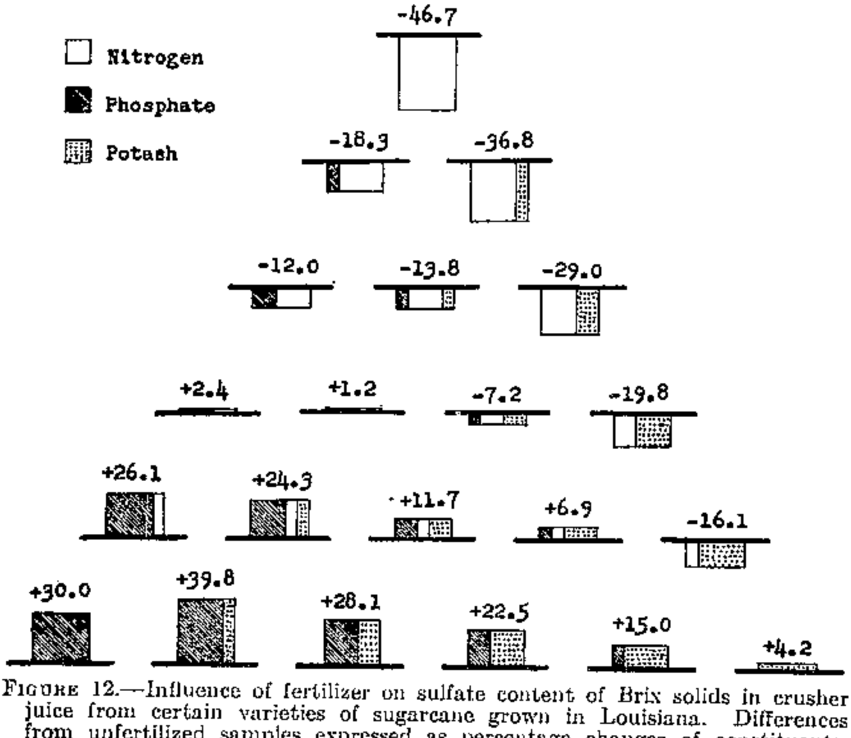

FIGURE 12.—Influence of fertilizer on sulfate content of Brix solids in crusher juice from certain varieties of sugarcane grown in Louisiana. Differences from unfertilized samples expressed as percentage changes of constituents. Average of five experiments.

phate. The influence of these three plant foods seems to be algebraically additive when used in mixtures, as the specific effects described for each component appear to be closely proportional to the amount used in each mixture, and the relationships are similar whether considered on the juice, juice solids, or ash basis (fig. 12).

The general effects discussed above applied to each of the five soil types on which the experiment was conducted. The effect of sodium nitrate was greatest on the Franklin silt loam and least on the Sharkey silty clay (table 7). The effect of superphosphate was greatest on the Yazoo very fine sandy loam and least on the Franklin silt loam. Potassium chloride caused the greatest increase in sulfate absorption on the Yazoo very fine sandy loam and decreased it by a negligible amount on the Franklin silt loam.

CHLORIDE

Changes in the quantity of chloride in the juice, juice solids, and ash were primarily due to differences in quantity of the potassium chloride used in the fertilizer mixtures (table 6). Superphosphate had no measurable effect on chloride absorption of any of the four soil types included in the study, although a decrease would not have been unexpected in view of the large increase in sulfate absorbed by sugarcane fertilized with this material. Sodium nitrate caused a significant decrease in chloride absorption in the samples collected from Lintonia silt loam, Yahola very fine sandy loam, and Yazoo very fine sandy loam (table 7). When mixed fertilizers were used the specific influence of each of the components appeared to be alge-

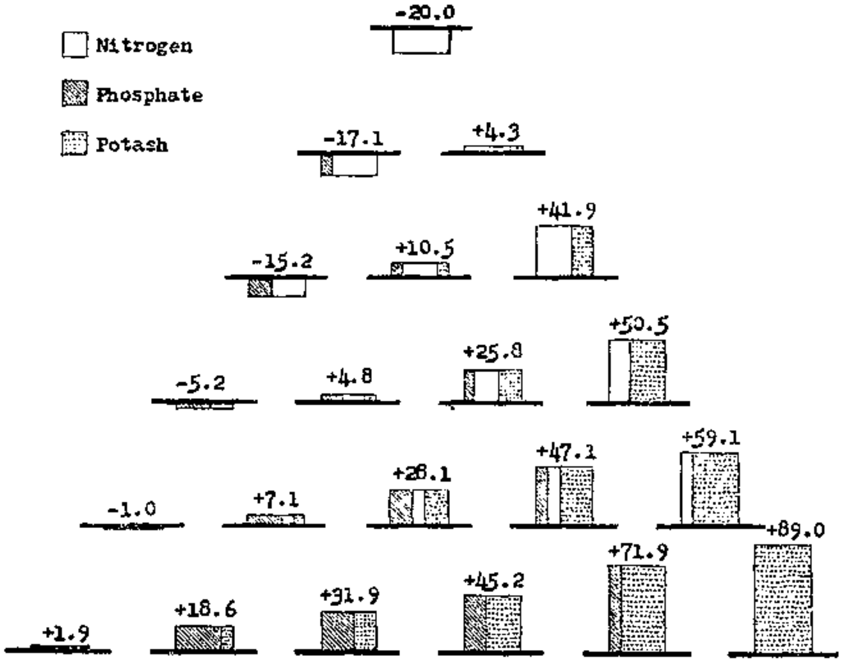

FIGURE 13.—Influence of fertilizer on chloride content of Brix solids in crusher juice from certain varieties of sugarcane grown in Louisiana. Differences from unfertilized samples expressed as percentage changes of constituents. Average of four experiments.

braically additive, as the chloride relationships on the three soil types were closely proportional to the composition of the fertilizer mixtures used (fig. 13). The relationships shown in the figure are similar whether the data are expressed on the juice, juice solids, or ash basis.

The effect of potassium chloride applied to sugarcane grown on Sharkey silty clay was similar to that observed on the other soil types, but sodium nitrate when used alone appeared to increase the absorption of chloride (table 8). The minimum chloride content of the fertilized samples was associated with the 12–8–0 mixture and was approximately equal to that in the juice solids of unfertilized sugarcane (fig. 14). Various other mixtures radiating from this point progressively increased in chloride concentration, in proportion to their composition within the limits of significance of the data.

TABLE 8.—*Effect of fertilizer on chloride content of juice from sugarcane grown on Sharkey silty clay, 1932–33*

[Average of 2 experiments]

Fertilizer ratio $N-P_2O_5-K_2O$ (300 pounds per acre)	Chloride[1] as Cl based on— Juice	Brix solids	Ash	Fertilizer ratio $N-P_2O_5-K_2O$ (300 pounds per acre)	Chloride[1] as Cl based on— Juice	Brix solids	Ash
	Percent	*Percent*	*Percent*		*Percent*	*Percent*	*Percent*
20-0-0	+0.0251	+0.163	+4.33	4-12-4	+0.0136	+0.075	+1.64
16-4-0	+.0137	+.089	+2.51	4-8-8	+.0216	+.135	+2.77
16-0-4	+.0228	+.148	+3.75	4-4-12	+.0350	+.211	+4.78
12-8-0	+.0006	−.001	+.09	4-0-16	+.0347	+.217	+4.86
12-4-4	+.0108	+.070	+1.80				
				0-20-0	+.0123	+.085	+1.09
12-0-8	+.0214	+.121	+3.54	0-16-4	+.0120	+.081	+.79
8-12-0	+.0119	+.068	+1.77	0-12-8	+.0157	+.097	+1.88
8-8-4	+.0086	+.050	+1.16	0-8-12	+.0322	+.205	+3.94
8-4-8	+.0169	+.108	+2.25	0-4-16	+.0332	+.207	+4.67
8-0-12	+.0268	+.168	+3.97	0-0-20	+.0422	+.276	+5.96
4-16-0	+.0111	+.059	+.75	0-0-0 (check)	.0335	.226	6.13

[1] Values for fertilized plots represent differences from values for unfertilized plots (check).

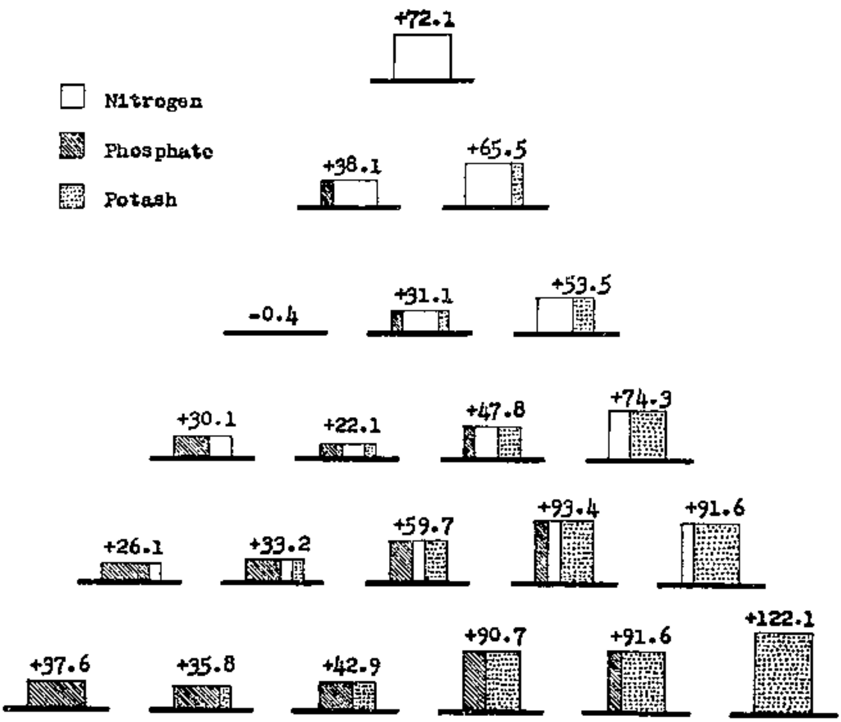

FIGURE 14.—Influence of fertilizer on chloride content of Brix solids in crusher juice from sugarcane grown on Sharkey silty clay. Differences from unfertilized samples expressed as percentage changes of constituents. Average of two experiments.

POTASSIUM

The potash content of the juice and juice solids was increased when potassium chloride was used as fertilizer (table 6). Sodium nitrate reduced the concentration of potash below that found in the corresponding samples from unfertilized sugarcane. Superphosphate alone caused a slight increase in the amount of potash in the juice except in the case of the Lintonia soil. This increase was in general much less in Louisiana than has been reported in Barbados (*52*) for potash-deficient soils. The three fertilizer components appeared to have the same specific effects when used in mixtures (fig. 15). Combinations

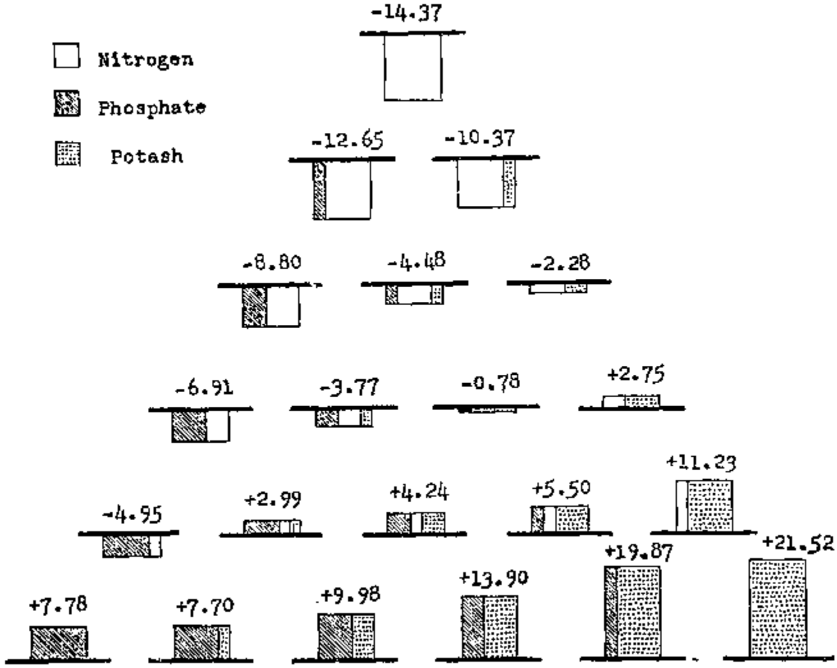

FIGURE 15.—Influence of fertilizer on potash content of Brix solids in crusher juice from certain varieties of sugarcane grown in Louisiana. Differences from unfertilized samples expressed as percentage changes of constituents. Average of 11 experiments.

of sodium nitrate and superphosphate reduced the potash content of the juice and juice solids below the values observed for unfertilized sugarcane, the reduction being roughly proportional to the quantity of sodium nitrate used. Combinations of superphosphate and potash produced sugarcane having more potash in the juice solids than unfertilized cane, the increase being more pronounced as the proportion of potassium chloride was increased. Combinations of sodium nitrate and potash resulted, when nitrogen predominated in the mixture, in potash values in the juice lower than those observed for unfertilized cane, and, when potash was the principal component, in potash values higher than those observed for unfertilized cane, the series increasing progressively with the potash content of the fertilizer combination.

With each of the nine mixtures of all three plant foods, the concentration of potash in the juice solids was intermediate between the extremes resulting from the use of each of the components singly.

The amount of potash in the ash of sugarcane juice was not greatly changed by fertilization (fig. 16). Superphosphate or sodium nitrate alone or in combination reduced the potash content of the ash slightly below that found in the unfertilized samples. Fertilization with potassium chloride alone or as the principal component of the mixture

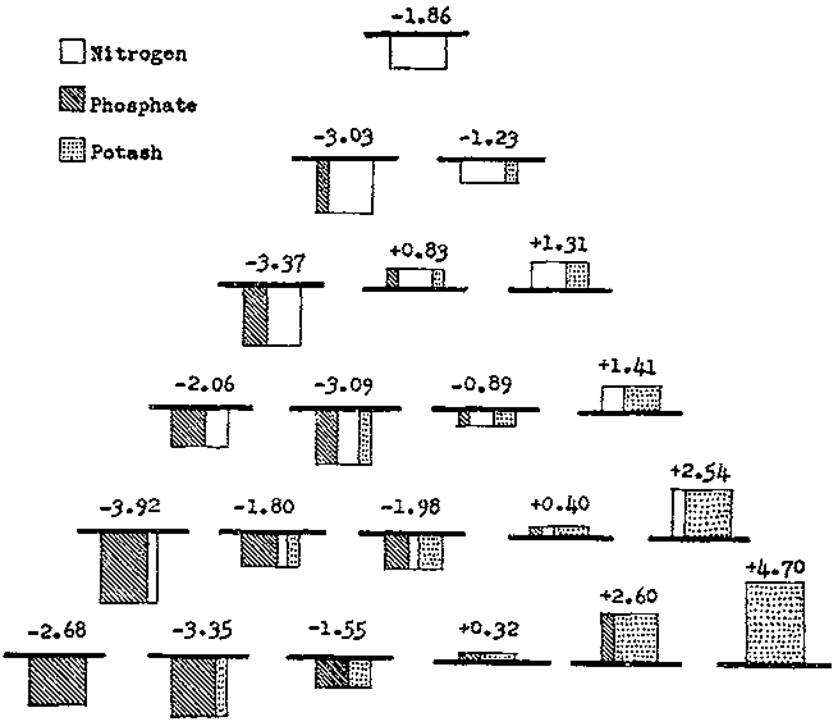

FIGURE 16.—Influence of fertilizer on potash content of carbonate ash in crusher juice from certain varieties of sugarcane grown in Louisiana. Differences from unfertilized samples expressed as percentage changes of constituents. Average of 11 experiments.

increased the amount of potash in the juice ash. Analyses of the ash or juice from sugarcane fertilized with the 18 mixtures gave a systematic series between the above extremes.

The foregoing discussion, which applies to the data as a whole, applies also, with slight modification, to the various soil types on which the experiments were conducted (table 7). Nitrogen fertilizer decreased the potash content of the juice solids of sugarcane grown on the Lintonia silt loam, the Yazoo very fine sandy loam, the Franklin silt loam, and the Yahola very fine sandy loam. The effect was comparatively slight on the Yahola soil. Sodium nitrate increased the potash in the juice solids of sugarcane grown on Sharkey silty clay. Fertilization with superphosphate appeared to slightly decrease the potash content of the juice solids in both experiments conducted on the Lintonia silt loam, but increased it on the other soil types, particularly on the Sharkey silty clay. Fertilization with potassium chloride increased the potash content of the juice solids on every soil type. The increase was greatest on the Yahola soil and was least on the Sharkey soil. The potash content of the ash was decreased by application of sodium nitrate to all but the Franklin silt loam, where a marked increase was noted. This is due to the effect of sodium nitrate on the total ash of juice from sugarcane grown on this soil type. Su-

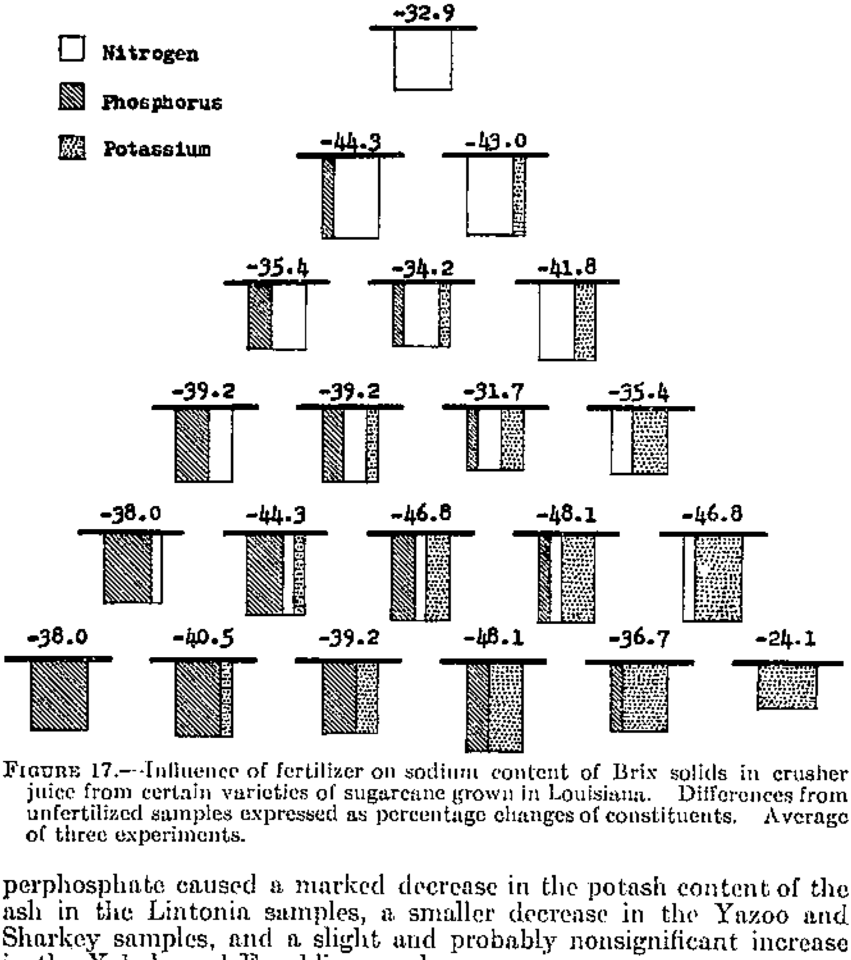

FIGURE 17.—Influence of fertilizer on sodium content of Brix solids in crusher juice from certain varieties of sugarcane grown in Louisiana. Differences from unfertilized samples expressed as percentage changes of constituents. Average of three experiments.

perphosphate caused a marked decrease in the potash content of the ash in the Lintonia samples, a smaller decrease in the Yazoo and Sharkey samples, and a slight and probably nonsignificant increase in the Yahola and Franklin samples.

SODIUM

Sodium is one of the minor constituents of Louisiana sugarcane juice, usually constituting about 3 percent of the total ash and less than 0.1 percent of the total solids present. This small quantity was markedly decreased by all of the fertilizers used (table 6 and fig. 17). The decrease was least marked where potassium chloride or sodium nitrate was used as a fertilizer. The decrease in sodium content due to fertilization was greater in the experiment on Lintonia silt loam than in the experiments on Yahola very fine sandy loam or Sharkey silty clay (table 7).

Calcium

Calcium forms the chief component of superphosphate, being present both as sulfate and as phosphate salts, and was therefore applied at systematic rates as one of the constituents of superphosphate. However, the juices from sugarcane fertilized with superphosphate alone contained slightly less calcium than the juices from unfertilized sugar-

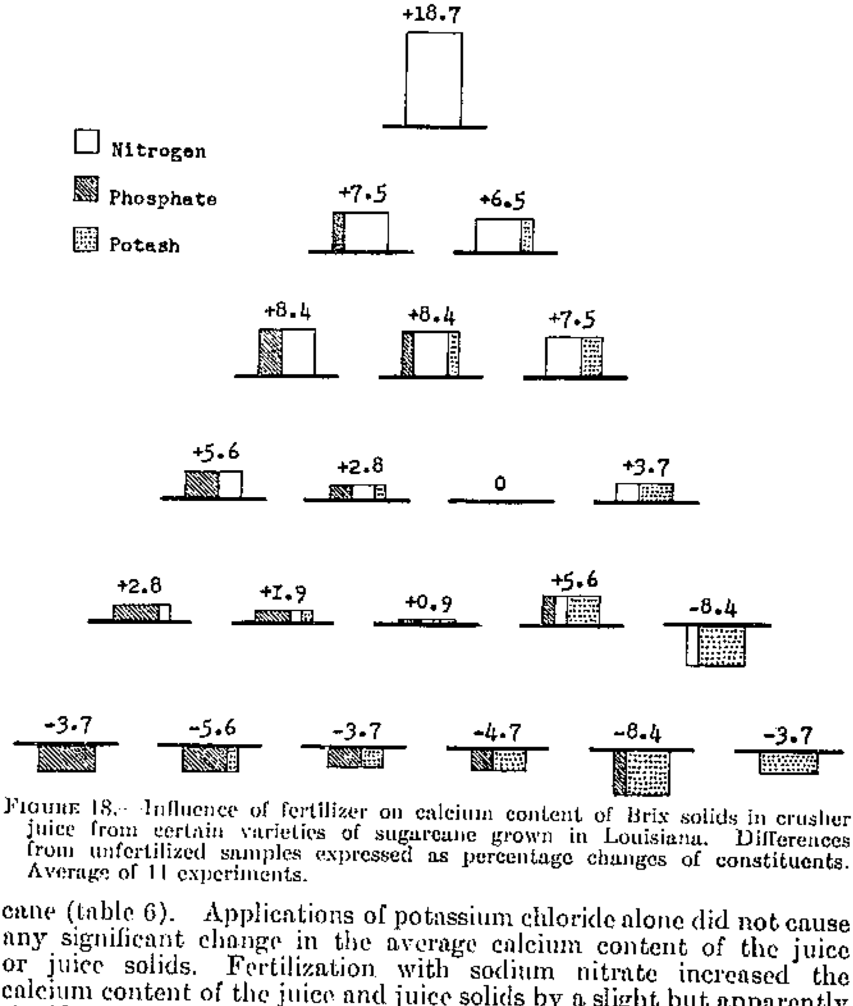

FIGURE 18.—Influence of fertilizer on calcium content of Brix solids in crusher juice from certain varieties of sugarcane grown in Louisiana. Differences from unfertilized samples expressed as percentage changes of constituents. Average of 11 experiments.

cane (table 6). Applications of potassium chloride alone did not cause any significant change in the average calcium content of the juice or juice solids. Fertilization with sodium nitrate increased the calcium content of the juice and juice solids by a slight but apparently significant amount on all the soil types except the Franklin silt loam (table 7). Where sodium nitrate was used in combination with either superphosphate or potash, or both, the increase of calcium in the juice solids was diminished approximately in proportion to the decrease in nitrogen content of the mixture used (fig. 18). All fertilizer mixtures that did not contain sodium nitrate produced sugarcane with slightly less calcium in the juice solids than was found in the unfertilized samples. As sodium nitrate decreased the ash but increased the calcium in the juice and juice solids and superphosphate and potash increased the ash but slightly decreased the calcium in these media, the relationships between fertilization and calcium in the ash were similar to but greater than those described for the juice solids, and the transition from increase over check to decrease below check occurred between the 4-percent and 8-percent nitrogen levels.

The above general relationships applied in a greater or less degree to four of the five soil types studied. The effects were most marked on the Lintonia silt loam (table 7), where sodium nitrate increased the calcium content of the juice 82 percent above the corresponding values of this constituent in unfertilized sugarcane. Superphosphate appeared to decrease slightly the calcium content of the juice, juice solids, and juice ash of sugarcane grown on this soil type; the corresponding decrease accompanying the use of potassium chloride as fertilizer was approximately twice as great. Smaller changes in calcium resulted from fertilization with sodium nitrate on the Yahola and Yazoo very fine sandy loams and Sharkey silt clay. The effects of potassium and phosphate fertilizers on the juice and juice solids of sugarcane grown on these soil types were small and probably not significant, although a definite decrease in calcium content of the ash was noted that was due to the effect of fertilizer on the total ash. Results of the two experiments on the Franklin silt loam indicated that the calcium content of the juice or juice solids was slightly decreased by fertilization with any of the ratios used. Owing to the marked effect of sodium nitrate on the juice ash of sugarcane grown on this soil type, this fertilizer slightly increased the calcium content of the ash.

Magnesium

All the mineral substances previously discussed except silica were constituents of one or more of the fertilizers used. Magnesium, however, was not a major component of any fertilizer, and any changes in the magnesium content of the juices were a result of change in the availability of soil magnesium caused by fertilizer application. The data of table 6 indicate that most of the fertilizer ratios reduced the magnesium content of the juice and juice solids below the corresponding values for unfertilized samples, but the changes were probably not significant except on the Lintonia silt loam, where an apparently significant increase accompanied use of sodium nitrate (table 7). The good correlation between fertilizer ratio and the magnesium content of the ash is due to the influence of the former on the total ash.

Manganese

The concentration of manganese in the juice was influenced to a greater extent by soil type than was any other constituent. Samples from the Yazoo very fine sandy loam, the Sharkey silty clay, and the Yahola very fine sandy loam contained approximately 0.0018, 0.0012, and 0.0005 percent of manganese oxide on the Brix solids basis, respectively, a concentration that was too small to permit, by the method used, of satisfactory determination of possible differences due to fertilization. Samples from the Franklin and the Lintonia silt loams were comparatively rich in manganese, averaging 0.0099 and 0.0097 percent of the solids, respectively. These two soils gave similar trends resulting from fertilization. The averaged data from these two fields indicated that fertilization with sodium nitrate decreased the manganese content of the juice and juice solids but that application of superphosphate or potassium chloride increased the concentration above the values found for juice from unfertilized sugarcane (table 6). When mixtures of these plant foods were applied to the crop, manganese concentrations in the juice appeared to be intermediate between the amounts found when the materials were used singly. Potassium chloride alone or as the principal component of mixtures appeared to decrease the manganese content of the ash; superphosphate and sodium nitrate seemed to increase it above the quantities found in the ash of juice from unfertilized sugarcane, within the limits of significance of the data.

Manganese doubtless occurs in too small concentration to have much effect in sugar-house operations, but it has been shown to be one of the essential nutritional elements of sugarcane (*23*). Little work has been done on the value of manganese added to Louisiana soils, and no symptoms of manganese deficiency have been described in published reports. However, as the data show that the manganese absorbed in the juice varies widely among the different soil types, it might be desirable to determine if improvement in crop yield or juice quality would result from its use as a fertilizer amendment, particularly on those soil types indicated as having only small amounts available. It has been reported (*4*) that manganese has an influence on juice quality of Philippine sugarcane, and its use is recommended on certain Florida soils (*5*).

Various Forms of Nitrogen

TOTAL NITROGEN

The total nitrogen content of the sugarcane juice was increased 0.0078 percent, equivalent to 0.050 percent of the Brix solids, by fertilization with sodium nitrate at the rate of 60 pounds of nitrogen per acre, compared with corresponding values observed for unfertilized samples (table 9). These differences, although small in amount, represent an increase of more than 40 percent in the total amount of this constituent. Reduction in the amount of nitrate in the fertilizer caused a proportional reduction in the total nitrogen found, applications of 12 pounds per acre or less apparently being without measurable effect (fig. 19). Neither superphosphate nor potassium chloride alone or in mixtures significantly changed the quantity of total nitrogen found.

TABLE 9.—*Effect of fertilizer on nitrogen in crusher juice from certain varieties of sugarcane grown in Louisiana, 1931–33* [1]

JUICE BASIS

Fertilizer ratio N-P_2O_5-K_2O (300 pounds per acre)	Total nitrogen as N [2]	Protein nitrogen as N [2]	Nonprotein nitrogen as N [3]	Protein nitrogen in total N [3]	Ammonia nitrogen as N [4]	Nitrate nitrogen as N [4]
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
20-0-0	+0.0078	+0.00174	+0.00660	−8.53	+0.00008	−0.00003
16-4-0	+.0054	+.00076	+.00522	−8.74		
16-0-4	+.0061	+.00114	+.00625	−9.78		
12-8-0	+.0039	+.00085	+.00449	−7.41		
12-4-4	+.0025	+.00067	+.00308	−5.41	−.00001	+.00025
12-0-8	+.0039	+.00035	+.00320	−6.52		
8-12-0	+.0012	+.00043	+.00152	−3.06		
8-8-4	+.0008	+.00024	+.00225	−4.84		
8-4-8	+.0020	+.00053	+.00243	−3.23		
8-0-12	+.0024	+.00038	+.00315	−5.75		
4-16-0	+.0010	+.00040	+.00067	−.54		
4-12-4	+.0005	+.00013	+.00069	−1.21		
4-8-8	+.0001	+.00019	+.00070	−1.01		
4-4-12	+.0003	+.00015	+.00064	−1.13		
4-0-16	−.0010	−.00016	−.00016	−.03		
0-20-0	−.0005	+.00021	−.00020	+.98	+.00006	+.00006
0-16-4	−.0007	+.00038	+.00021	−.43		
0-12-8	+.0002	+.00034	+.00012	−.07		
0-8-12	−.0001	+.00012	+.00067	−.82		
0-4-16	−.0005	+.00026	−.00028	+1.71		
0-0-20	−.0014	+.00004	−.00074	+1.61	+.00011	+.00008
0-0-0 (check)	.0157	.01005	.00563	56.37	.00023	.00012
Differences required for significance:						
P=0.05	±.0017	±.00045	±.00189	±3.02		
P= .01	±.0022	±.00059	±.00250	±3.00		

BRIX-SOLIDS BASIS

Fertilizer ratio N-P_2O_5-K_2O (300 pounds per acre)	Total nitrogen as N [2]	Protein nitrogen as N [2]	Nonprotein nitrogen as N [3]	Protein nitrogen in total N [3]	Ammonia nitrogen as N [4]	Nitrate nitrogen as N [4]
20-0-0	+0.050	+0.0119	+0.0423		+0.0005	−0.0002
16-4-0	+.036	+.0054	+.0333			
16-0-4	+.039	+.0075	+.0393			
12-8-0	+.024	+.0055	+.0281			
12-4-4	+.017	+.0048	+.0198		−.0001	+.0016
12-0-8	+.023	+.0020	+.0203			
8-12-0	+.006	+.0020	+.0089			
8-8-4	+.007	+.0009	+.0135			
8-4-8	+.011	+.0025	+.0146			
8-0-12	+.014	+.0020	+.0194			
4-16-0	+.002	+.0015	+.0049			
4-12-4	.000	−.0004	+.0033			
4-8-8	.000	+.0003	+.0035			
4-4-12	−.001	−.0009	+.0024			
4-0-16	−.007	−.0023	−.0021			
0-20-0	−.001	+.0014	−.0012		+.0004	+.0004
0-16-4	−.003	+.0017	+.0015			
0-12-8	−.001	+.0013	+.0022			
0-8-12	−.002	−.0002	+.0032			
0-4-16	−.003	+.0010	−.0022			
0-0-20	−.008	−.0003	−.0038		+.0009	+.0005
0-0-0 (check)	.135	.0624	.0533		.0015	.0008
Difference required for significance:						
P=0.05	±.010	±.0028	±.0117			
P= .01	±.014	±.0037	±.0154			

[1] Values for fertilized plots represent differences from values for unfertilized plots (checks).
[2] Average of 12 experiments.
[3] Average of 9 experiments.
[4] Average of 3 experiments.

The direct relationship between nitrogen fertilization and total nitrogen content of the juice and juice solids applied to sugarcane harvested from each of the six soil types was studied. The effect was greatest on those soil types occurring in the western and northern part of the sugarcane district (table 10). Applications of 60 pounds of nitrogen to sugarcane grown on the Lintonia silt loam nearly doubled the total nitrogen in the juice and juice solids. Corresponding in-

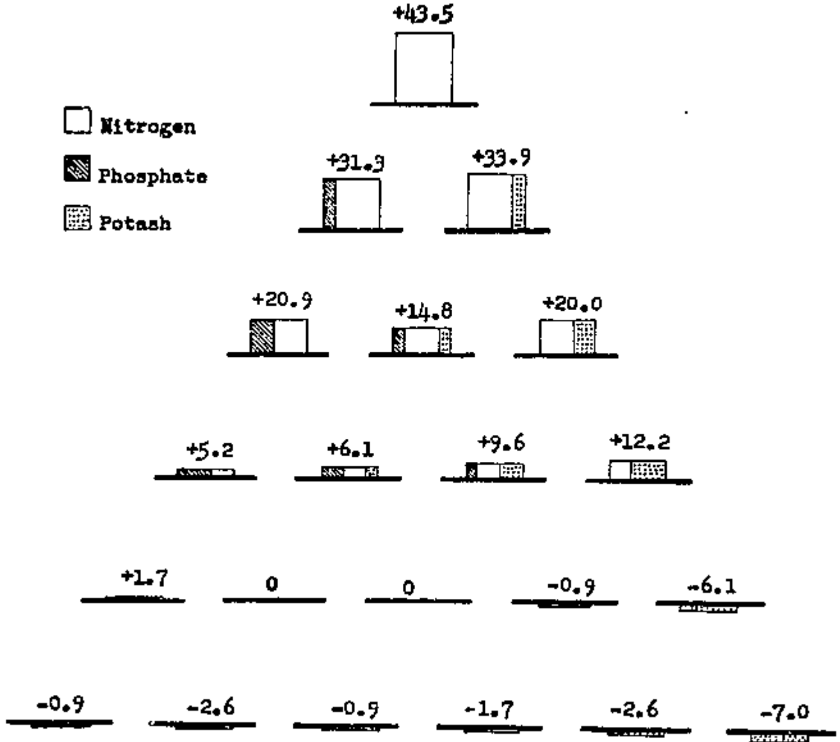

FIGURE 19.—Influence of fertilizer on nitrogen content of Brix solids in crusher juice from certain varieties of sugarcane grown in Louisiana. Differences from unfertilized samples expressed as percentage changes of constituents. Average of 12 experiments.

creases on the Yahola very fine sandy loam and the Franklin silt loam were 48 percent and 35 percent on the constituent basis, respectively. Similar applications of sodium nitrate to the Yazoo very fine sandy loam and the Sharkey silty clay, the two soil types that dominate the eastern part of the sugarcane district, increased the total nitrogen of the juice and juice solids about 23 percent and 13 percent on the constituent basis, respectively. No marked change in total nitrogen content of the juice solids accompanied the use of either superphosphate or potassium chloride on any of the soil types.

TABLE 10.—*Effect of different fertilizers on nitrogen in crusher juice from certain varieties of sugarcane grown on various soil types in Louisiana, 1931–33* [1]

Fertilizer ratio N-P_2O_5-K_2O (300 pounds per acre)	Total nitrogen as N	Protein nitrogen as N	Nonprotein nitrogen as N	Protein nitrogen in total N
LINTONIA SILT LOAM				
	Percent	*Percent*	*Percent*	*Percent*
20-0-0	+0.129	+0.0168	+0.1119	−20.0
0-20-0	−.010	−.0030	−.0074	+2.1
0-0-20	−.028	−.0096	−.0186	+5.3
0-0-0 (check)	.139	.0758	.0627	54.7
YAHOLA VERY FINE SANDY LOAM				
20-0-0	+0.065	+0.0136	+0.0539	−0.3
0-20-0	+.009	+.0010	+.0045	−.1
0-0-20	.000	+.0034	−.0038	+2.6
0-0-0 (check)	.141	.0688	.0721	48.8
YAZOO VERY FINE SANDY LOAM				
20-0-0	+0.024	+0.0108	+0.0128	−1.7
0-20-0	.000	+.0004	.0000	+.2
0-0-20	−.003	−.0022	−.0005	−.7
0-0-0 (check)	.104	.0571	.0470	54.9
FRANKLIN SILT LOAM				
20-0-0	+0.031	+0.0101	+0.0204	−7.7
0-20-0	+.004	+.0038	+.0022	.0
0-0-20	.000	+.0021	−.0020	+2.3
0-0-0 (check)	.089	.0557	.0328	62.9
SHARKEY SILTY CLAY				
20-0-0	+0.013	+0.0057	+0.0069	−0.8
0-20-0	+.000	+.0004	−.0004	+3.1
0-0-20	+.008	+.0067	+.0013	+2.3
0-0-0 (check)	.098	.0518	.0466	52.6

[1] Values for fertilized plots represent differences from values for unfertilized plots (checks), expressed on Brix-solids basis.

PROTEIN AND NONPROTEIN NITROGEN

The nitrogenous compounds present in sugarcane juice may be grouped conveniently into two classes, one of which consists of substances readily removed by usual clarification methods and the other, of substances that pass into clarified sirups. The former group doubtless contains a large number of complex materials but is probably predominantly protein in nature; the latter probably contains simpler compounds such as asparagine, aspartic acid, etc. (*17*). Although the separation of these classes by clarification procedures in the factory and precipitation methods in the laboratory is arbitrary, depending largely upon the methods used, the distinction is of value. The fraction that is easily removed in clarification obviously does not interfere in any way with manufacturing processes; in fact, it may be regarded as beneficial in that its flocculation assists in removing suspended material from the juice, and it is available in the press cake for return to the land as fertilizer. The noncoagulated portion, on the other hand, has been considered a possible source of some of the turbidity and poor color of effect sirups, and of the bad taste and rapid spoilage of edible sirups (*2*, *25*). Preliminary tests (*27*) showed that precipitation of this "protein" class by either tannic acid or alcohol gave reproducible results and that the nitrogen content of the material thus separated was roughly comparable to that precipitated by usual clarification methods. As alcohol precipitated more nitrogen than the tannic acid reagent, and thus may have precipitated part of the asparagine, the tannic acid method (*27*, *36*) was used to separate the classes, which are here referred to as protein and non-

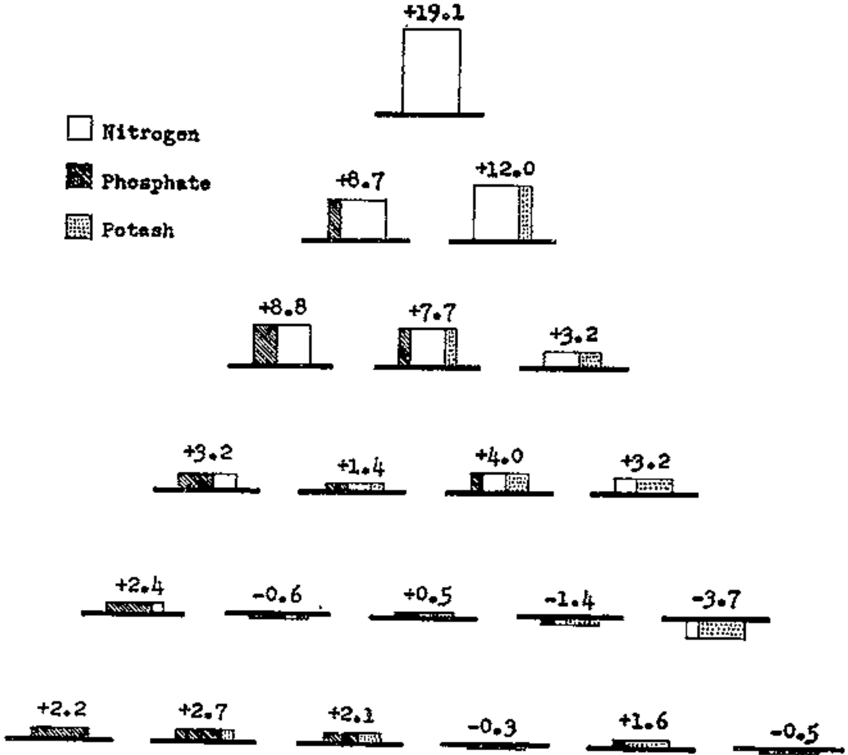

FIGURE 20.—Influence of fertilizer on protein nitrogen content of Brix solids in crusher juice from certain varieties of sugarcane grown in Louisiana. Differences from unfertilized samples expressed as percentage changes of constituents. Average of 12 experiments.

protein, respectively, until more information is available concerning their chemical nature.

Fertilization of sugarcane with sodium nitrate alone or in mixtures at the rates indicated increased the quantity of protein nitrogen in the juice. Superphosphate may tend to increase the protein nitrogen content of the juice slightly, but significant increases were not obtained in these experiments. Decreases of doubtful significance were obtained when potassium chloride was the sole or principal fertilizer used. Mixtures of nitrogen with phosphorus and potash produced sugarcane having a protein-nitrogen content in the juice that appeared to be directly proportional to the nitrogen content of the fertilizer mixture (fig. 20).

These effects applied to each of the soil types of the test fields to a greater or less extent. The three plant foods, when applied to sugarcane grown on the Sharkey silty clay and the Franklin silt loam, appeared to increase the protein nitrogen content of the juice solids above that from unfertilized cane. Nitrogen increased the protein content of the juice solids to a greater extent on the Lintonia experiments than on any other soil type. The effect was least on the Sharkey silty clay. Both superphosphate and potash decreased the protein nitrogen in the Lintonia experiments, and the latter plant food caused

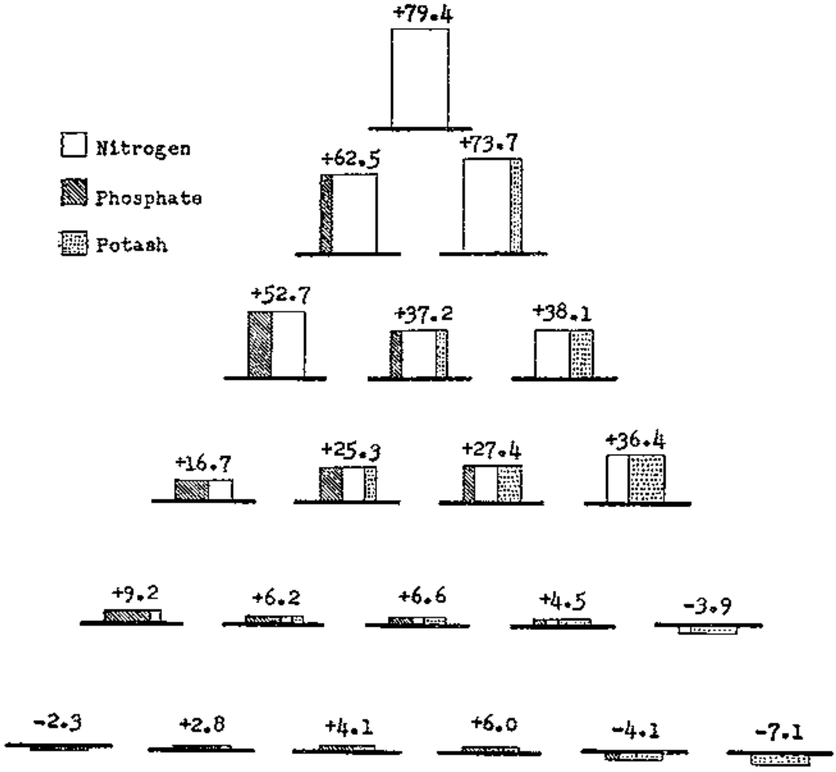

FIGURE 21.—Influence of fertilizer on nonprotein nitrogen content of Brix solids in crusher juice from certain varieties of sugarcane grown in Louisiana. Differences from unfertilized samples expressed as percentage changes of constituents. Average of 10 experiments.

a decrease in protein nitrogen in the Yazoo experiments but either caused no significant change or slightly increased this constituent on the other soil types.

The general effect of fertilizer on the "nonprotein" fraction was similar to the effects noted above for the protein fraction, as shown in figure 21, but the changes were not identical in magnitude in the two classes of substances. The use of nitrogenous fertilizer increased the proportion of nonprotein to protein nitrogen, compared with the ratio observed for juices from unfertilized sugarcane, whereas changes associated with the use of either superphosphate or potash were of insignificant magnitude. In mixtures of two or three plant foods, the decrease in proportion of protein nitrogen was apparently dependent only on the nitrogen content of the mixture. These effects were marked in the case of sugarcane from soils of the western part of the district and of doubtful significance in samples from the eastern test fields.

AMMONIA AND NITRATE NITROGEN

During the course of these investigations, an attempt was made to determine whether an appreciable part of the nitrogen in the sugarcane juice was in the inorganic form, either as nitrate or as ammonium salts. For this purpose, a modification of a method described by Sessions (*58*, *59*) was used. The modification consisted of adjusting a 100-gm. portion of standard raw juice to slight alkalinity with sodium carbonate and aspirating at room temperature overnight or until no more ammonia was given off, followed by the addition of Devarda's alloy to the liquid and a second similar aspiration. Because there is a possibility that the analytical procedure may have liberated ammonia from acid amide or other relatively unstable groups, the values obtained are considered as maximum values for ammonia and nitrate concentration in the juice, and the real concentration may actually have been smaller. The ammonia nitrogen recovered averaged 0.0028 percent of the juice, or less than 2 percent of the total nitrogen, and the nitrate nitrogen found was approximately half as great, or about 1 percent of the total nitrogen in the juice. Although analyses were made on juices obtained from sugarcane receiving different plant foods, the data obtained (table 9) did not show that fertilization at the rates used influenced the concentration of ammonia and nitrate nitrogen in the juices.

EFFECT OF RATE OF APPLICATION OF FERTILIZERS

It was shown in the preceding section that the composition of crusher juice was changed by various fertilizer mixtures, each containing a total of 60 pounds of plant food per acre. Data were obtained in an experiment near Lafayette, La., with P. O. J. 36 second-ratoon (stubble) sugarcane on the Lintonia silt loam and with Co. 281 plant sugarcane from the Yazoo very fine sandy loam at Cinclare, La., to determine how much different quantities of the same fertilizer would change the composition of the juice. The fertilizers were prepared from sodium nitrate, superphosphate, and potassium chloride, in the 20–0–0, 12–8–0, 12–4–4, 12–0–8, 4–12–4, and 4–4–12 ratios, as in the triangle experiments, and were applied at rates of 40, 80, 120, and 160 pounds of plant food per acre.

Increasing the fertilizer application from 200 to 400 pounds per acre decreased the Brix solids, apparent sucrose, and apparent purity of the juice (table 11). The changes were greatest where the nitrogen content of the fertilizer was 12 percent or more. Applications of more than 400 pounds of fertilizer (80 pounds of plant food) per acre caused little or no additional decrease in these constituents. The changes were larger in the apparent sucrose than in the Brix solids, as shown by purity changes in the same direction. The relationships between rate of fertilization and the solids, sucrose, and purity were practically the same when calculated as true values by the methods

TABLE 11.—*Changes in chemical composition of sugarcane juice caused by different rates of fertilizer application, 1933*[1]

[Average of 2 experiments]

Fertilizer: Ratio N—P_2O_5—K_2O	Fertilizer: Application per acre	Brix solids	Apparent sucrose	Apparent purity	Reducing sugars	Ash	Chloride as Cl	Silica as SiO_2	Total nitrogen as N	Protein nitrogen as N	Nonprotein nitrogen as N	Protein N in total N	Ammonia nitrogen as N	Nitrate nitrogen as N	Ratio of ammonia N to nitrate N	Acidity (0.1 N alkali): Lintonia soil	Acidity (0.1 N alkali): Yazoo soil
	Pounds	*Percent*[2]	*Percent*[2]	*Percent*	*Percent*[3]	*Percent*[3]	*Percent*	*Percent*[3]	*Percent*[3]	*Percent*[3]	*Percent*[3]	*Percent*	*Percent*[3]	*Percent*[3]		*Cc.*	*Cc.*
20-0-0	200	−0.10	−0.33	−1.46	+1.98	−0.302	−0.030	−0.002	+0.107	+0.0200	+0.087	35.5	+0.0017	−0.0003	1.70	−0.19	+0.04
20-0-0	400	−.58	−1.21	−4.42	+3.54	−.480	−.038	+.008	+.114	+.0197	+.095	37.7	+.0043	+.0011	1.76	−.29	−.10
20-0-0	600	−.91	−1.26	−3.10	+3.71	−.491	−.042	+.003	+.232	+.0255	+.207	26.8	+.0079	+.0034	1.68	−.20	−.06
20-0-0	800	−.62	−1.12	−3.68	+2.80	−.334	−.040	+.006	+.295	+.0256	+.270	22.8	+.0115	+.0053	1.74	+.12	−.16
12-8-0	200	+.17	+.06	−.49	+.32	−.336	−.040	−.002	+.081	+.0195	+.062	43.7				−.28	−.04
12-8-0	400	−.60	−.95	−2.74	+2.68	−.270	−.047	−.008	+.089	+.0171	+.072	40.9					+.07
12-8-0	600	−.69	−1.21	−3.89	+2.58	−.307	−.034	+.006	+.139	+.0195	+.120	34.0				−.18	−.14
12-8-0	800	−.82	−1.38	−4.30	+3.28	−.379	−.017	+.003	+.182	+.9227	+.160	30.3				−.16	−.25
12-4-4	200	+.13	.00	−.64	+1.06	−.313	−.014	+.006	+.088	+.0080	+.080	36.8	+.0009	−.0014	2.89	−.18	.00
12-4-4	400	−.60	−1.07	−3.47	+2.35	−.206	+.014	+.011	+.090	+.0147	+.076	39.6	+.0024	−.0005	2.28	−.18	+.15
12-4-4	600	−.33	−.54	−1.59	+2.15	−.440	+.060	+.006	+.088	+.0164	−.072	40.8	+.0024	−.0006	2.41	−.38	−.18
12-4-4	800	−.55	−.98	−3.17	+1.82	−.221	+.081	.000	+.162	+.0191	+.143	31.1	+.0038	−.0010	4.23	−.02	−.37
12-0-8	200	+.13	−.02	−.76	−.10	−.261	+.018	−.017	+.048	+.0124	+.036	48.0				−.25	+.02
12-0-8	400	−.45	−.83	−2.75	+1.70	−.195	+.095	−.009	+.081	+.0180	+.063	32.0				−.26	−.09
12-0-8	600	−.55	−1.01	−3.35	+2.43	−.262	+.179	−.006	+.108	+.0179	+.061	37.9				−.27	−.34
12-0-8	800	−.53	−.92	−2.90	+2.21	−.060	+.242	−.001	+.156	+.0198	+.137	32.0				−.13	−.28
4-12-4	200	+.33	+.22	−.33	+.52	−.235	+.023	−.003	+.034	+.0057	+.029	48.0				−.25	−.06
4-12-4	400	+.10	−.15	−1.37	−.65	+.023	+.047	−.007	+.039	+.0093	+.030	48.7				−.12	+.06
4-12-4	600	+.05	+.04	−.02	+.80	−.049	+.074	−.006	+.040	+.0093	+.031	48.4				−.22	−.04
4-12-4	800	−.19	−.34	−1.08	+.69	+.163	+.133	−.001	+.023	+.0110	+.012	55.2				−.10	−.17
4-4-12	200	+.08	+.06	−.05	+.66	−.207	+.104	−.003	+.020	+.0128	+.008	57.6				−.24	−.07
4-4-12	400	−.11	−.29	−1.18	+1.32	−.109	+.184	+.003	+.023	+.0118	+.012	55.8				−.28	−.16
4-4-12	600	−.10	−.24	−.93	+.96	+.033	+.232	−.002	+.033	+.0137	+.020	53.4				−.24	−.10
4-4-12	800	+.06	−.17	−1.30	+.65	+.111	+.307	−.007	+.018	+.0120	+.036	47.7				−.09	−.37
0-0-0 (check)	0	16.96	14.21	83.79	4.61	2.938	.183	.086	.123	.0696	.053	56.6	.0017	.0023	.74	.96	1.74

[1] Values for fertilized plots represent difference from values for unfertilized plot (check).
[2] Juice basis.
[3] Brix-solids basis.

previously described (pp. 10, 12). Opposite effects were usually noted for the reducing sugars. Fertilization at 200 pounds per acre in most cases slightly increased the reducing sugars in the juice, compared with values for juice from unfertilized cane. A further increase in reducing sugars followed applications at the rate of 400 pounds per acre, but no further significant increases were associated with the 600-pound and 800-pound applications. The highest reducing-sugar values were noted where the nitrogen content of the fertilizer was greatest.

Sixty pounds of nitrogen applied as sodium nitrate was shown in the triangle experiments to decrease the ash content of sugarcane juice from the values observed for unfertilized sugarcane. The rate-of-application experiments confirmed this observation and also showed that the ash content continued to decrease under increasingly larger applications of this material, at least until applications as high as 120 pounds of nitrogen, equivalent to 600 pounds of 20-0-0 fertilizer per acre, were used. The 800-pound fertilizer application showed still further decrease at Cinclare but a large increase in ash content of the juice at Lafayette, hence no conclusions can be made with the existing data as to the final limit of the effect of sodium nitrate on the ash of Louisiana sugarcane juices in general. It is safe to conclude that any ordinary amount of nitrogen supplied to Louisiana sugarcane as sodium nitrate will decrease the ash content of the resulting juice. Increasing the quantities of either potash or phosphate, with low ratios of nitrogen, increased the ash content of the juice solids.

No information is available as to the effect of various rates of fertilization on the mineral constituents of the juice, other than silica and chlorine. The former substance was not changed significantly by the rates of fertilization used. The chloride concentration of the juice increased in proportion to the amount of potassium chloride included in the fertilizer and decreased in proportion to the amount of nitrogen used. If the quantities of nitrogen and potash shown by the ratios of table 11 are converted into pounds of each applied to the crop and the corresponding chloride contents of the sugarcane are represented graphically, the combined depressing effect of nitrogen and the augmenting effect of potash are apparent (fig. 22). If it is assumed that superphosphate was without effect, each rate of potash application established a curve of chloride concentration at a higher level, indicating a direct relationship between potassium chloride applied as fertilizer and chloride content of the resulting juice solids. At each level of potassium chloride application, increasing the amount of sodium nitrate in the fertilizer decreased the chloride content of the juice solids, and in the available comparisons the first increment of sodium nitrate decreased the chloride concentration proportionally more than the second.

The data on total, protein, and nonprotein nitrogen obtained from the rate-of-application experiments supported the results of the fertilizer-ratio experiments. Increase of these constituents was closely related to the amounts of nitrogen applied in the fertilizer, and, of the two classes of compounds, the nonprotein fraction increased more rapidly than the protein. No definite evidence was obtained to indicate that either potash or phosphate in the fertilizer had any influence in modifying the amount of nitrogen in the juice solids.

No positive evidence was obtained in the triangle experiments that fertilization with nitrogen at rates up to 60 pounds per acre changed the ammonia or nitrate-nitrogen content of the juice, but it was found that the ammonia nitrogen exceeded the nitrate nitrogen concentration. Application of larger amounts of sodium nitrate increased the concentration of these constituents in the juice. The increases were roughly proportional to the amount of nitrogen applied as a 20-0-0 fertilizer. The proportionality was less marked when a complete

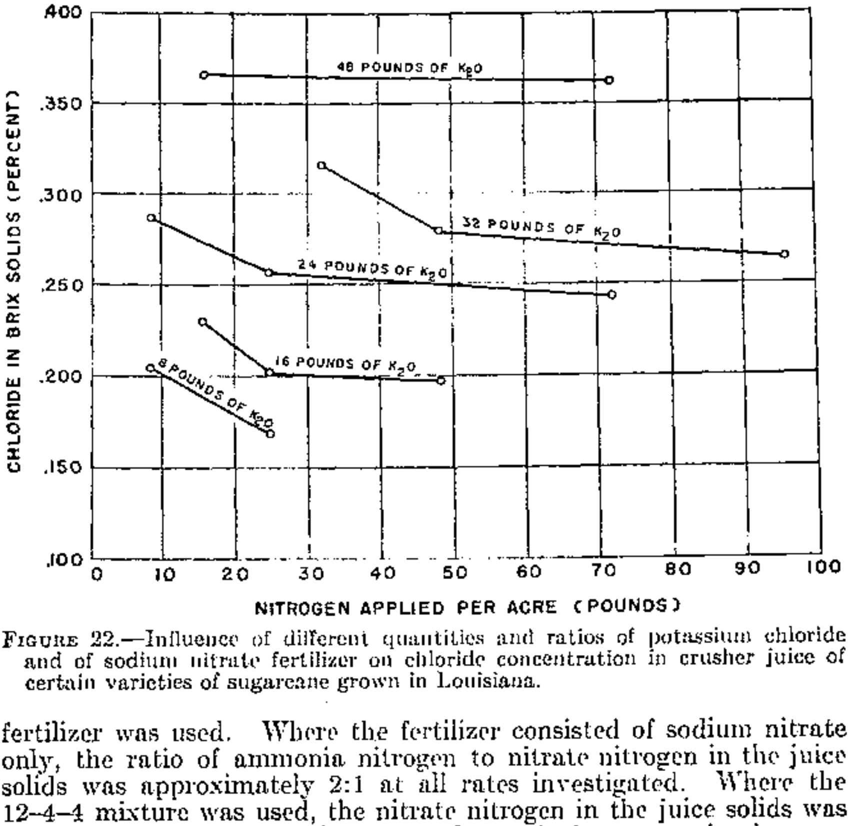

FIGURE 22.—Influence of different quantities and ratios of potassium chloride and of sodium nitrate fertilizer on chloride concentration in crusher juice of certain varieties of sugarcane grown in Louisiana.

fertilizer was used. Where the fertilizer consisted of sodium nitrate only, the ratio of ammonia nitrogen to nitrate nitrogen in the juice solids was approximately 2:1 at all rates investigated. Where the 12-4-4 mixture was used, the nitrate nitrogen in the juice solids was less than that in unfertilized samples and the ammonia nitrogen-nitrate nitrogen ratio was roughly 3:1 at the various rates of fertilization.

In all the preceding relationships, the characteristic effects noted were more marked in the experiment on the Lintonia soil than on the Yazoo soil, confirming previous observations that fertilization causes greater effects on the juice of sugarcane grown on the former soil.

Different rates of fertilization gave different trends on the titratable acidities at the two locations. The data for each location are therefore shown separately. In the Yazoo experiment, all the ratios at the rate of 600 or 800 pounds per acre decreased the juice acidity below that of unfertilized sugarcane, whereas applications of 200 or 400 pounds had no pronounced effect (table 11). The fertilized sugarcane from the experiment on the Lintonia silt loam near Lafayette had lower juice acidity than the unfertilized sugarcane, except for one sample, but the use of increasing amounts of fertilizer led to more or less irregular but generally increasing juice acidities (table 11). These differences at the two locations did not appear to be closely related to any juice constituent determined. The effect might have been due, at least in part, to relative maturity, as the Lintonia experiment was harvested comparatively early (November 6) and the Yazoo experiment a month later (December 6–7).

EFFECT OF SOURCE OF NITROGEN

Material and Methods

The agronomic experiments cited on page 1 show that nitrogen is the limiting plant food for sugarcane on all the soil types investigated and that this element must be furnished to insure a satisfactory tonnage, although use of moderate amounts of potash or phosphorus or both may increase the yield of sugar per acre on the various soil types. Some of these experiments and unpublished data by the authors [8] have shown that nitrogen may be supplied to the crop by several carriers with more or less similar results on tonnage of cane produced. In view of the general use of several different nitrogen fertilizers and the fact that they are fundamentally different types of chemical compounds, it was considered desirable to determine how the specific chemical nature of some of the more common materials affected the composition of the juice.

Replicated source-of-nitrogen plots were included with the fertilizer-ratio experiments at some of the locations in order to obtain this information. In all cases, the nitrogen was applied at the rate of 60 pounds per acre and no superphosphate or potash was used. The nitrogen carriers included ammonium sulfate, cottonseed meal, sodium nitrate, calcium cyanamide, Calnitro, which is a mixture of ammonium nitrate and calcium carbonate, and Calurea, a combined source of nitrogen which contains about 20 percent of its nitrogen in the form of calcium nitrate and 80 percent in the form of urea. All of these except cottonseed meal were compared at Mandalay plantation on Yazoo very fine sandy loam in 1931; and at Bubenzer plantation on Yahola very fine sandy loam, Sterling plantation on Franklin silt loam, Roy plantation on Lintonia silt loam, Mandalay plantation on Sharkey silty clay, Raceland plantation on Yazoo very fine sandy loam, and Mandalay plantation on Yazoo very fine sandy loam in 1932; and all except Calnitro and Calurea at Bubenzer plantation on Yahola very fine sandy loam, Albania plantation on Iberia silt loam, and Upper Ten plantation on Yazoo very fine sandy loam in 1933. In the following tables the values for the unfertilized samples and the differences caused by use of sodium nitrate, ammonium sulfate, and calcium cyanamide are averages of the entire period covered by the investigation. The values given for Calnitro, Calurea, and cottonseed meal are likewise average differences from comparable unfertilized samples, which are not shown separately. Thus, the reported differences in the case of these three materials are adjusted to make them comparable with those fertilizers which were tested for the entire period. The cultivation, harvesting, milling, and analytical methods

[8] On file in the Division of Soil Fertility Investigations.

in the source-of-nitrogen experiments were the same as were used in the fertilizer-ratio studies described above.

Total Solids, Sucrose, Purity, Nonsucrose Solids, and Reducing Sugars

The different nitrogen fertilizers caused only minor changes in the total solids of the juices analyzed (table 12). Ammonium sulfate and Calurea decreased the solids more than the other materials, of which none caused a significant change from the juice solids in the unfertilized sugarcane. Most of the data were obtained in 1932, when an unusually mature crop was harvested and the effects of fertilizer were smaller than would usually be observed. Under more nearly normal conditions, it is believed that characteristic changes would be found. The relative order was similar but not identical when the data are considered as Brix or calculated "true" solids. The change in relative position was due to the characteristic effects of the nitrogen fertilizers on the ash content of the juice.

Table 12.—*Effect of various kinds of nitrogen fertilizers on the solids, sucrose, purity, and reducing sugars in crusher juice from certain varieties of sugarcane grown in Louisiana, 1931–33* [1]

Fertilizer (60 pounds of nitrogen per acre)	Brix solids	Calculated true solids	Apparent sucrose	Calculated true sucrose	Apparent purity	Calculated true purity	Nonsucrose solids	Reducing sugar[2]		Glucose ratio[2,3]
		Percent[4]	*Percent*[4]	*Percent*[4]			*Percent*[5]	*Percent*[4]	*Percent*[6]	
Ammonium sulfate	−0.28	−0.26	−0.56	−0.53	−1.66	−1.85	+1.85	+0.181	+1.15	+1.45
Calcium cyanamide	−.10	−.13	−.30	−.28	−.46	−1.14	+1.14	+.236	+1.58	+2.03
Calnitro	−.05	+.02	−.31	−.29	−1.00	−1.99	+1.99	...	...	------
Calurea	−.31	−.24	−.46	−.45	−.74	−1.59	+1.59	...	...	------
Cottonseed meal	+.08	+.12	+.15	+.13	+.63	+.20	−.20	+.118	+.70	+.83
Sodium nitrate	+.03	+.10	−.12	−.11	−.18	−1.32	+1.32	+.158	+.98	+1.22
Unfertilized (check)	15.76	15.21	13.09	13.30	82.56	87.26	12.74	.802	5.09	6.51
Difference required for significance (10 experiments):										
P=0.05	±.20	±.21	±.25	±.28	±.94	±.92	±.92	±.119	±.84	±1.07
P= .01	±.27	±.29	±.38	±.38	±1.27	±1.24	±1.24	±.167	±1.18	±1.50

[1] Values for fertilized plots represent differences from values for unfertilized plot (check).
[2] Average of 4 experiments in 1933.
[3] Grams reducing sugars per 100 gm. of calculated "true" sucrose.
[4] Juice basis.
[5] Calculated true-solids basis.
[6] Brix-solids basis.

The different nitrogen fertilizers had a greater effect on the sucrose than on the total solids. Ammonium sulfate and Calurea decreased the sucrose below the values for unfertilized samples. Equivalent applications of Calnitro and calcium cyanamide depressed the sucrose content to a less and hardly significant extent; nitrate of soda and cottonseed meal appeared to have no significant effect. The changes were similar when considered either as apparent sucrose or calculated "true" sucrose.

The inorganic-nitrogen fertilizers decreased the purity and increased the nonsucrose solids on all the soil types except the Franklin silt loams. The changes were small and probably not significant on the Sharkey silty clay. The effect was greater on the calculated true purity than on the apparent purity, and different in order; Calnitro caused the greatest decrease in the average calculated true purity and the greatest increase in nonsucrose solids, followed in order by ammonium sulfate, sodium nitrate, and calcium cyanamide. Cottonseed meal did not change the purity or concentration of nonsucrose solids in the samples analyzed. The decrease in purity compared with that of unfertilized samples was greater following use of any of the inorganic nitrogen fertilizers than the differences caused by the use of any one compared with the others.

REDUCING SUGARS

Reducing sugars appeared to be increased by the various nitrogen carriers used, whether considered on the juice or the solids basis. Nitrogen supplied by cottonseed meal caused the smallest increase in the reducing sugars. The effects were successively greater when sodium nitrate, ammonium sulfate, and calcium cyanamide were used. The relationships between sucrose and glucose, as expressed by the glucose ratio, are changed in the same manner by use of the indicated fertilizer materials. Sugarcane that received no fertilizer had the smallest glucose ratio in the juice, which was successively increased by cottonseed meal, sodium nitrate, ammonium sulfate, and calcium cyanamide.

ACIDITY AND HYDROGEN-ION CONCENTRATION

The juice from unfertilized sugarcane had definitely greater titratable acidity than that from comparable sugarcane fertilized with any of the nitrogen carriers studied (table 13). Ammonium sulfate produced sugarcane with lowest titratable acidity in the juice, the other materials forming an ascending series in the following order: Calurea, Calnitro, sodium nitrate, cottonseed meal, and calcium cyanamide. The hydrogen-ion concentration was not proportional to the titratable acidity, indicating a considerable variation in buffer capacity caused by the various fertilizers, probably due to the influence of the fertilizer on the kind and amount of the various salts and other substances present in the juice. The juice from the unfertilized sugarcane had the lowest pH value, or greatest effective acidity, and that from a crop fertilized with calcium cyanamide the highest pH value, or least effective acidity. These differences between fertilized and unfertilized samples, although small, appear to be statistically significant. No significant difference in pH value was observed in comparing the fertilized samples among themselves.

The apparently significant differences in the character of juice acidity resulting from nitrogen fertilization with different materials might, on further study, be found to have an influence on the liming of the juice. Titration curves are not available to show whether the buffering action is uniform in the various samples, but such information would be of value in determining whether over- or under-limed sirups, as determined by pH value, would occur when the juice was limed in accordance with titration data without regard for the variable buffering of the juice resulting from use of different fertilizers.

TABLE 13.—*Effect of various kinds of nitrogen fertilizers on acidity, pH value, and ash in crusher juice from certain varieties of sugarcane grown in Louisiana, 1931–33*

Fertilizer (60 pounds of nitrogen per acre)	Total acidity [1 2 3]	Hydrogen-ion concentration [2 3] $\times 10^{-6}$	Effective acidity
	Milliliters [4]		*pH*
Ammonium sulfate	−0.20	−0.38	5.51
Calcium cyanamide	−.06	−.44	5.52
Calnitro	−.15	−.36	5.51
Calurea	−.17	−.38	5.51
Cottonseed meal	−.07		
Sodium nitrate	−.10	−.35	5.50
Unfertilized check	1.42	3.49	5.46
Difference required for significance:			
P=0.05	±.06	±.26	
P= .01	±.08	±.38	

[1] Titrated to pH 7.0.
[2] Average of 6 experiments.
[3] Values for fertilized plots represent differences from values for unfertilized plot (check).
[4] Expressed as milliliters of 0.1 N sodium hydroxide (NaOH) per 10 ml. of juice.

ASH

It was shown in the fertilizer-ratio experiments that sodium nitrate decreased the ash content in proportion to the amount used on all but one of the soil types studied. This effect is shown in table 14 to apply to all the nitrogen carriers studied, but the extent of the decrease was influenced by the chemical nature of the fertilizer used. Considered on a Brix-solids basis, Calnitro decreased the ash content of the juice more than any of the other materials. Sodium nitrate and Calurea were almost as effective. The decrease when ammonium sulphate was used was not highly significant. Because of the effect of these materials on the solids content of the juice, the relationships are somewhat altered when the data are considered on the juice basis. Calnitro and Calurea reduced the ash content of the juice somewhat more than sodium nitrate. The reduction following use of cottonseed meal was more apparent when considered on the juice rather than on the solids basis. Sugarcane fertilized with ammonium sulfate had more ash in the juice than was observed from samples fertilized with any of the other nitrogen sources. Although the available data are hardly conclusive, it appeared that ammonium sulfate was about equal to sodium nitrate in reducing the ash content of the juice on the Lintonia and Franklin soils of the western part of the Louisiana sugarcane district, but its use on the Yazoo and Sharkey soils in the eastern part of the district led to a somewhat higher ash content than was observed for samples from unfertilized sugarcane. These relationships are indicated in table 15. As the ash content of the juice has an important effect on sugar recoveries, the interrelationship between soil, fertilizer, and this aspect of juice quality should not be ignored when developing a fertilizer program for sugarcane.

TABLE 14.—*Effect of various kinds of nitrogen fertilizers on composition of ash of crusher juice from certain varieties of sugarcane grown in Louisiana, 1932–33* [1]

Fertilizer (60 pounds of nitrogen per acre)	Ash	Silica as SiO_2	Phosphate as P_2O_5	Sulfate as SO_4	Chloride as Cl	Potassium as K_2O	Calcium as CaO	Magnesium as MgO	Manganese as MnO
JUICE BASIS									
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Ammonium sulfate	−0.017	−0.0001	−0.0202	+0.0213	−0.0077	−0.021	+0.0043	+0.0042	−0.00005
Calcium cyanamide	−.048	−.0002	−.0103	−.0159	−.0062	−.020	+.0017	−.0021	−.00010
Calnitro	−.060	+.0005	−.0142	−.0205	−.0033	−.026	+.0017	−.0011	−.00004
Calurea	−.060	+.0006	−.0158	−.0210	−.0050	−.030	+.0013	−.0013	−.00008
Cottonseed meal	−.038	−.0003		------	−.0057	------	------	------	------
Sodium nitrate	−.053	−.0005	−.0009	−.0211	+.0070	−.021	+.0016	−.0003	−.00010
Unfertilized check	.433	.0141	.0713	.0405	.0335	.204	.0151	.0277	.00079
Difference required for significance:									
P=0.05	±.020	±.0007	±.0024	±.0095	±.0041	±.016	±.0013	±.0021	±.00009
P= .01	±.028	±.0009	±.0033	±.0128	±.0058	±.022	±.0017	±.0028	±.00012
BRIX-SOLIDS BASIS									
Ammonium sulfate	−0.06	−0.0007	−0.110	+0.143	−0.040	−0.11	+0.030	+0.031	−0.0003
Calcium cyanamide	−.28	+.0002	−.061	−.097	−.037	−.12	+.011	−.012	−.0005
Calnitro	−.37	+.0030	−.088	−.128	−.020	−.18	+.011	−.006	−.0002
Calurea	−.33	+.0057	−.092	−.134	−.028	−.18	+.010	−.005	−.0004
Cottonseed meal	−.26	−.0020			−.038	------	------	------	------
Sodium nitrate	−.31	−.0031	−.063	−.132	+.026	−.14	+.010	−.002	−.0008
Unfertilized check	2.73	.0503	.448	.291	.215	1.29	.097	.174	.0049
Difference required for significance:									
P=0.05	±.13	±.0045	±.015	±.060	±.025	±.10	±.008	±.013	±.0006
P= .01	±.18	±.0061	±.021	±.081	±.036	±.14	±.011	±.018	±.0008
ASH BASIS									
Ammonium sulfate	------	+0.20	−3.80	+7.31	−1.70	−1.80	+1.71	+2.26	+0.04
Calcium cyanamide	------	+.47	−.11	−3.05	−.98	+1.48	+1.00	+.45	+.01
Calnitro	------	+.76	−1.05	−3.85	−.26	−.18	+1.14	+.90	+.03
Calurea	------	+.81	−1.44	−4.15	−.69	−.79	+1.05	+.84	+.01
Cottonseed meal	------	+.70	------	------	−.15	------	------	------	------
Sodium nitrate	------	+.44	−.05	−4.42	+.00	+1.43	+1.05	+1.19	+.02
Unfertilized check	------	3.36	17.00	11.38	7.62	49.87	3.98	6.95	.21
Difference required for significance:									
P=0.05	------	±.22	±.98	±1.99	±.86	±2.78	±.58	±.92	±.03
P= .01	------	±.30	±1.32	±2.66	±1.22	±3.75	±.78	±1.23	±.04

[1] Values for fertilized plots represent differences from values for unfertilized plots (checks).

TABLE 15.—*Comparative effect of two nitrogen fertilizers on the carbonate ash content of juice from sugarcane grown on different soils*

Fertilizer	Ash content of juice from sugarcane grown on—		Fertilizer	Ash content of juice from sugarcane grown on—	
	Yazoo and Sharkey soils [1]	Lintonia and Franklin soils [2]		Yazoo and Sharkey soils [1]	Lintonia and Franklin soils [2]
	Percent [3]	*Percent* [3]		*Percent* [3]	*Percent* [3]
Ammonium sulfate	3.055	1.929	Unfertilized check	2.952	2.363
Sodium nitrate	2.630	1.931			

[1] Average of 6 experiments.
[2] Average of 3 experiments.
[3] Brix-solids basis.

COMPOSITION OF ASH

The data of table 14 show that the various sources of nitrogen had little, if any, effect on the silica content of the juice or juice solids. Although the table indicates a trend for the quantity of silica to be lowest in the juice from sugarcane fertilized with nitrate of soda and highest when Calurea was used, examination of the individual-plot data does not justify any definite conclusions, since in the seven experiments, four showed that juice from Calurea-fertilized sugarcane was slightly higher in silica than juice from cane fertilized with sodium nitrate and that the other three were reversed with no apparent influence of soil type. Owing to the pronounced effect of nitrogen fertilizers on the ash content, the presumably constant quantity of silica in the juice showed significant differences when computed as percentage of total minerals present. Nitrogen-fertilized sugarcane had more silica in proportion to the ash than did unfertilized sugarcane.

It was noted in the fertilizer-ratio experiments that sodium nitrate decreased the phosphate content of the juice, juice solids, and ash on all the soil types studied. Calcium cyanamide had practically the same effect, and these two materials caused the least change in phosphate of any of the nitrogen carriers studied. The effects were appreciably greater when Calurea or Calnitro were used and very much more pronounced when ammonium sulfate was used to supply nitrogen to the crop. Deficiency of phosphate is not at present an important problem in the Louisiana sugarcane district, either as a plant nutrient or as a clarification material, but the possibility of eventual phosphate depletion in juice phosphates following continued use of nitrogen fertilizers, particularly those that are acid in reaction, should be considered in fertilizer experimentation. It would be desirable to know whether long-continued use of nitrogenous fertilizer, particularly the physiologically acid forms, would lead to progressive decrease in phosphate availability, for lack of available phosphate not only decreases the tonnage of sugarcane harvested but interferes with clarification in the factory.

Large and significant decrease of sulfate was caused by Calurea, sodium nitrate, and Calnitro. The decrease caused by calcium cyanamide was highly significant, compared with values for unfertilized sugarcane, but was less than that caused by the first-named three materials. The sulfate content was significantly increased by use of ammonium sulfate. These changes apply to the data either on the juice, juice solids, or ash basis. The fact that a large increase was noted in the proportion of sulfate in the juice ash of sugarcane fertilized with ammonium sulfate indicated that this material replaced some other mineral constituent to a greater or less degree. As ammonium sulfate caused a pronounced decrease in both the chloride and phosphate of the ash, as compared with that of unfertilized sugarcane, it seems that sulfate will more or less substitute for phosphate and chloride in the juice. Substitution of sulfate for phosphate is undesirable, as sulfates are scale formers and are also detrimental to sugar recoveries, whereas phosphates are beneficial in promoting clarification. Evidence is given in table 16 that the displacement of phosphate ion by sulfate ion in fertilizer mixtures applied to Yazoo silt loam can be reversed, and therefore the unfavorable action can be controlled. In this experiment, equivalent quantities of fertilizer were applied as ammonium sulfate and as 10–10–0 ammonium phosphate containing about two parts of crude ammonium phosphate, with three parts of ammonium sulfate. The readily soluble ammonium phosphate not only decreased the absorption of sulfate to a value comparable to that of unfertilized sugarcane but apparently phosphate assimilation was better than when other nitrogen sources were used (compare table 14). The comparison shows that the composition of the juice was favorably influenced by the ammonium phosphate, it being quite similar to that of the unfertilized cane, and the yield obtained was as good as that produced by ammonium sulfate. Preliminary experiments (*27*) indicated that the sugarcane fertilized with ammonium phosphate was more easily clarified and the effect sirups were more brilliant than sirups from other samples in this field which received other fertilizer treatments.

TABLE 16.—*Comparison of effects of ammonium sulfate and ammonium phosphate on composition of juice of sugarcane grown on Yazoo silt loam, 1931*

Fertilizer	Plant food per acre	Cane per acre	Brix	Apparent sucrose	Apparent purity	Total nitrogen	Protein nitrogen	Nonprotein nitrogen
	Pounds	*Tons*	°	*Percent*	*Percent*	*Percent* [1]	*Percent* [1]	*Percent* [1]
Ammonium sulfate	80	29.77	15.17	12.23	80.62	0.191	0.092	0.099
Ammonium phosphate	80	29.67	15.57	12.91	82.92	.126	.069	.057
Do.	40	26.60	15.47	12.74	82.35	.124	.070	.054
Unfertilized	0	21.01	15.72	13.17	83.78	.112	.066	.046

Fertilizer	Plant food per acre	Total acidity	Ash	P_2O_5	SO_4	K_2O	CaO	MgO
		Ml. [2]	*Percent* [1]	*Percent* [1]	*Percent* [1]	*Percent* [1]	*Percent* [1]	*Percent* [1]
Ammonium sulfate	80	1.70	3.00	0.43	0.68	1.37	0.096	0.241
Ammonium phosphate	80	2.10	2.76	.59	.20	1.36	.040	.127
Do.	40	2.00	2.68	.59	.26	1.37	.040	.139
Unfertilized	0	2.10	2.75	.60	.29	1.40	.045	.141

[1] Brix-solids basis.
[2] Milliliters of 0.1 N sodium hydroxide (NaOH) per 10 ml. of juice.

The quantity of chloride in the juice, juice solids, and ash was reduced by all the nitrogen fertilizers except sodium nitrate (table 14). In general, the differences in chloride concentration are hardly significant when the nitrogen fertilizers other than sodium nitrate are compared among themselves. The greatest decrease was associated with the use of ammonium sulfate, particularly when the results are considered on the basis of ash composition. This indicates that the soluble sulfate of ammonium sulfate reduced the absorption of chloride by the sugarcane, and thus differed from sulfate furnished by superphosphate (cf. table 6 and fig. 12). The apparent increase in chloride concentration in the juice, juice solids, and ash caused by sodium nitrate is due to the inclusion in the average of the results of two experiments conducted on Sharkey silty clay. Fertilization with sodium nitrate decreased the chlorides on all other soil types studied, but in both years of the experiment on Sharkey silty clay its use increased the chloride concentration of the juice solids approximately 70 percent. Ammonium sulfate and calcium cyanamide on this soil type, however, decreased the chloride in the juice compared with corresponding data from the juice of unfertilized sugarcane.

The various nitrogen fertilizers definitely decreased the potash content of the juice and juice solids when compared with corresponding analyses of the juice of unfertilized sugarcane, but caused no marked difference in the potash content of the juice, juice solids, or ash when the various materials are compared with one another. The comparison of fertilized and unfertilized samples did not show significant differernces when the data were calculated on the ash basis.

The fertilizer-ratio experiments showed that the calcium content of the juice, juice solids, and juice ash was increased by sodium nitrate. The source-of-nitrogen experiments showed that Calurea, Calnitro, and calcium cyanamide were essentially equal to sodium nitrate in their influence on juice calcium. Ammonium sulfate caused a greater increase than the other nitrogen carriers in the calcium content of the juice and juice solids, but the effect was less pronounced when considered on the ash basis because of the tendency for ammonium sulfate to increase the total ash more than the other nitrogen sources used on several of the more important soil types.

Calnitro, Calurea, and sodium nitrate caused a nonsignificant decrease in the magnesium content of the juice and juice solids. Calcium cyanamide appeared to reduce the concentration of magnesium more than the other materials. All the nitrogen sources increased the magnesium content of the juice of sugarcane grown on the Lintonia silt loam. Ammonium sulfate increased the magnesium content of the juice and juice solids and was the only source of plant food studied which caused this effect on all the soil types. All the nitrogen fertilizers appeared to increase the proportion of magnesium in the juice ash because of the general effect of these substances in decreasing the ash content of the juice. Because ammonium sulfate had, on the average, less effect on the ash than the other nitrogen sources, the proportion of magnesium in the ash is smaller than would be expected from the amount present in the juice.

There was a trend toward a reduction in the amount of manganese in the juice and juice solids following use of all nitrogen sources, but significant decreases were not obtained except possibly with sodium nitrate and calcium cyanamide. Because the ash was influenced more than manganese by fertilizers, the data show a slight and doubtful increase of manganese in the mineral matter of the sugarcane juice following fertilization with the various nitrogen carriers. The effect was similar, within the limits of accuracy of the work, on each of the soil types, but the availability of manganese on the different soil types varied widely, as noted previously (p. 36) in the triangle experiments.

NITROGEN

All the nitrogen fertilizers significantly increased the total nitrogen content of the juice and juice solids on all the soil types studied compared with that found in the juice of unfertilized sugarcane (table 17). Cottonseed meal had the least effect, which would be expected in view of the well recognized lower availability of the nitrogen in this material. Calnitro, sodium nitrate, and calcium cyanamide appeared to cause a similar increase in nitrogen. Ammonium sulfate and Calurea increased the nitrogen somewhat more than the other materials, which is in agreement with the data of a number of investigators showing that ammonium salts are absorbed in preference to nitrates by young plants and by certain grasses (*34, 38, 63, 64*). Although calcium cyanamide is believed to yield urea and ammonia in the course of its decomposition in the soil and would, on that basis, be expected to yield a juice comparable to that obtained when ammonium salts were employed, it may have been changed in the soil at such a rate that the absorption of nitrogen was somewhat lower than in the case of Calurea and ammonium sulfate.

TABLE 17.—*Effect of fertilizer on nitrogen in crusher juice from certain varieties of sugarcane grown in Louisiana, 1931–33* [1]

JUICE BASIS

Fertilizer (60 pounds of nitrogen per acre)	Total nitrogen as N	Protein nitrogen as N	Non-protein nitrogen as N	Protein N in total N	Alcohol-insoluble nitrogen as N	Alcohol-insoluble N not precipitated by tannic acid	Ammonia nitrogen as N	Nitrate nitrogen as N
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Ammonium sulfate	+0.0058	+0.00155	+0.00307	−6.18	+0.00161	+0.00038	+0.00012	+0.00008
Calcium cyanamide	+.0044	+.00124	+.00298	−4.65	+.00231	+.00011	+.00005	+.00003
Calnitro	+.0047	+.00122	+.00283	−3.03	+.00116	−.00006		
Calurea	+.0057	+.00138	+.00394	−5.24	+.00148	−.00009	--------	--------
Cottonseed meal	+.0013	+.00036	+.00096	−3.74	--------	--------	--------	--------
Sodium nitrate	+.0052	+.00134	+.00361	−4.36	+.00131	−.00013	+.00008	−.00003
Unfertilized check	.0174	.00969	.00784	57.26	.01128	.00153	.00023	.00012
Difference required for significance:								
P=0.05	±.0012	±.00044	±.00190	±2.68	±.00075	±.00043	±.00008	±.00009
P= .01	±.0016	±.00059	±.00257	±3.64	±.00100	±.00057	±.00012	±.00015

BRIX-SOLIDS BASIS

Fertilizer (60 pounds of nitrogen per acre)	Total nitrogen as N	Protein nitrogen as N	Non-protein nitrogen as N	Protein N in total N	Alcohol-insoluble nitrogen as N	Alcohol-insoluble N not precipitated by tannic acid	Ammonia nitrogen as N	Nitrate nitrogen as N
Ammonium sulfate	+0.030	+0.0100	+0.0244	--------	+0.0146	+0.0024	+0.0008	+0.0005
Calcium cyanamide	+.020	+.0080	+.0108	--------	+.0103	+.0007	+.0003	+.0002
Calnitro	+.031	+.0079	+.0177	--------	+.0073	−.0004		
Calurea	+.040	+.0102	+.0263	--------	+.0094	−.0006	--------	--------
Cottonseed meal	+.008	+.0019	+.0061	--------	--------	--------	--------	--------
Sodium nitrate	+.033	+.0084	+.0220	--------	+.0082	−.0008	+.0005	−.0002
Unfertilized check	.109	.0613	.0493	--------	.0700	.0095	.0015	.0008
Difference required for significance:								
P=0.05	±.007	±.0030	±.0125	--------	±.0047	±.0027	±.0005	±.0009
P= .01	±.010	±.0040	±.0170	--------	±.0063	±.0036	±.0008	±.0010

[1] Values for fertilized plots represent differences from values of unfertilized plots (checks).

The total nitrogen of the juice from sugarcane fertilized with the various nitrogen carriers was fractionated into protein and nonprotein portions by the arbitrary method of separation discussed on page 40. All the sources of nitrogen appeared to increase both the protein and nonprotein nitrogen content of the juice and juice solids. The data show a well-defined series of responses to the various materials, ranging from a slight to a pronounced increase. Cottonseed meal had only a slight tendency to increase both classes of these constituents, the increase in the protein being somewhat less than the increase in the nonprotein fraction. The increase became larger as the more readily available sources of nitrogen were used (see table 17). Ammonium sulfate caused the largest increase in protein compounds and resulted in the greatest increase in the proportion of undesirable nonprotein substances. Calurea caused the greatest increase in nonprotein compounds.

The increase in nitrogen content of the juice following fertilization with nitrogen appeared to be general for all the soil types studied, but was greatest on the soils of the western part of the district, particularly the highly acid Lintonia silt loam. There seemed to be a marked difference in the absorption of ammonia and nitrate nitrogen by sugarcane grown on the different soil types, probably because of inherent differences in soil acidity, drainage, or other factors. For example, the experiment on the acid Lintonia silt loam not only showed a lower proportion of protein in the juice resulting from fertilization but also showed that less protein nitrogen resulted from the use of sodium nitrate than from ammonium sulfate, whereas both experiments conducted on the nearly neutral Yazoo very fine sandy loam showed a higher proportion of protein and more protein nitrogen following fertilization with sodium nitrate than with ammonium sulfate (table 18).

TABLE 18.—*Effect of soil type and kind of nitrogen fertilizer on relative proportion of protein and nonprotein nitrogen in juice of sugarcane*

Fertilizer	Protein nitrogen		Fertilizer	Protein nitrogen	
	Lintonia silt loam [1]	Yazoo very fine sandy loam [2]		Lintonia silt loam [1]	Yazoo very fine sandy loam [2]
	Percent [3]	*Percent* [3]		*Percent* [3]	*Percent* [3]
Sodium nitrate	33.5	65.4	Unfertilized	49.4	62.3
Ammonium sulfate	42.9	54.9			

[1] 1 experiment. [2] Average of 2 experiments. [3] Percentage of total nitrogen.

The tannic-acid method was used to estimate the protein nitrogen present in the juice in order to avoid the possibility of including asparagine. Preliminary tests showed that addition of alcohol to the juice so that the final volume was approximately 80 percent alcohol caused the formation of a white flocculent precipitate, which was largely organic and which contained more nitrogen than the tannic-acid precipitate. Other tests showed that the filtrate from the tannic-acid precipitation yielded a precipitate containing nitrogen when made up to an 80-percent alcoholic solution, indicating either that the precipitated material was more insoluble in alcohol than was the tannic-acid compound or, more probably, that selective precipitation occurred. The precipitate was not ammonium sulfate. Several samples from the source-of-nitrogen experiments were analyzed both by the tannic-acid and the alcohol method. The results showed that the relative effect of the different nitrogen fertilizers was the same on the tannic-acid-insoluble nitrogen and the alcohol-insoluble nitrogen. In both cases, the amount of nitrogen precipitated was least in unfertilized treatments, and, within the limits of significance of the data, progressively greater following fertilization with nitrates and ammonical materials. The amount of material not precipitated by tannic acid but insoluble in alcohol was, however, affected in a different manner. Although the analytical errors involved in dealing with such small quantities of nitrogen made the data as a whole of doubtful significance, they suggest that nitrate fertilizers reduce the concentration of this unidentified material below the concentration found in the juice of unfertilized sugarcane, but that ammonium sulfate caused a significant and marked increase in the quantity of such material. As ammonia has been considered a precursor of asparagine in plants (*51, p. 58*) the foregoing tests indirectly indicate that ammonium-sulfate fertilizer may cause a pronounced increase in the asparagine content of sugarcane juice.

It was shown previously that the inorganic forms of nitrogen represented only a small portion of the total nitrogen present in the juice when moderate quantities of sodium nitrate were used (table 9), but that large applications of this fertilizer increased both the ammonia and nitrate nitrogen concentration (table 11). Experimental data from three fields harvested in the fall of 1933 showed that the other nitrogen fertilizers did not add any considerable quantity of either constituent to the juice. Ammonium sulfate increased the ammonia concentration slightly compared with that in samples from unfertilized sugarcane and possibly increased it more than either calcium cyanamide or sodium nitrate.

SUMMARY

Sugarcane used in these experiments was grown on and harvested from replicated plots in experiments located on several of the principal soil types of the Louisiana sugarcane district during the 1931, 1932, and 1933 harvest seasons. The cultivation and harvesting operations were similar to local commercial practices. Representative samples of millable cane from each plot were crushed in a hydraulically equipped mill. The crusher juice thus obtained was closely comparable with that obtained by the double crusher and first mill of a commercial factory. Samples of the fresh juice from the replicate plots at each location were composited and after removal of soil particles, bagacillo, and other adventitious matter by a standardized procedure the juice was analyzed for total solids, sucrose, purity, reducing sugars, acidity, pH value, carbonate ash, silica, phosphate, sulfate, chloride, potassium, sodium, calcium, magnesium, manganese, total nitrogen, protein nitrogen, and ammonia and nitrate nitrogen to determine the influence of fertilizer on these components.

The fertilizer managements may be conveniently grouped into 3 classes: (1) Fertilizer-ratio studies according to the triangle system, in which sodium nitrate, superphosphate, and potassium chloride were used singly and in 18 different mixtures each equivalent to an application of 60 pounds of total plant food per acre; (2) rate of application studies, in which 6 representative ratios of fertilizer were applied at rates of 200, 400, 600, and 800 pounds, equivalent to 40, 80, 120, and 160 pounds of total available plant food per acre; and (3) source of nitrogen studies, in which equivalent applications of ammonium sulfate, calcium cyanamide, Calnitro, Calurea, cottonseed meal, and sodium nitrate were compared. Unfertilized plots at each location served as a basis of comparison.

Compared with analyses of juice from unfertilized sugarcane, fertilization with sodium nitrate generally caused a decrease in the total solids, sucrose, purity, acidity, pH value, ash, phosphate, sulfate, chloride, potash, sodium, and probably the manganese content of the juice and juice solids and an increase in the nonsucrose solids, reducing sugars, calcium, total nitrogen, protein nitrogen, nonprotein nitrogen, and proportion of nonprotein nitrogen (table 19). No measurable effect was noted on the silica, ammonia, or nitrate nitrogen content of the juice. The effect on the magnesium content of the juice and juice solids was uncertain. Sodium nitrate decreased the sulfate, chloride, sodium, and probably the phosphate content of the carbonate ash of the crusher juice, and increased the calcium, magnesium, silica, and probably the manganese.

Fertilization with superphosphate increased the ash content of the juice and juice solids, apparently by causing a large increase in the sulfate concentration. This material also increased the potash content of juice slightly and probably increased the manganese. It did not significantly change the total solids, sucrose, purity, nonsucrose solids, reducing sugars, total nitrogen, protein nitrogen, pH value, silica, phosphate, or chloride, but decreased the acidity, and possibly the calcium and magnesium content of the juice and juice solids of the samples analyzed. It increased the sulfate, caused no change in the silica and chloride, decreased the phosphate, potash, sodium, and calcium, and appeared to decrease the magnesium content of the ash.

TABLE 19.—*Summary of data on effect of fertilization on composition of crusher juice from certain varieties of sugarcane grown in Louisiana, in comparison with that from unfertilized sugarcane* [1]

BRIX-SOLIDS OR JUICE BASIS

Fertilizer	Total solids [2]	Sucrose [2]	Purity	Nonsucrose solids	Reducing sugars	Total nitrogen	Protein nitrogen	Nonprotein nitrogen	Acidity	pH
Nitrogen	−	−	−	+	++	++	++	++	−	−
Phosphoric acid	0	0	0	0	0	0	0	0	−	0
Potash	+	+	+	−	− −	0	0	0	−	+
	Ash	SiO_2	P_2O_5	SO_4	Cl	K_2O	Na_2O	CaO	MgO	MnO
Nitrogen	−	0	−	− −	0	−	− −	+	+?	−
Phosphoric acid	+	0	0	++	0	+?	− −	−?	−?	+
Potash	+	0	+	0	++	++	− −	−?	0?	+

ASH BASIS

Fertilizer	SiO_2	P_2O_5	SO_4	Cl	K_2O	Na_2O	CaO	MgO	MnO
Nitrogen	+	−?	− −	0	?	− −	++	+	+?
Phosphoric acid	0	−	+	0	−	− −	−	−?	?
Potash	−	−	0	++	++	− −	−	−	?

[1] Changes in composition of juice as effects of fertilization are indicated as follows: ++, marked increase; +, increase; ?, doubtful; 0, no effect; −, decrease; − −, marked decrease.
[2] Maximum value observed in complete mixture high in potash and low in nitrogen and phosphoric acid.

Application of potassium chloride as fertilizer increased the total solids, sucrose, purity, pH value, ash, chloride, potash, and manganese in the juice and juice solids, and the chloride and potash content of the juice ash compared with the amounts present in similar but unfertilized samples. This fertilizer did not influence the total nitrogen, protein nitrogen, nonprotein nitrogen, silica, or sulfate content of the juice and juice solids, nor the sulfate content of the ash. It decreased the nonsucrose solids, reducing sugars, acidity, sodium, and possibly the magnesium content of the juice and juice solids, also the proportion of silica, phosphate, sodium, calcium, and magnesium in the ash. The effect on the manganese content of the ash was indefinite.

The magnitude of the above effects was generally directly related to the quantity of each of the plant foods used. This was especially true of the organic-nitrogen fractions, total nitrogen, phosphate, and potash in the juice where apparently only one fertilizer component caused the effect. In cases where two or more plant foods exerted each a definite effect on a constituent, the resultant effect of their use in mixtures was a summation of the two separate effects and was related to the concentration of each in the mixtures; for example, the sulfate, chloride, reducing sugar, and ash relationships. The available data indicate that potash is the plant food most closely associated with increase in sucrose content, but that the maximum increase occurred when it was supplemented with a small quantity of both nitrogen and phosphate. As sucrose is the principal solid substance in sugarcane juice, the above effect was also reflected in the total solids data but not in the juice purity.

Application of large quantities of fertilizer appeared to accentuate any specific influences observed when smaller quantities were used, but the changes were asymptotic rather than proportional to the increased rate of application. Very large amounts of nitrogen not only greatly increased the total nitrogen content but also increased the ratio of nonprotein to protein nitrogen and the ammonia and nitrate nitrogen in the juice. In no case, however, were these inorganic forms of nitrogen present in such quantity that they would have measurable effect on sugar-house operations.

Comparisons of several common nitrogen fertilizers showed that all act in the same manner but to a different degree with respect to their influence on certain juice components but have specific action on other components (table 20). Ammonium sulfate decreased the acidity, phosphate, and chloride of the juice and juice solids, the proportion of phosphate, chloride, and possibly potash in the ash, and seemed to reduce the total solids and sucrose of the juice more than any of the other nitrogen fertilizers investigated. It decreased the ash content of the juice in a manner comparable with the other nitrogen fertilizers when used in the western part of the Louisiana sugarcane district but apparently increased the ash content in the eastern experiments. It caused the greatest increase in calcium and protein nitrogen, particularly the alcohol-insoluble "protein," and was the only nitrogen fertilizer that caused a general increase in the sulfate and magnesium content of the juice and juice solids above that in samples from unfertilized sugarcane. Ammonium sulfate was the only nitrogenous material that increased the proportion of sulfate in the ash. It increased the proportion of calcium and magnesium and reduced the proportion of silica in the ash more than the other materials.

TABLE 20.—*Effect of various kinds of nitrogen fertilizers on chemical composition of crusher juice from certain varieties of sugarcane grown in Louisiana, in comparison with that from unfertilized sugarcane* [1]

BRIX-SOLIDS OR JUICE BASIS

Fertilizer	Total solids	Sucrose	Purity	Nonsucrose solids	Reducing sugars	Total nitrogen	Protein nitrogen	Nonprotein nitrogen	Ammonium nitrogen	Nitrate nitrogen
Ammonium sulfate	−	−−	−−	++	++	++$_a$	++	+	+	0
Calcium cyanamide	−	−	−	+	++	++$_b$	++	+	+?	0
Calnitro	−	−	−−	++		++$_b$	++	+		
Calurea	−	−−	−−	++		++$_a$	++	+		
Cottonseed meal	?	?	?	?	+	+	+	+		
Sodium nitrate	−?	−	−−	++	+	++$_b$	++	+	+?	0

Fertilizer	Acidity	pH	Ash	SiO_2	P_2O_5	SO_3	Cl	K_2O	CaO	MgO	MnO
Ammonium sulfate	−−$_a$	−−	−?	0	−−$_a$	++	−	−	+	+	−
Calcium cyanamide	−−$_b$	−−	−−	0	−−$_c$	−−	−	−	+	−	−
Calnitro	−−$_a$	−	−	+?	−−$_b$	−−	−	−	+	?	−
Calurea	−−$_b$	−−	−	+?	−−$_b$	−−	−	−	+	?	−
Cottonseed meal			−	−?			−				
Sodium nitrate	−−$_c$	−	−−	−?	−−$_c$	−−	[2] −	−	+	?	−

ASH BASIS

Fertilizer	SiO_2	P_2O_5	SO_3	Cl	K_2O	CaO	MgO	MnO
Ammonium sulfate	+	−−	++	−−	−?	++	++	+
Calcium cyanamide	++$_b$	0	−−	−	+?	+	+	+?
Calnitro	++$_a$	−	−−	−?	−?	+	+	+?
Calurea	++$_a$	−	−−	−	−?	+	+	+?
Cottonseed meal	++$_a$			−				
Sodium nitrate	++$_b$	0	−−	[2] −	+?	+	+	+?

[1] Changes in composition of juice as effects of fertilization are indicated as follows: ++, marked increase; +, increase; ?, doubtful; 0, no effect; −, decrease; −−, marked decrease; subscripts $_a$, $_b$, $_c$ indicate materials acting similarly, $_a$ being the group causing the greatest change, $_b$ the next in magnitude of effect, and $_c$ the least.

[2] See text, p. 53.

The action of Calurea was similar in many ways to that of ammonium sulfate, being essentially equal or second to the latter in its effects on the total solids, sucrose, purity, nonsucrose solids, total nitrogen, protein nitrogen, percent of protein nitrogen in the total nitrogen, pH value, and ash.

Calnitro, sodium nitrate, and calcium cyanamide were not extreme in their effects, except that the two first-named caused the greatest decrease in the ash content and smallest decrease in the phosphate content of the juice and juice solids. The former decreased the phosphate content of the ash in a manner comparable to Calurea; the latter caused a somewhat higher reducing-sugar content than the other materials except ammonium sulfate and the lowest content of magnesium in the ash.

Cottonseed meal had the least influence on juice composition of any of the nitrogen fertilizers studied. It differed from the other nitrogen carriers in apparently causing no change in total solids, sucrose, purity, and nonsucrose solids, and comparatively little increase in reducing sugars and the various organic nitrogen fractions.

Ammonium phosphate increased the yield of cane without apparently causing much change in the composition of the juice compared with that of unfertilized samples.

The specific effects of fertilizer ratio, rate of application, and source of nitrogen varied among the different soil types. In general, fertilization caused a greater change in the composition of the juice on the soils of the western than of the eastern part of the Louisiana sugarcane district. The effects were pronounced on the Lintonia silt loam and definite on the Yahola very fine sandy loam, Iberia silt loam, and Yazoo very fine sandy loam. The general effects of fertilizer on the Franklin silt loam were in qualitative agreement with the general trends except that sodium nitrate appeared to have little if any influence in decreasing the total solids and sucrose, and it decreased the calcium content of the juice and increased the proportion of potash in the ash. The effects of fertilization were generally least on the Sharkey silty clay and were exceptional in that the influence of nitrogen on sucrose, purity, and ash was doubtful; sodium nitrate appeared to increase the amount of chlorides present, and all fertilizers increased the proportion of protein nitrogen in the juice compared with values observed for unfertilized samples.

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