Bulletin 183 May, 1912

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

Deterioration in the Quality of Sugar Beets Due to Nitrates Formed in the Soil

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PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1912

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THE STATE BOARD OF AGRICULTURE

DETERIORATION IN QUALITY OF BEETS DUE TO NITRATES

By WM. P. HEADDEN

We have, heretofore, considered only extreme instances of the occurrence of nitrates in some of our Colorado soils, namely, in Bulletins 155, 160 and 178. The statements of these Bulletins were scarcely believable by persons who may not themselves have seen the facts, and the number of persons who have seen them is, even now, comparatively small. The difficulty in believing the facts set forth in these bulletins lay partly, in the newness of the measure in which the nitrates occur, partly in the general doubt of the sufficiency of the agency to which their formation was attributed, but still more largely to the fixedness of conviction that these things, if they were possible, would certainly have been observed before, especially as students of soil chemistry have been diligent in their investigations of kindred subjects, if not of this.

The conditions under which the investigations, pertaining to the presence and formation of nitrates in the soil, have already been made are openly or tacitly assumed to have been so general that the conclusions arrived at are accepted as of universal application and the occurrence of large territories to which the established conclusions are only partially applicable is deemed by many very improbable. I was keenly alive to this incredulity on the part of scientific men who, because of their persistent efforts to find out the facts, hold tenaciously to such views as their observations have led them to accept as embracing the whole case. The views of men who have done the work and made their records for our benefit are most surely worthy of consideration and respect, which we most willingly accord them, but there may be other conditions and other facts than those on which they based their deductions, and their conclusions may not be of such universal application as we, for no other reason than because of our confidence in the cumulative authority of the *dicta* of various investigators, believe. I have no sympathy whatever with captious objections to honest results obtained by worthy men or caviling at established facts in order to give the caviller the air of an investigator by belittling and trying to make the results of others appear to be of no import.

In presenting the following facts which many, perhaps, will consider as even more groundless and more contradictory to general experience than the statements of the bulletins referred to, i. e., 155, 160 and 178, I accept fully all of the statements of results obtained by others as the result of experiment or of facts established by research under the conditions obtaining in those cases.

The task which I have set myself, to study the effects of nitrates upon the quality of our sugar beets, is a more difficult one than any which I have, heretofore, attempted. The subject itself, the quality of sugar beets, is not so definitely fixed as to remove it from serious discussion. We have no definite quality which is fixed. The best that we can do will be to adopt a standard for comparison and abide by it throughout. The factors influencing these qualities and the manner and extent to which they modify one another are so good as wholly unknown.

The German and French chemists have studied the composition of the beet, the questions pertaining to its culture and nutrition, the effect of fertilizers, etc., upon its sugar content and factory qualities, till they know with a high degree of accuracy what these effects are under their conditions, but their results cannot be safely accepted as necessarily holding under our Colorado conditions. If, however, we seek information on these subjects we are compelled to avail ourselves of German or at least of foreign data. So far as I am aware no serious study of the chemical composition of the sugar beet, beyond the determination of its sugar and ash content, the ordinary fodder analysis of the root and leaves and the determination and composition of the ashes had been undertaken in this country till within the past two years.

The composition of the sugar beet, in the sense just stated, i. e., its percentage of sugar, its composition as indicated by the ordinary fodder analysis and the composition of the ash, was studied by this Station for several years to determine these data for the beet as it grows under our Colorado conditions, including as great a variety of soils as was at that time feasible.

Among the factors which distinguish our problems, from those of Germany for instance, is the presence of large amounts of soluble salts in the soil. Such definite data as I have been able to find indicate that the water-soluble in ordinary arable soils varies from a few thousandths to approximately four-tenths of one percent, while our soils often carry from one to one and one-half or even two percent. The top two inches of such soils frequently carry much higher percentages, from two to eight percent or even more of water-soluble. Such conditions render our questions involved ones, making it difficult to determine the actual effect of any single factor. We constantly hear seepage and alkalization put forth as the actual causes of many of our troubles. Further, unexpected results, either good or bad, are attributed to climatic influences when no other cause seems evident.

In regard to seepage existing in many places, and that in extended areas, no one acquainted with the facts would attempt to deny. The presence of alkalis in such areas is frequent; the quantity of these salts often being very large. These conditions are evident to the average man and are both undesirable and harmful in some measure, but both of these are used to designate, in most cases, extreme conditions in respect to the amount of water and alkali present. They are further used without any definite or even approximate idea of the amount of either water or alkali which may be injurious. When crops fail in such areas, the water and the alkali are easily seen conditions to which the public has persistently attributed the failure and many other mishaps which have overtaken their crops without any question as to the actual effects of these conditions, or any regard to the possibility of there being other causes which they cannot see with their own eyes.

The questions of seepage and alkali appeal to all as serious questions, especially at first. Our soils are alkaline and so much was said about this fact, especially in the more remote past, that we all came to believe that the alkalis were much worse than we now believe them to be. Our Colorado people read of the alkali questions of California and applied all of the statements relative to the California conditions to the facts in Colorado, which was not justified. I may illustrate this by the treatment given a certain piece of land, the composition of which has been studied in considerable detail. The piece of land is rather strongly alkaline. In California they have found that the application of land plaster, ground gypsum in quantities proportioned to the amount of sodic carbonate, black alkali, present ameliorates the conditions. These parties applied land plaster in liberal quantity, perhaps as much as five tons per acre, whereas, the facts were that this land contained no sodic carbonate but was already so rich in gypsum that the mineral had crystallized out in little aggregates and veinlets, carrying many tons of it in each acre-foot of soil. Much has been said about alkali, and we are apt to apply all of the recorded evils attributed to it in accounting for troubles, the causes of which we do not more definitely know.

I began the study of this subject sixteen years or more ago, and have analyzed alkalis from very many sections of this state, likewise ground and seepage waters and also drain waters, and have further made persistent efforts to establish the amount of alkali in the soil and irrigating waters which would do damage to crops. *The limits found have been so wide that I abide by the statement made ten years ago that our alkali questions resolve themselves into questions of drainage.* Our alkali salts consisting essentially of sulfates of soda, magnesia and lime, with the chlorid and carbonate of sodium as subordinate constituents, are so mild in their action, that but little, if any, serious damage is caused by them in the quantities present, even to young plants.

EXPERIMENTS WITH BEETS ON ALKALI SOILS.

As our nitrates appear in many places at or near to the margins of alkalized areas, and further, because the poor quality of many beets is attributed to the presence of either water or alkali, or as is generally the case, to both, it will be advisable to inquire into the question of what effect these factors have upon the quality of the sugar beet. By quality we here understand the sugar content and purity because these are the factors usually considered, especially on a commercial basis. I grew beets on a piece of seeped and alkalized land for four consecutive years, using beets grown on what we were pleased to call good land for standards of comparison. This soil, sampled to a depth of ten inches, yielded from 3890 to 25500 parts of water-soluble material per million. In determining the water-soluble in these samples they were treated with water so long as the filtrate showed the presence of sulfuric acid. We were quite well aware of the fact that further treatment with water would still take a portion into solution but some point had to be taken at which to stop and we chose the point given, i. e., when the filtrate ceased to yield with baric chlorid a precipitate for sulfuric acid. This was already an extreme extent to which to carry the washing because of the presence of considerable quantities of calcic sulfate, gypsum, in the soil. We did not attempt to study the distribution except in the first and second two-inch portions of the soil. In the top two inches we found a maximum of 39300, and a minimum of 2890 parts per million; the land represented by the former sample became heavily encrusted with alkali both in summer and winter under favorable conditions of the weather. Sometimes these incrustations became as much as one-half inch thick. The salts dissolved out of the soil were essentially sulfates of calcium, magnesium, sodium and potassium. The relative quantities of these salts differed considerably without showing any definite order of distribution. The predominant salts in the aqueous extracts of the soil were the calcic and magnesic sulfates. The sodic sulfate varied from none in the second two inches of some sections up to twenty-seven percent of the water-soluble of the top two inches from other sections. The effloresced alkali consisted chiefly of sodic and magnesic sulfate, these salts forming eighty percent of the effloresced mass.

THE HIGHT OF THE WATER PLANE.

The hight of the water plane was determined daily during the second year of the experiment and weekly during the third year. There were four wells sunk in the strip of land which had a length of six hundred feet. To avoid too many details and extended explanation I will give the depth of the water plane below the surface for the months of May, June, July and August in one group, and for September, October and November in a second group. The depth of the water plane in Well A in 1897 was from 1.2 to 2.3 feet for the first period and from 2.4 to 3.3 feet for the second period;

in 1898 it was from 0.9 to 3.6 feet for the first and from 3.4 to 4.4 for the second period. In Well B in 1897 the depths were from 2.3 to 3.6 for the first and from 3.6 to 4.2 feet for the second period; in 1898 from 2.2 to 4.9 for the first and from 4.3 to 5.4 feet for the second period. In Well C in 1897 the depths were from 2.3 to 3.5 for the first and from 3.3 to 3.6 feet for the second period; in 1898 they were 1.4 to 4.3 for the first and from 3.5 to 4.7 feet for the second period. In Well D in 1897 the depths were from 2.5 to 3.6 feet for the first and from 3.6 to 4.0 feet for the second period; in 1898 they were from 2.2 to 5.8 feet for the first and from 5.4 to 6.0 feet for the second period. It will be noticed that the water plane at the end of the season of 1898 was materially lower than at any other period given but that it did not at any time fall to quite five feet below the surface during the first period, i. e., in May, June, July and August, except in Well D in 1898 and this was only for a very short period as our records show. I think that I am perfectly safe in assuming that the concensus of opinion would be that it is objectionable to have the water plane four feet or less below the surface though in the practice of sub-irrigation the water is brought to within 2.5 feet of the surface. In this ground it was only exceptionally as low as or lower than four feet. These exceptions were due to a shortage of water for irrigation and a very scanty rainfall. This land was not drained and though there were drains in some adjoining lands they were not efficient either in cutting off seepage water from flowing into or in taking the water out of this land. The average depth of the water below the surface for the two seasons mentioned would range from two and a half to three and a half feet. The surface of the ground at Well D was 3.3 feet higher than at Well A. The field had a fall of this amount, 3.3 feet in six hundred feet.

The ground water did not pass freely into the gravel below this land because of a stratum of clay lying on top of the gravel. Considerable attention was given to the composition of this ground water. Its content of dissolved salts varied greatly from time to time as its varying nearness to the surface and the richness of the soil in alkali would lead us to expect. The quantity of these salts found varied from two thousand to eight and, under conditions of continued high water, to over ten thousand parts per million. The salts held in solution were calcic, magnesic and sodic sulfate with some sodic chlorid and carbonate and almost always some potash. The nitric nitrogen was determined in a large number of samples of this ground water and was found to range from one to fourteen parts per million, mostly from two to five parts per million.

The physical condition of this soil at the beginning of our experiments was bad and while it was greatly improved by cultivation and the treatment that it received, its tilth was never good. The yield of beets ranged from eight to fifteen tons per acre.

We had in this land the following conditions: First, the presence of a large amount of the ordinary so-called alkali; second, a water-plane which varied, but which was always near the surface; third, the ground water was rich in the alkali salts, varying from two thousand to ten thousand parts per million; fourth, the physical condition of this soil was never such as one might designate as good.

This was the worst piece of land at my disposal at the time it was chosen for the purposes of our experiments. The results were, in regard to yield, from eight to fifteen tons per acre as already stated, which compared favorably with yields obtained from better lands. The beets grown on this land were compared with others of the same varieties and supposedly from the same lot of seed grown on land free from all of these objections. In this way we eliminated the questions of climatic conditions, strains of seed, etc. The plots ran lengthwise of the piece of ground and were divided into three sections for the purposes of sampling the beets. The final samples for the first season were taken October 13 and gave as averages for the three sections, Kleinwanzlebener 11.76, Vilmorin 10.94, Lion Brand 12.76, Imperial 13.65 percent sugar. Samples gathered from the farm plots on the same date gave: Kleinwanzlebener 12.32 and Vilmorin 13.02 percent sugar. In 1898 the beets grown on this bad ground gave, Kleinwanzlebener 15.2, Vilimorin 15.4, Lion Brand 14.82, Imperial 14.35, while the Kleinwanzlebener grown on one of the horticultural plots gave 15.7 and the Vilimorin 13.9 percent sugar in the beet. In 1899 only two varieties were grown on the land in question, i. e., Kleinwanzlebener and Zehringen, these varieties showing the presence of 15.77 and 15.86 percent sugar in the beet. They were harvested 10 November. The coefficients of purity were 84.0 and 84.2 respectively.

The conclusion at which we arrived, as the result of our observations of four crops grown on this land, was that neither the alkali *per se* nor the combined conditions obtaining in this land were sufficiently adverse to produce any decidedly prejudicial effect upon the composition of the beet. It may be stated that the supply of potash in this soil, as indicated by the ordinary agricultural analysis, is very abundant, 1.18 percent average of twelve analyses, and that a determination of the total potash showed 2.295 percent. The amount of phosphoric acid present was moderate or low, ranging in the twelve analyses made from 0.054 to 0.138 with an average of 0.095 percent. The nitrogen in the twelve samples referred to ranged very close to 0.10 percent, the average being 0.1020 percent. The nitrates in this soil and ground water were determined in a number of samples. The surface soil was found to be at least well supplied with this form of nitrogen as the nitric nitrogen ranged from 7.0 to 36.0 parts per million in the top two inches of soil, while in the second two inches it ranged from a trace to two parts per million. The ground water from Well A showed as the result of fifty-six determinations that the nitric nitrogen varied from 0.4 to 3.6 parts per million. These samples were taken from March 23 to May 21. The amount of nitrates in the water of a well in an adjoining piece of land was very much larger and varied much more with the rise and fall of the ground water.

We formulated our conclusions as follows:

The effect of the alkali, present in our soil, upon the sugar content of the beet is, of itself, not detrimental.

The presence of alkali increases the weight of the leaves very slightly, and has no marked influence on the date of maturing.

The amount of dry matter is the same in beets grown in alkali ground as in those grown in ground free from alkali.

The effect of the alkali upon the composition of the beet, as shown by the ordinary fodder analysis is an increase in the percentages of the ash and the crude protein and a decrease in the percentage of nitrogen-free extract. The effects of the alkali are greater upon the composition of the beet (the roots) than upon that of the leaves.

The composition of the ash of the beets did not seem to be affected by the different character of the soils experimented with, either because there was so great an abundance of available, and to the plant acceptable, mineral matter present that it was not affected by the presence of a large quantity of other salts or the composition of the ash of the sugar beet is very constant.

Again two years later we came to the same general conclusion, i. e., that the alkali *per se*, in such quantities as it is present in any portion of our plot, does not injuriously affect the percentage of sugar in the beets.

Several years later while still pursuing the alkali question my attention was directed to a piece of land that was planted to beets. Concerning the condition of this land no one could entertain a doubt. The stand of beets in the portion of the field that I visited was good, the tops were large and the promise for a crop was good. The ground between the rows was thickly incrusted with alkali and the water plane was at this time, October 4, within eighteen inches of the surface. The water used in irrigating this land was seepage water which carried 3711.4 p. p. m. A sample of this soil taken to a depth of three inches showed the presence of 3.582 percent of matter soluble in water or 143,000 pounds of water-soluble in each 4,000,000 pounds of such soil. The alkali incrustation was not included in this sample. Calcic, magnesic and sodic sulfates constituted upwards of eighty percent of this water-soluble. As in the preceding land, potash, soluble in water, was present in quantities, calculated as sulfate, equal to 2.409 percent of the thoroughly dried water-soluble portion.

The analysis of the soil showed phosphoric acid equal to 0.10 percent, potassic oxid 0.72 percent and nitrogen equal to 0.091 percent of the air-dried soil.

The alkali incrustation varied from one to three-eights of an inch in thickness and was well distributed over the patch. This alkali consisted of sodic sulfate 54.860 percent, magnesic sulfate 25.684 percent and sodic chlorid 10.751 percent, together 91.3 percent. I was fortunate enough to obtain from the factory that purchased these beets the average yield together with the sugar content on which the factory settled for the year in question; the average tonnage was nine tons per acre; the sugar in the beets was 15.9, apparent purity 83.3; for the ensuing year the yield was ten tons per acre and the sugar content 16.0 percent.

These results fully sustain the conclusions to which we had come as the results of our experimentation on alkalized land, i. e., that our ordinary alkali *per se* is not injurious and that the question of too high a water-plane is, under some conditions at least, of far less importance than is generally supposed.

These cases are not the only, and are by no means the most striking ones that might be cited to support the view that ordinary alkali, essentially sulfates, do not necessarily cause either low tonnage of beets or low quality and that good results are quite often obtained on land in which the water-plane is higher than we suppose that it should be.

These cases have been cited and these statements made to show that the generally entertained notion which attributes poor crops, especially a failing in successive crops and a poor quality of beets to the action of the alkalis in the first and to seepage in the second place, may often be a mistaken one. There is some other factor which has been left out of the reckoning.

I may in this connection again call attention to the fact that in both of these soils there is not only an abundance of potash present but that a significant quantity of it is soluble in water, further that the ground water from my own experimental plot contained noticeable quantities of phosphoric acid. I do not know much about the ratio of phosphorus to potassium to nitrogen whcih is advantageous for the highest production of sugar or the part that soda may play in the economy of the plant but we have in my own plot soil containing essentially 0.10 (0.095) percent phosphoric acid 1.18 percent of potash (K_2O) soluble in acid, and 0.102 percent of nitrogen producing good crops and good beets, the maximum sugar content reaching 18.3 percent in the perfectly fresh beet. In the second case we have the soil with 0.10 percent phosphoric acid, 0.72 percent potash and 0.091 percent of nitrogen producing according to the record of the factory, ten tons of beets with 16.0 percent of sugar.

These facts are given to put the questions pertaining to the effects of alkali and seepage in a fuller light and to give us a basis of fact on which to found our judgment and to remove the necessity of accepting a current opinion which may be in part justified but which being based upon observation without a knowledge of the facts is for far the greater part unjustified. The general prevalence of the opinion, however, takes cognizance of a big fact that something is amiss and two things are amiss. One fact is that continued excessive irrigation of the land has already produced a considerable amount of seepage and another is that in some districts the quality of the sugar beet has deteriorated materially within the past seven or eight years. It is perfectly natural that these results should be associated in the relation of cause and effect and this has happened without sufficient regard to the facts.

In order that a better understanding of the importance of these facts may be had I will state that in 1899, which was prior to the opening of any sugar factory in the Arkansas Valley, the beets grown at our station at Rocky Ford ranged from 13.3 to 21.0 percent sugar with an average of 17.3 percent for the season. The number of samples analyzed was 52, the beets were wrapped in paper and sacked to prevent drying out. Another grower in the valley raised beets ranging from 15.3 to 21.2 percent with an average of 17.5 percent. I have been informed on the best of authority that the factory average for the years 1900, 1901 and 1902, or for the first three campaigns, was 17.5 percent or thereabouts. From that time till the present the sugar content has gradually fallen till the factory average is about 14.5 percent, and some years less than this. As there are always many fields of excellent beets it is evident that there must be very many beets below 14.0, probably even below 11.0 percent. These figures hold for the valley and do not pertain to any particular factory. While the average sugar content of these beets has fallen approximately 3.0 to 3.5 percent the beet seed breeders have improved the average beet by 1.1 percent since 1903. (This was the amount in the increase from 1903-1908 according to Schulze and Lipochitz quoted by Stift and Gredinger, p. 83.) It was to be expected that the farmer and the factory people would both become uneasy under such conditions and some answer had to be given to the serious question regarding the cause. My object is merely to state the situation so fully and clearly that the reader may realize that the problem is in the first place serious enough to justify full and detailed consideration, and second, that it cannot be answered by any *ex cathedra* statements.

In the preceding paragraphs I have given some facts which show that the beet can tolerate large quantities of our ordinary alkali and a high water-plane, which are the two causes probably most generally assigned for this deterioration of the beet. In our experiments of 1897, 1898 and 1899 to which we have referred we obtained as good beets on what we considered seeped, alkali land as were grown on land which we considered well fitted for the production of this crop, and further the beets were quite up to the standard of sugar content for that time—about 15.2 percent. In 1897, the first year that the land was cropped, they fell somewhat below the standard, but so did our beets on land entirely free from these objections. In the next two years they were quite up to the standard, our final samples for the seasons giving 15.2, 15.4, 14.8 and 15.3 for 1898, and 15.8 and 15.9 percent for 1899. The other field of alkali land, which we have described, yielded beets with 15.9 percent sugar in 1906 and 16.0 percent in 1907. The average standard according to the authorities cited at this time was about 17.85. In these cases we have such effects as we believe can justly be attributed to the alkali and the high water plane, and they do not account for the deterioration observed, despite the fact that the producers of beet seed had effected a general increase in the quantity of sugar contained in the beet. We may further add that the deterioration affects large areas, which are not involved in the questions of seepage and alkalization.

A second question raised is relative to the plant food furnished by our soils and the ratio of the various nutrients to one another. It is a fact, I think, that our beets do not ripen early; the ready answer of the expert is, add phosphoric acid, this will correct the trouble. The advice is good but the results are as a rule wholly negative. In making this statement I am fully aware that but few if any will be quite willing to accept it, because it appears to contradict the observations of many experimenters whose results, obtained with much painstaking labor, have come to be held as fixed and fundamental facts and which are known to the veriest novice. I regret the facts, but I shall endeavor to record them as we find them though I know them to be sadly out of joint with results with which they should articulate in order to be quite proper.

We can only present a partial view of this very interesting subject in this place, the biggest features of the problem and these *en masse*. We cannot enter into the questions pertaining to the effects of the individual elements of plant food or the determination of the effects of definite ratios, we will not even question which element of plant food is really the determining factor, but state our results. I applied to alternate sections of my experimental land a dressing of sheep manure at the rate of sixty-four tons per acre; the results were a prompter and better germination, the first crop of roots was objectionable in shape and only slightly increased in weight over the unmanured plots, the sugar content and coefficient of purity were both slightly depressed. We applied in this dressing nitrogen at the rate of 1,861 pounds per acre after allowing a loss of 25 percent, due to the evaporation of ammonia and ammonia salts, of phosphoric acid we added 837 pounds, equivalent to 1,573 pounds of calcic hydric phosphate and of potash (K_2O) 4,077 pounds. The effect of this dressing was still marked in the color and growth of the foliage, the next or second year after its application and the roots were of a better shape than they were the first year. The average sugar content for the season on the manured plots was a trifle low as was also the coefficient of purity. These may be considered as extreme effects, for the manure used was as unusual in quality as was the quantity applied per acre. Perhaps the slight differences in the sugar content and coefficient of purity in favor of the unmanured plots may have been due to the difference in the degree of maturity of the plants, but the experiments were continued till the end of October the first year and till November 10 the second year, which dates may be taken as the end of our growing season. The composition of the ashes of these beets was determined, but it does not present any points of sufficient interest to justify discussion. The ash (carbonated) in the fresh Kleinwanzlebener beets from the manured plots equalled 1.117 percent, from the unmanured plots it equalled 1.131 percent. The lowest percentage of carbonated ash found in any variety grown on unmanured ground was 0.94 percent. The beets grown in these experiments were not subjected to any further investigation than has already been indicated. It seems entirely superfluous to add that it would not pay anyone to apply such quantities of manure, at least not during the first two years after its application, but more moderate applications of well rotted farmyard manure to most of our lands is to be strongly advised. We have in the foregoing simply recorded our experience in applying this quantity of manure to this strongly alkalized land, the general composition of which has been given in a preceding paragraph.

Through the kindness of the management of the American Beet Sugar Company, especially through that of their former Consulting Agriculturist, Mr. W. K. Winterhalter, I am able to give the results of quite an extended series of experiments with a variety of fertilizers.* The beets from some of these plots have been subjected

*I may at this point state that after I had become fully convinced of the very general distribution of nitre-areas throughout the state, particularly after I had found a number of occurrences of it in the extreme eastern end, as to further investigation, but we will give only the general crop results in this place. The American Beet Sugar Company had made experiments with a variety of fertilizers some years previous to this with results which were not at all decisive in showing any benefit arising from their use. Mr. Winterhalter, in writing to me about their work in 1904 says, "Experiments with nitrate of soda were made by several of our growers upon small plats in their best fields, but, as in the past, we secured no results showing its benefits." Again in the same communication he refers to five particular plats on which sodic nitrate had been applied, of these he says: "Two of them produced a smaller yield than a corresponding plat which had received no nitrate and three of them showed an increase of 2,097, 605 and 357 pounds per acre respectively."

During the same year, 1904, Mr. Winterhalter, on the part of the company, carried out the following series of experiments. The fertilizers were applied just before planting the seed. In some cases the fertilizers were sown and cultivated in to a depth of four inches, in one experiment a portion of it was plowed under to a depth of eight inches. The seed was drilled in two inches deep, between May 10 and 17. All plots received two irrigations each, May 23-31, and July 17-24. The plots were harvested between October 15 and Nov. 15.

No. of Plat	Fertilizer Applied	Yield of Beets Net Pounds	Percentage Sugar 1st Sample	2d Sample	Purity
1.	None	19.961	17.7	16.3	81.8
2.	200 lbs potassic sulfate; 270 lbs. precipitated phosphate	21,743	18.0	16.6	81.8
3.	200 lbs. potassic sulfate; 200 lbs. dried blood	22,120	18.7	17.1	82.9
4.	None	24.026	18.9	17.3	84.3
5.	270 lbs. precipitated phosphate; 240 lbs. dried blood	23,420	18.7	17.2	84.4
6.	240 lbs. dried blood	20,223	20.6	19.0	84.2
7.	None	21.107	20.5	18.9	84.9
8.	200 lbs. potassic sulfate; 270 lbs. precipitated phosphate; 240 lbs. dried blood	21,722	17.6	16.2	81.7
9.	170 lbs. potassic sulfate; 270 lbs. precipitated phosphate; 200 lbs. nitrate of soda	21,374	17.9	16.5	81.2
10.	None	21.325	18.9	17.4	84.1
11.	270 lbs. precipitated phosphate; 200 lbs. nitrate of soda	20,842	18.5	17.0	83.3
12.	200 lbs. nitrate of soda	19.697	19.0	17.5	84.0
13.	None	17,294	19.1	17.5	85.8
14.	300 lbs. nitrate of soda	19,121	19.4	17.9	84.5
15.	None	16,370	21.0	19.3	87.1

well as in other portions of the Arkansas Valley, it occurred to me that a continued and excessive supply of nitre, throughout the season, especially during the later portion of the season, would account for the immature condition of the beets and perhaps some of the difficulties met with in the factories. I stated my views and reasons for them to Mr. W. M. Wiley, at that time President of the Holly Sugar Co., and examined the beets which they were then

The aggregate value of the beets yielded by the six unfertilized plot was 300.21 dollars or 50.04 dollars per acre, that of nine fertilized plots was 474.75 dollars or 52.75 dollars per acre. Five other plots received dressings of fertilizers in which the constituents were given in percentages, i. e., as ammonia 4-4½ percent, soluble phosphoric acid 8-9 percent, potash, actual K_2O, 4½-5½ percent, against these were run two check plots. The total value of the beets gathered from the two check plots, one acre each, was 109.09 dollars or 54.545 dollars per acre and from the five fertilized acres the total value was 214.60 or 42.92 dollars per acre. I have taken these plots in two groups, one favorable to the application of fertilizers which shows for the nine fertilized acres a gain of 2.73 dollars per acre over the unfertilized, the other group, unfavorable, which shows for the fire acres that received fertilizers a return of 11.62 dollars per acre less than the return from the unfertilized plots.

Mr. A. H. Danielson, formerly assistant agriculturist at this institution, carried on experiments to determine the effect of fertilizers on the yield and sugar content of beets for three years, 1903, 1904 and 1905, and formulates his results as follows: "Nitrogen in the form of nitrate of soda is the only element which has any decided effect in increasing the yield of sugar beets over the cost of application."

"Potash in the form of sulfate and phosphoric acid in the form of raw bone meal, basic slag, dissolved or acid bone and phosphate rock used alone or together have very little or no effect upon the yield.'

"There are strong indications that potash and phosphoric acid fertilizers largely, if not entirely, neutralize the effect of nitrate of soda upon the yield of sugar beets, although the quality of the beet is good." Colo. Expt. Sta. Bulletin 115, p. 23.

In 1909 Mr. Winterhalter again instituted experiments with fertilizers on a still larger scale than heretofore and continued them for two years, 1909 and 1910, and has kindly furnished me with such a detailed report of the crops of these two years that a full

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cutting and also the Steffens waste water, and found a surprisingly large amount of nitric acid present in both. I next took up the subject with Mr. W. H. Baird, General Superintendent of the American Beet Sugar Company, who immediately interested himself in the subject. I realized fully that there were and are many questions to be settled which can be settled only by experimentally established facts, consequently in the spring of 1910 I approached Mr. Winterhalter, Consulting Agriculturist, with a proposition to make certain experiments which subsequently met with the approval of the General Manager, Mr. Howe, the General Superintendent, Mr. Baird, and the Manager, Mr. Wietzer. I am indebted to all of these gentlemen for their co-operation, especially to Mr. Winterhalter for his interest in the agricultural features of the problem and to Mr. Baird for his interest in the technical end of it. Further, our thanks are due to the officers of both companies ,the Holly and the American Beet Sugar Co., for the liberal view that they take in regard to access to and use of their data. The public will realize that much of the factory data is not of general interest and that only such as pertain directly to the questions involved in this investigation and are necessary to a complete statement of the problems may properly be considered.

statement of them in this connection will be interesting, especially as I shall, in another place, discuss the composition of these beets so that we shall see the effects upon both the crop and its composition. The area of the field used is almost exactly fourteen acres divided into one-half acre plots, so there were twenty-eight plots. The field is very nearly level but the soil of the west half may be a little lighter than that of the east half. It is all quite heavy. In 1909 six acres of this land received a dressing of stockyard manure, at the rate of twenty tons to the acre. Stockyard manure is the dung of cattle fed on alfalfa hay, beet pulp, molasses and straw to which grain is added during the final stages of feeding. This manure was plowed under to a depth of 10 inches. The other fertilizers were sown on the surface and cultivated in to a depth of four inches. There were twelve plots that received an application of stockyard manure in 1909 and sixteen that received none. There were two check plots selected, one in the west, the other in the east half, which received no fertilizer of any sort, and one plot which received no frtilizer other than the stockyard manure. In 1909, the plan of experimentation included the following fertilizers, potash, phosphoric acid, nitrogen, lime, both burnt and waste lime, and farmyard manure. The plots were divided into two groups of fourteen each and one plot in each group received the same treatment, in other words, was duplicated. The numbers on the west half run from 12 to 25 inclusive, and on the east half from 26 to 39 inclusive. The weights given are the amounts applied to each half-acre plot. P. stands for superphosphate, K. for potassic sulfate and N. for sodic nitrate.

The statement of the results shows that the returns from the west side of this field were very much better than those from the east side, though there is nothing but an arbitrarily taken line to divide them. While each combination of fertilizers was applied to two plots, one on each side of the middle line, it is evident at a glance that we can only compare the results obtained on the same side and these are so capricious that no one would venture to draw any conclusions even tentatively except of the most general sort, i. e., such as that the application of fertilizers did some good. There was only one check plot on the west side of the field; this yielded 10.1 tons of beets per acre. Two plots received an application of 20 tons stockyard manure per acre and yielded 10.3 and 12.8. Two received phosphoric acid, potash and nitrogen and the yields were 12.8 and 11.6. Two received phosphoric acid and nitrogen and the yields were 16.6 and 9.4. Two received phosphoric acid and potash and the yields were 14.2 and 14.6. Two received potash and nitrogen and the yields were 15.2 and 13.2. Two received phosphoric acid, potash, nitrogen and lime and the yields were 21.9 and 13.1, and one received waste lime alone and yielded 10.4 tons.

Plot No.	Fertilizer Applied per Acre	Tons per A.	Percent Sugar in Beets	Apparent Purity	Sugar per A.
12.	20 tons manure	10.3	14.27	81.4	2,939
18.	20 tons manure	12.8	14.62	82.8	3,742
31.	20 tons manure	11.3	13.30	79.5	3,005
13.	P. 110 and manure; K. 130, N. 200	12.8	13.92	82.2	3,558
30.	P. 110 and manure; K. 130, N. 200	11.6	14.46	82.6	3,325
14.	P. 110 and manure; K. 130	14.2	14.27	82.3	4,223
29.	P. 110 and manure; K. 130	10.6	14.53	83.4	3,074
15.	K. 130, N. 200	15.2	12.95	79.0	3,921
27.	K. 130, N. 200 and manure	8.9	14.20	82.9	2,527
16.	P. 110, N. 200 and manure	16.6	13.94	81.7	4,628
26.	P. 110, N. 200	9.7	14.56	81.4	2,824
17.	P. 110, K. 170, N. 200, Ca 4 tons and manure	21.9	13.33	80.9	5,825
28.	P. 110, K. 130, N. 200, Ca 4 tons.	9.3	14.50	82.1	2,697
19.	Nothing added	10.1	13.66	81.5	2,747
38.	Nothing added	7.2	15.10	81.7	2,174
20.	P. 250, K. 170, N. 200	11.6	13.94	82.1	3,234
37.	P. 250, K. 170, N. 200	6.5	16.30	84.8	2,119
21.	P. 250, K. 170	14.6	13.75	82.3	4,015
36.	P. 250, K. 170	8.6	15.13	83.7	2,602
22.	K. 170, N. 200	13.2	14.22	82.7	3,754
34.	K. 170, N. 200	9.9	14.46	83.1	2,863
23.	P. 250, N. 200	9.4	14.76	84.3	2,774
33.	P. 250, N. 200	7.4	12.75	79.5	1,887
24.	P. 250, K. 170, N. 200, Ca. 4 tons	13.1	14.37	83.0	3,746
35.	P. 250, K. 170, N. 200, Ca. 4 tons	8.9	14.40	82.3	2,563
25.	Ca. 10 tons, waste	10.4	14.20	81.0	2,953
39.	Ca. 20 tons, waste	6.4	14.30	82.2	1,830
32.	Ca. 20 tons, factory lime from settling pond	10.4	15.03	82.9	3,126

If we consider the east half by itself we have still more perplexing results; we have one plot without any fertilizer which yielded 7.2 tons per acre, one plot with stockyard manure, 20 tons to the acre, with a yield of 11.3 tons, two that receive phosphoric acid, potash and nitrogen with yields of 11.6 and 6.5 tons, two that received phosphoric acid and nitrogen with yields of 9.7 and 7.4 tons, two that received phosphoric acid and potash with yields of 10.6 and 8.6 tons, two that had received phosphoric acid, potash, nitrogen and lime with yields of 9.3 and 8.9 tons, two that had received waste lime in different amounts with yields of 10.4 and 6.4 tons. In one-half of the cases the minerals were applied in conjunction with and in the other half without stockyard manure. In regard to the effect of any or all of the combinations of the fertilizers used upon the tonnage no one, I think, would be willing to say more than this, that taking the east and west halves separately the plot that received the addition of nothing made the smallest return except in one case in each half, but the aggregate result in regard to tonnage shows an advantage accruing from the application of fertilizers, but this is neither large enough nor uniform enough to satisfy any one, besides, the plots which give the best returns had in every case received a dressing of farmyard manure at the rate of 20 tons per acre. While I do not consider this season's results at all satisfactory and do not intend to discuss them, I will simply point out that the interpretation of these results would be very difficult, viz., plots 17 and 24, both in the west half of the field, received the same kinds of fertilizers except that 17 had received a dressing of stockyard manure; plot 17 yielded 21.9 tons to the acre and 24 yielded 13.1 tons. I think it wholly unsafe to argue that this difference in the yield was due to the stockyard manure. In the other pair of experiments, in which the same fertilizers were employed, we have a difference, it is true, in favor of the combination of stockyard manure and minerals but in this case the difference is only 0.4 of a ton, besides the yields are very small, 9.3 and 8.9 tons per acre.

If we consider the percentage of sugar in the beets we do not find the results much more satisfactory. There is in this respect one thing evident, namely, that in regard to the percentage of sugar the east half was the better without any relation to the fertilization. We cannot justly state, so far as these experiments go, that the fertilizers have either increased or decreased this factor in the crop, or rather we can show either according to our choice of samples. These unsatisfactory results cannot be attributed to a different history for the two portions of the field, nor to differences in preparation, in time of planting, irrigation, cultivation, harvesting or testing, nor yet to hail, to insects, or to fungi which attacked or injured one half more than the other.

These experiments were repeated in 1910 on the same ground with but little variation in details and none in the plan of experimentation. The results are tabulated below. In 1909 twelve of the plots, six in either half, were dressed with stockyard manure at the rate of 20 tons to the acre or 10 tons to each half-acre, but no stockyard manure was applied in 1910, neither was the application of either the burnt lime or waste lime repeated in 1910, as the respective plots had received 4, 10 and 20 tons of these matrials per acre in 1909. The west half of the field received the same treatment as in 1909 except as already stated. The numbers are the same as before, 12-25 inclusive represent the west and 26-39 the east half.

This year again the results show a better yield on the west than on the east half, but the difference is much less than in 1909. The beets from the east half, however, are not richer in sugar than those from the west half as they were the preceding season. Plots 16 and 17 produced the heaviest crops of beets and sugar in both years, while plots 14 and 15 rank close to them. It is a question in my mind whether this may not be due to differences in the productiveness of the different plots rather than to the effects of the fertilizers

Plot No.	Fertilizer Applied per Acre	Tons per A.	Percent Sugar in Beets	Apparent Purity	Sugar per A.
12.	20 tons manure in 1909.........	13.36	14.6	85.9	3,911
13.	P. 110, K. 130, N. 200...........	13.22	13.2	82.3	3,379
14.	P. 110, K. 130..................	13.17	13.3	83.1	3,532
15.	K. 130, N. 200	14.16	13.3	80.9	3,723
16.	P. 110, N. 200	14.94	15.3	82.7	4,746
17.	P. 110, K. 65, N. 200, CaO 4 tons in 1909	15.90	14.0	82.3	4,463
18.	10 tons manure in 1909........	13.94	15.0	80.8	4,187
19.	Nothing	12.44	13.3	79.1	3,309
20.	P. 250, K. 170, N. 200...........	13.41	15.4	82.8	4,071
21.	P. 250, K. 170..................	12.83	14.7	82.9	3,736
22.	K. 170, N 200............	12.20	15.2	82.2	3,678
23.	P. 250, N. 200..................	11.94	14.9	82.7	3,546
24.	P. 250, K. 170, N. 200, CaO in 1909	11.59	15.4	84.4	3,560
25.	Ten tons waste lime, 1909......	9.77	14.6	85.6	2,849
26.	P. 220, N. 400	14.57	13.6	82.4	3,960
27.	P. 220, K. 260, N. 100...........	11.75	14.5	84.4	3,397
28.	P. 220, K. 260, 4 tons CaO, 1909.	11.90	15.0	85.1	3,567
29.	K. 260, N. 100..................	11.74	14.9	81.7	3,514
30.	P. 240, N. 100..................	12.67	13.6	82.9	3,450
31.	P. 500, K. 400, N. 200...........	13.16	14.8	82.9	3,895
32.	CaO, 20 tons, from settling pond, 1909	10.10	13.9	80.2	2,806
33.	P. 400, N. 200	11.69	13.7	82.1	3,166
34.	K. 300, N. 200..................	11.10	13.7	83.2	2,929
35.	P. 400, K. 300, N. 200...........	12.00	14.2	82.4	3,391
36.	K. 300	10.11	14.0	81.5	2,816
37.	P. 400	10.86	14.4	83.8	3,131
38.	Nothing	10.09	14.6	83.4	2,940
39.	CaO waste 20 tons, 1909........	11.30	12.4	82.1	2,676

applied. One thing seems evident, i. e., that, in experimenting with this soil, the check plots ought to alternate with the experimental plots. While this arrangement of plots would have been a little more satisfactory it would not have removed all the difficulties. Plots 17 and 31 lie end to end and each received 10 tons of stockyard manure in 1909. Plot 17 received in addition to this in 1909, P. 55, K. 65, N. 100 and burnt lime 2 tons, and yielded 21.9 tons of beets; in 1910 the same fertilizers were added with the exception of the burnt lime and yielded 15.9 tons of beets. Plot 31 received nothing in addition to the 10 tons of stockyard manure in 1909, and yielded 11.3 tons of beets; in 1910, P. 250, K. 200 and N. 100 were applied and the yield was 13.2 tons of beets. With such results I do not think it possible to distinguish how much is due to differences in the soil and how much to other causes. An inspection of all of the results will simply justify a general statement that the application of fertilizers increased the crops, but that this increase is neither great nor regular enough to commend the practice from the standpoint of profit.

It may be worth the while to indicate the composition of the fertilizers used. The Chile saltpetre, sodic nitrate, 90.62 percent nitrate, potassic sulfate 89.87 percent, equivalent to 48.50 percent

K_2O, superphosphate, total phosphoric acid 13.19 percent, water-soluble 8.35 percent, citrate soluble 2.11 percent. The waste lime carried potash 0.27, phosphoric acid 1.90, and nitrogen 0.075 percent. Ten tons of this lime carried 380 pounds of phosphoric acid, 50 pounds of potash and a small amount of nitrogen. The burnt lime was practically pure and its action as a fertilizer would be that of caustic lime. Our soils are already alkaline so there would be no soil acidity to correct and its benefit if any would probably be attributed to its action on the potash minerals or on the organic matter in the soil.

The composition of the stockyard manure is sufficiently indicated by its content of nitrogen, potash and phosphoric acid which was as follows: nitrogen 0.598, potash 0.89 and phosphoric acid 0.82 percent and a ten-ton dressing of such manure added to each half-acre, nitrogen 119.6 pounds, potash 17.8 pounds, and phosphoric acid 16.4 pounds. In addition to these and probably of considerable importance, is 2,800 pounds of organic matter which is finely divided and easily incorporated with the soil.

The crops of 1910 ought to show the residual effects, if any, of the 1909 applications, plus that of the applications of 1910. There was applied to plot 28 for instance in 1909, P. 55, K. 65, N. 100, CaO 2 tons; in 1910, P. 110, K. 130 and no nitrate or lime, but the effects of the lime applied in 1909 should still be felt in 1910. The crop in 1909 was 9.3 tons per acre, in 1910 11.9 tons, an increase of 2.6 tons. In the case of plot 15 there were added in 1909, 10 tons stockyard manure, K. 65, N. 100, in 1910 the same except that no manure was added. In 1909 the crop was 15.2 tons, in 1910 14.2 tons, a slight decrease in crop with practically the same percentage of sugar.

The results obtained in these two years, 1909 and 1910, show a slight benefit accruing from the application of the fertilizers. The results are, however, so irregular, whether we estimate the benefits in tons of beets or pounds of sugar per acre, that the application of fertilizers does not commend itself. We usually, in discussing a subject of this kind, consider the more favorable results, as they tend to show the possibilities of the practice, and excuse less favorable ones on a variety of grounds. We also are apt to take tonnage of beets as our measure of the effects produced, but the amount of sugar produced is a much better one. In 1909 we had only four plots that produced 4,000 or more pounds of sugar per acre. The maximum yield was 5,825 pounds. The plot that produced this showed an exceptionally high tonnage, 7.3 tons more than the next best yield. The fertilizers applied to this plot were phosphoric acid, P_2O_5 7.2 pounds, potash K_2O 31.72 pounds and nitrogen N. 13.60 pounds, burnt lime 2 tons, with 10 tons stockyard manure plowed under to a depth of 10 inches which contained 119.6 pounds nitrogen, 178 pounds potash and 164 pounds phosphoric acid. There were two plots that received this treatment, one as just stated produced 5,825 pounds of sugar, but the other produced only 2,697 pounds, or less than half as much and actually less than one of the plots to which nothing whatever had been added, and only 520 pounds more than the poorer of the two check plots. The lack of concordance in the results cannot be attributed to lack of careful and intelligent cultivation or any difference in treatment from the beginning of the experiment till the weighing of the beets delivered at the factory.

We find the same irregularities in the results of 1910. They are in fact so inconsistent that they lend themselves to any interpretation that one may wish to give them. The results of 1904 were likewise wholly indecisive, one series showing a small gain and the other a fourfold greater loss per acre from their use. The question of importance to the grower is whether these results faithfully indicate what he would have a right to expect from the use of fertilizers.

Three years experimentation on this subject at this station in a very different soil, one with which no fault could well be found, led to similar conclusions as far as the experiments were parallel.

The effect of fertilizers upon the yield whether it be measured by the pounds of beets or sugar is an interesting, and to the grower, an important one, but there are other questions, the importance of which is not indicated by the size of the crop.

The results show that it is doubtful whether the application of commercial fertilizers to these lands would be attended with increased profits; in other words, it is doubtful whether the increase yield will cover the increased costs. These results are not in harmony with those obtained in other sections of our country where their use has been shown to be remunerative. It would be interesting to further establish these results and determine whether they really be facts, and if facts, to ascertain the reasons for them, but our present purpose lies in another direction.

The quality of our beets leaves much to be desired. By a good quality of beets I do not merely mean a beet with a high percentage of sugar, but one which will also keep well and work well. That the supply and ratio of the various plant foods affect these properties has been repeatedly shown and is accepted as a fact and emphasis has also been placed upon the fact that the soil itself and its supply of plant food must be taken into the account.

There are two properties shown by some of our beets which are undesirable; they produce an undue amount of molasses and they do not keep well. Both of these faults may be attributed to *immaturity* of the beet at harvest time and the readiest suggestion in the way of correction would be the application of phosphoric acid. We will later give some results obtained with this fertilizer.

In regard to the production of molasses some of our beets produce as much as nine and even more percent. Molasses is here used to designate the second green syrup that goes to the Steffens house and the percentage is calculated on the beets cut. The statement is made by Ruempler that the German factories average two and one-half percent, but as the most of them produce only raw sugar this may retain a great deal of the molasses which in our factories goes to the Steffens plant. I am, however, credibly informed that some factories in this country have produced as low as two and one-half percent of molasses calculated on the beets.

It is not customary here to use artificial fertilizers and there is not enough manure produced to dress more than a small fraction of the acreage planted to beets annually. Some people are now using manure more liberally than formerly, which is much to their credit and to the benefit of our farming, but the effects of the amounts used, whether they be good or bad, constitute no factor in the questions which present themselves. I have stated the results obtained by the use of artificial fertilizers without going into any considrable discussion of the results, but will repeat that the experiments show that the application of fertilizers increases the yield of beets and in most cases the yield of sugar in pounds per acre; the duplicate trials are not concordant and the results cannot be interpreted, but seem to indicate that the question is not one of plant food but something else. The twenty-six trials, repeated a second year on the same grounds, making in all fifty-two trials and four checks, leave us in the greatest uncertainty regarding the whole matter. There is no apparent reason for this lack of agreement. The soil of the west half may be a little lighter, but this half varies as much from north to south as the field does from east to west, still the results are different on the east and west halves irrespective of the fertilizers applied, so we are left to determine or to guess whether the differences are in greater measure due to differences in the soil or to the different effects of the fertilizers applied. This is most strikingly shown by the tabulated results for 1909.

These differences cannot be attributed to differences in cultivation such as date of planting, preparation of seed bed, variety of seed, thinning, cultivation, irrigation, time of harvesting, weather conditions, attack of fungi or insects, or time of harvesting and subsequent treatment before delivery to the factory; in all these respects the conditions were alike. The amounts of the fertilizers added were neither so small as to produce no results nor so heavy as to be of themselves injurious, both extremes were avoided. These beets in regard to their sugar content were fully average beets for the season, but scarcely more than that. We do not know how the juices of these beets worked in the factory. I know that beets of the same average percentage of sugar and apparent coefficient of purity gave about seven and one-half percent of molasses when worked in a well appointed factory and I think it perfectly safe to assume that these beets gave about the same. One of the questions is, can we by the use of any particular fertilizer or combination of fertilizers obtain better results both for the grower and the factory? If we could accomplish all that we wish we would of course have a better tonnage, a higher percentage of sugar and early ripening beets that would keep well and work at the lowest possible cost in the factory. The tonnage, however, is apt to continue variable and the average low, owing to a number of factors, including the grower himself and his lack of means to provide himself with proper implements for the cultivation of his crops, in short, owing to the limitations imposed in many cases by poverty and the lack of knowledge. The questions which I proposed to study pertain rather to the factory than to the growing of the beets or to the grower, i. e., why do the beets remain green? Why are they so low in sugar? And why do they produce so much molasses?

A few years ago the beets produced on these same lands were not low in sugar (see table page 14 for percentage of sugar in crop of 1904); the percentage of sugar, on the other hand, was extremely good, but I do not know how the working of the beets then compared with their working in more recent years, and it would be very difficult for technical men in the factory to judge of this, because of the improvements in the factories made from year to year as the result of each campaign's lessons and also in methods and details of technique. Each year's problems have become more difficult but have been met by improvements in the factory and in their practice till the factory of today is a very different plant from the initial one established ten or twelve years ago. The beets, then, have deteriorated from a sugar content of 17.5 to 14.5 or 14.0 percent and in some sections almost as low as 13.0 percent. The cause must be a general one, for the very good reason that the effect is general. There are always fields of good beets but the factory average is too low, which increases the cost of working the beets and makes the grower suspicious and discontented. The grower is a difficult person to convince that there are big problems to be solved which involve him and the factory alike and which are not of any man's making, but such are the questions which I have mentioned, i. e., why are the sugar beets of large sections slow in maturing and poor in quality, or putting this question differently, why has the average beet of recent years been so poor in sugar and why has it produced so large a percentage of molasses calculated on the beet? We may safely eliminate the following possible causes: first, any lack of proper appointments in the factories, for these are of the best; second, faulty methods or processes; third, unskillful management in the factory; fourth, lack of attention in taking care of the beets; fifth, inferior seed, for only the seed of the best varieties grown and furnished by reliable parties has been used; sixth, inexperience in growing the crop, for this feature has been supervised by the factories for years; seventh, climatic influences, for these are the same now as they were from 1896-1904, when the average sugar content was from 2.5 to 3.5 percent higher than it was from 1906 up to and including the last campaign. Further, we should take into account in this connection the fact that the beet seed growers have materially increased the sugar producing qualities of the beets, without depressing their crop production within the last fifteen years, and also that the community in general, and not a few individuals, has had at least eleven years experience in the management of this crop under their respective local conditions of soil, water-supply, etc. It is not intended to so much as intimate that all of the growers of beets are wise, energetic, thrifty men who have studiously and conscientiously endeavored to solve these problems for themselves, but the factories have provided men of experience and fitness for this work to counsel and aid the growers in all possible, feasible ways, so that the changed results mentioned cannot be attributed to either the inexperience or ignorance of the general farming community. I think that the factors of this kind that have been specified as possible contributors in producing the conditions pertaining to the sugar beet problems for the past few years may be dismissed from further consideration. The only point in which some persons may disagree with me in this is in regard to the effects of climatic conditions. This is because they know that there are serious questions presenting themselves, for which there is no other ready answer rather than because they have any definite fatcs to adduce to prove that the climatic conditions have changed, or to show any relation between the changed results and the climate.

The most serious problem that presents itself in connection with the climate and its influence is probably its bearing upon the development of the leaf-spot or *Cercospora beticola*. This is a factor which it seems we will have to accept as an unavoidable one in the Arkansas Valley. In the northern part of the state it is present, but wholly negligible. I do not doubt but that the climatic conditions may be the determining factor in this difference, but so far as I know nothing is proven in this regard.

In passing it may be permissible that I should call attention to the fact that different localities within this state may be very widely separated. The Arkansas Valley is about 200 miles south of the Cache la Poudre Valley, and the Grand Valley must be 350 miles in an air line south and west and 1,000 feet lower than the farming sections of the Poudre Valley. I do not know that there is no cercospora in the Grand Valley, but I know that there has been no damage done in the valleys, either of the Grand, the Gunnison or the Uncompahgre, and while this fungus is present in the Poudre Valley sections it has done no damage. In the Arkansas Valley, however, it has been very bad, destroying the foliage of many fields. Portions of the Arkansas Valley have as great an altitude as the Grand Valley and the latter is as warm as the former. Whatever the reason may be, this fungus has, in past years, been very bad in the Arkansas Valley. I will digress further to state that the sugar content of the beets from badly infested fields is not always low nor the yield necessarily below the average. It is scarcely to be doubted but that the destruction of a very large part of the foliage of the beets in August has some effect upon both the yield and the percentage of sugar. At my request Mr. Winterhalter kindly collected the record of 127 fields affected in various degrees by the leaf-spot. The variations appear to me to be due more to other causes than to the leaf-spot as we find the leaf-spot beets from sections in which the beets are generally rich also rich and in sections which produce poor beets we find them poor. I will give only a part of this data as my object is simply to show to what extent we may be justified in entertaining serious doubts in regard to the conclusions which we almost unconsciously accept as evident or fully proven, when we see a field of beets quite denuded of its foliage, i. e., that the beets are poor.

The climatic conditions in 1910 were as favorable as we can ever expect to have them. The aggregate acreage repreesnted by these 120 fields is 2,425.5 acres. The crop grown on the land the previous year was in most of the cases beets but in some cases it was not; wheat, oats, alfalfa, melons, cantaloupes and sorghum had been grown on some of the land. One piece had been fallow and one was new sod land. These districts represent the valley for a distance of about 120 miles. The individual fields represened a range in area from two to one hundred and nine acres. The percentage of sugar in the beets are averages for the whole field. The violence of the attack can not well be described more accurately than by the general terms used. I recall a field that I visited in which I do not think that any of the plants had escaped having at least 90 percent of their foliage destroyed. I do not know what the average sugar content of the beets from this field was as they were taken to the factory but the field samples averaged something above 16.0 percent. The attack in this case was very bad. If these samples show

RECORDS OF FIELDS AFFECTED BY LEAF-SPOT, 1910.

District No.	No. of Field	Character of Soil	Attack	Av. Sugar in Beets	Yield—tons	District No.	No. of Field	Character of Soil	Attack	Av. Sugar in Beets	Yield—tons
I	1	sandy	badly af.	16.5	14.0	IX	61	sandy	very bad	12.5	13.1
I	2	"	"	16.1	12.0	IX	62	"	".	12.3	10.8
I	3	"	"	15.6	17.8	IX	63	sandy l.	medium	13.8	10.0
I	4	"	"	14.7	12.1	IX	64	"	"	15.1	11.5
II	5	"	very bad	15.0	8.9	IX	65	"	bad	14.1	9.6
II	6	"	"	14.4	12.2	IX	66	"	medium	13.2	9.8
II	7	"	"	13.5	13.4	X	67	sandy	very bad	15.9	11.4
II	8	"	"	15.7	7.4	X	68	heavy	"	13.7	12.2
II	9	"	"	15.8	7.0	X	69	sandy	light	14.7	11.1
II	10	"	"	14.9	10.6	X	70	"	"	14.1	11.5
II	11	"	"	15.5	9.5	X	71	heavy	medium	17.0	5.2
II	12	"	"	14.8	12.2	X	72	sandy	very bad	15.4	10.6
III	13	sandy loam	"	12.8	13.4	X	73	heavy	light	15.9	12.0
III	14	" "	"	13.2	15.6	X	74	"	medium	14.9	10.2
III	15	v. h. adobe	"	14.6	8.9	XI	75	sandy l.	very bad	14.7	12.1
III	16	sandy loam	"	14.4	14.4	XI	76	heavy	"	14.6	14.2
III	17	"	"	13.3	13.6	XI	77	light	"	14.3	15.7
III	18	"	"	14.9	17.0	XI	78	heavy	light	15.2	11.8
III	19	"	"	13.7	15.9	XI	79	sandy	"	17.3	10.3
III	20	"	"	12.9	12.8	XI	80	sandy l.	medium	14.3	5.7
IV	21	heavy	"	13.2	11.4	XI	81	sandy	light	15.2	13.8
IV	22	"	"	13.8	10.8	XI	82	heavy	"	15.5	11.2
IV	23	"	bad	14.7	11.8	XI	83	"	very bad	14.0	8.7
IV	24	"	"	14.7	8.7	XI	85	"	"	12.4	6.0
IV	25	light	medium	14.4	10.4	XII	85	"	"	13.2	10.9
IV	26	"	bad	14.2	13.1	XII	86	"	medium	14.0	13.3
IV	27	"	medium	13.7	9.8	XII	87	light	very bad	15.8	10.6
IV	28	"	"	16.0	15.1	XII	88	heavy	"	13.0	12.3
V	29	heavy	very bad	14.1	8.8	XII	89	"	medium	14.4	10.4
V	30	"	"	12.4	11.7	XII	90	"	"	13.7	12.9
V	31	"	"	14.5	11.4	XIII	91	sandy l.	medium	14.9	6.3
V	32	"	"	12.6	17.5	XIII	92	"	very bad	13.4	6.1
V	33	light	"	12.7	14.6	XIII	93	lt. clay	bad	12.4	11.9
V	34	"	bad	14.3	13.8	XIII	94	sandy l.	"	13.6	6.6
V	35	heavy	very bad	14.0	16.5	XIII	95	"	"	12.6	9.7
V	36	medium	bad	13.2	14.6	XIII	96	lt. clay	light	13.3	11.7
VI	37	heavy	very bad	12.8	16.5	XIII	97	sandy l.	medium	11.4	9.0
VI	38	"	"	12.3	10.7	XIII	98	"	light	14.8	8.2
VI	39	medium	"	12.6	13.3	XIV	99	hv. clay	very bad	11.7	10.1
VI	40	heavy	"	13.0	17.2	XIV	100	lt. clay	bad	12.5	7.7
VI	41	"	"	13.0	10.9	XIV	101	hv. clay	medium	14.9	9.0
VI	42	medium	bad	11.9	12.4	XIV	102	lt.clay	"	16.0	8.5
VI	43	varying	"	13.6	7.1	XIV	103	sandy l.	very lt.	12.3	7.8
VI	44	heavy	"	11.8	12.9	XIV	104	"	light	13.3	11.6
VII	45	sandy l.	very bad	14.0	12.0	XIV	105	"	"	14.1	3.7
VII	46	"	medium	14.5	9.7	XV	106	"	very bad	11.6	14.8
VII	47	heavy	very bad	14.9	12.0	XV	107	"	bad	12.1	16.4
VII	48	sandy l.	medium	13.0	10.6	XV	108	"	medium	15.7	9.4
VII	49	sandy	light	15.0	9.5	XV	109	"	"	12.0	19.5
VII	50	"	very bad	14.7	8.5	XV	110	"	very lt.	14.0	16.3
VII	51	sandy l.	"	13.6	8.1	XV	111	"	"	12.2	7.4
VII	52	"	medium	13.6	10.9	XV	112	"	light	12.8	15.1
VIII	53	sandy	very bad	12.7	15.7	XV	113	"	very lt.	14.0	8.1
VIII	54	loam	"	12.1	12.8	XV	114	"	very bad	14.9	8.6
VIII	55	"	light	12.7	13.9	XVI	115	"	light	15.2	9.3
VIII	56	"	very bad	14.2	10.0	XVI	116	lt. adobe	light	12.5	9.9
VIII	57	sandy	"	12.8	13.3	XVI	117	"	"	13.8	12.0
VIII	58	sandy l.	light	13.1	11.9	XVI	118	"	"	13.6	8.0
VIII	59	"	very bad	12.3	18.9	XVII	119	"	"	13.2	13.8
VIII	60	heavy	"	12.4	11.6	XVII	120	hv.adobe	very bad	14.8	7.7

NOTE—af.—affected. v. h.—very heavy. l.—loam. lt.—light. hv.—heavy anything they point to a relation between the yield and the percentage of sugar rather than to one between the virulence of the attack and this percentage. I do not know the actual average percentage of sugar in the crop of 1910 for the whole valley but it was about 14.0 percent and not above 14.2 percent. It is true that the leaf-spot was very prevalent in the valley during this year, and may have influenced the general average, but the results shown by this compilation of returns from 120 fields representing nearly 2,500 acres, attacked with varying degrees of virulence, leads one to question very seriously whether we have not attributed a more injurious effect to this fungus than the facts justify. We have no other way that I see of judging of these effects than the one here adopted, namely, of taking a large number of fields in the same section of country, noting the virulence of the attack and comparing the yields and average percentages of sugar obtained by taking a sample from each load of beets as it is delivered at the factory or dump. We admit that there may be errors in the determinations but when we take the average of from two loads to four hundred or more loads our approximation to the truth is very close, besides we are not dealing with differences of a tenth or two of one percent, but as a glance at the table will show, with maximum differences of several percent. A cursory examination of the tabulated results makes it evident that we cannot compare the samples of one district with those of another. We have, for instance, in District No. I, very badly affected fields of from six to twelve acres in area, giving averages ranging from 14.7 to 16.5 percent sugar and yields between 12 and 18 tons per acre, while in District No. XVI we have slightly affected fields of 15 to 20 acres in area, giving averages ranging from 12.5 to 15.2 percent of sugar in the beets and yields of from 8 to 10 tons per acre. In District No. II in which the fields are mostly about 20, but one was much larger, we have eight fields, the lowest average is 13.5 and the highest 15.75 with yields of from 7 to 12 tons. These fields were all very badly affected. In District No. VI we have likewise eight fields either badly or very badly affected. These fields vary from 12 to 65 acres in area. The lowest average percentage of sugar in these beets was 11.8, the highest 13.0, the yields ranged from 7 to 16.5 tons per acre. The irregularity of the results in a given district is altogether disconcerting. We can select from these a series of results which can be so arranged as to make it appear that the action of the leaf-spot is to lower the percentage of sugar and to lessen the tonnage of beets, which we would expect to be the case, but this would be a case of finding facts to prove a theory. The fact is we find in the same district cases of very badly affected fields yielding excellent beets, 15.9 percent sugar, and 11.4 tons and other fields only slightly affected yielding beets with 14.7 percent sugar and

11.1 tons, again 14.1 percent sugar, 11.5 tons. In another district a very badly affected field yielded 14.2 tons per acre with 14.6 percent sugar in the beets and a slightly affected field yielded 11.2 tons with 15.2 percent sugar in the beets. The 127 fields selected from different districts and showing the effects of the leaf-spot in varying degrees show a tonnage and sugar content quite up to the average. The higher percentages in some of the samples cannot be attributed to the drying out of the beets in the ground for the ground was as moist as in other fields and the beets continued to produce new leaves, in other words, to grow. Neither the percentage of sugar in the beets nor the yield of beets in the various districts show such persistent and concordant relations to the virulence of the attack as to make evident beyond doubt the kind and extent of the injury to be attributed to this disease.

I have said that it is not permissible to compare the results obtained in one district with those obtained from another, much less is it permissible to compare results obtained in one section of the state with those obtained in another; for instance, the Department of Agronomy at the College had two small fields planted to sugar beets in 1910. There was some leaf-spot on them. The fields were planted early, the varieties were good ones, the seed reliable, the cultivation and stand were also good and the soil most excellent in quality; there was no reason why either the yield of beets or the percentage of sugar should be low, but the yield was seven tons per acre and the best percentage of sugar obtained from any sample taken was 13.3 with a coefficient of purity of 79.6. The leaves on these beets were exceedingly heavy and remained green till actually frozen, about Nov. 7. No one who saw this field would for a moment think of attributing the disappointingly low yield, the low percentage of sugar and low coefficient of purity to the damage done by the leaf-spot, for while leaf-spot was present the foliage was not damaged in any noticeable degree. It would be wholly wrong to attempt to compare such a field as this with the fields in the Arkansas Valley.

There is no question but that water will drown plants and that alkali may be so excessive and of such composition as to kill them. The question to be answered is whether they have done as much damage as we think them to have done or are we attributing bad effects to these causes which are due to others? I think that we are doing the latter to a very considerable extent. There is no question but that to fertilize the soil is a good and proper thing to do. The question is how much relief have we to expect from this? We have given the best answer that we can so far as the yield of beets and the percentage of sugar is affected by the usual fertilizers used for this purpose, i. e., nitrates, ammonia salts, dried blood, superphosphate, potassic sulfate, etc., under our conditions of climate and soil. The answer is that the results have not been such as to justify any expectation of a sufficient increase in yield of beets or percentage of sugar to be at all profitable. We shall in subsequent paragraphs present their effects upon the composition of the beet.

As our chief fungus disease, up to the present time, has been the leaf-spot, which is generally supposed to be dependent upon climatic conditions for its rapid development, and no one can doubt its very rapid development and general distribution in the Arkansas Valley in 1909 and 1910, we have presented such facts as are available, and which we think properly usable in this case, to show to what extent we are justified in attributing severe damage to the crop to this cause. While the leaf-spot certainly destroys the foliage and probably affects both the sugar content and yield of beets the extent of the injury done by this fungus is not very clearly shown, at least not by the observations of 1910. There are, on the other hand, clear indications that whatever may be the influence of the leaf-spot, soil conditions are quite as potent if not more so, in determining the yield and sugar content of the crop.

After having described the effects of excessive quantities of nitrates in the soil upon the apple tree in Bulletin 155, I added, "This is the only effect of this soil condition that I wish to present at this time though there are other serious agricultural conditions which I believe we will find attributable to this cause, i. e., to an excess of nitre in the soil. Sometimes due to too much at one time as is attested by the death of apple and also other kinds of trees, sometimes to too great an aggregate supply during the season. The following may illustrate what I mean by the latter statement. It is generally conceded that the application of nitrates to the sugar beet, except in the earlier stages of its growth, is detrimental to the quality of the beet." It has been and is now recommended that if nitrate is to be used on this crop that it be applied just before planting the seed. I understand that in some parts of Germany they now apply some nitrate as late as the middle or latter part of June. Touching upon this point in Bulletin 155 I put the question as follows: "But what will be the condition of the crop if it receives a continuous supply, amounting, during the season, to 600 or 800 pounds (of nitrate) or is planted in soil which already contains several times this amount per acre? If the assumption that nitrates, when present in large quantities, injuriously affect the quality of the beet be true, then beets grown in such soils ought to be very poor in quality, but not necessarily in crop." We, at that time, October 1909, endeavored to establish the amount of nitric nitrogen in the soil of one of the fields on the College farm, a part of which was planted to beets. I think that eight parts of nitric nitrogen per million of soil may be taken as the maximum amount that occurs in ordinary soils, and I doubt whether this quantity is usually maintained throughout the season. In samples taken to a depth of two inches, October 7, 1909, we found, in a fallow spot in the beet field 12 p. p. m., in a fallow portion of another plot 22.5 p. p. m. and in the space between the beet plots 35 p. p. m. On October 18 we again found 35 p. p. m. in a fallow spot in the beet field. On the other hand, samples of soil taken on the same dates from among the beets, i. e., between the beets in the row, showed from 1 to 4 p. p. m., and samples taken between the rows showed only from 1 to 5 p. p. m., but in the space between the rows which happened to be devoid of plants, was fallow, we found 28 p. p. m. We found that in land which had been cropped to grain from 2 to 8 p. p. m., in a cornfield 8 p. p. m., in an oat field 1 p. p. m., in virgin soil from the prairies, 8 p. p. m. Again, we gave the nitric nitrogen found in 46 samples of soils taken from as many different beet fields. These samples were kindly furnished me by the Holly Sugar Co. and were taken to a depth of six inches, October 1-15, 1909. The nitric nitrogen ranged in these samples from a trace to 160 p. p. m. Seventeen of the forty-six samples contained materially above 8 p. p. m. of nitric nitrogen. I do not know where these samples were taken, in the rows, between the rows or at the edge of the field and for this reason I obtained another set of 54 samples taken from 18 fields, or three from each field as follows—in the rows of beets, between the rows and in the turn row. These samples were taken six inches deep. Of the 18 samples taken in the beet rows four of the samples showed the presence of more than 8 p. p. m., but did not exceed 15 p. p. m., one sample showed 50 p. p. m.; of those taken between the rows, five samples showed more than 8 p. p. m., with 30 p. p. m. as the maximum; of those taken in the turn rows, eight samples showed more than 8 p. p. m., with the maximum of 140 p. p. m. These data were collected to show in the first place how much nitric nitrogen we may consider as normally occurring in our soils, i. e., in good soil and under fair conditions. Our farm samples fully meet these conditions, the weather had been fair and no irrigating water had been applied for weeks, so that the nitric nitrogen had not been leached out, and as the fallow ground was covered with a thick layer of fine earth capillary action was minified and our samples give us, I believe, reliable results. They show that at this place, land in crops other than alfalfa contains less than 8 p. p. m., and that well conditioned, good soil, lying fallow, acquires nitric nitrogen in quantities very much in excess of this, up to 35 p. p. m. having been obtained. In the samples from the Arkansas Valley, which represented cultivated, and at least average fields, we found a maximum of 160 p. p. m. in the soil collected in October and taken to a depth of six inches. This quantity is very large, speaking from the standpoint from which we are accustomed to consider this question, but is very much below excessive occurrences with which we meet in case of some lands actually planted to beets. This figure, 160 p. p. m., calculated as sodic nitrate, is equal to 960 p. p. m., or taking the top six inches of soil as weighing 2,000,000 pounds, we would have 1,902 pounds of this salt within reach of a growing crop. It is not proven nor do we wish to assert that the beet crop grown on the College farm in 1909 actually used up an amount of nitrates represented by the difference between the amounts found in fallow spots in these beet plots and in the ground between the beets, but we do hold it as fully proven that the conditions obtaining in our soils make it probable that unless some prohibitive condition exist the beets grown on this particular piece of ground will be furnished with so liberal a supply of nitrates as to be detrimental to the quality of the crop. This means that this land will be apt to produce top or turnip-shaped beets, with big crowns, heavy foliage, a very moderate sugar content and a low coefficient of purity, unless the season be unusually long and permit of their maturing. The facts in this case will be taken up later.

Here be it stated with emphasis that I do not propose to explain all the ills that beset the sugar beet crop by attributing them directly or indirectly to the formation of nitrates in the soil, but I do claim that we have here an old question in such an intense form as to practically become a new one of the most serious import to the industry of producing sugar from the beet root in large sections of, if not in the whole of the state. My object has been to try to find out to what extent my views are in harmony with the facts and I am happy to believe that, in trying to do this, I have the good will of the people most directly concerned, for they have become fully convinced that there is a big problem involved which has not yet been solved. This is the real reason why I have discussed in their bigger features the questions of seepage, of alkali, of fertilizers, of the leaf-spot and their effects upon the crop and its sugar content. No one knowing very much about Colorado agriculture would deny or attempt to minify the importance of these questions; they are real questions, but, on the other hand, persons with only a very moderate knowledge of our agricutural problems or men engaged in this pursuit when brought into actual contact with problems which they cannot solve, whose solution is perhaps unknown, are apt to assign a role to known or visible agencies which belong to wholly different ones. In the estimation of the public, alkali has, from the beginnings of our agriculture, been a veritable *bete noir*, likewise an excess of water. The latter of course presents important questions but the question is whether we have not, in too great a measure laid upon these things the iniquity of our ignorance. We are likewise in danger of going to the other extreme in placing our hopes and confidence in the virtues of fertilizers. It is too late in the development of agriculture to question their benefits but it is no sin even in the presence of the learned to assert that there are limitations to their beneficent effects and that there are yet unsolved questions pertaining to their use and action. This is the frame of mind in which I approach the questions presented in this bulletin free enough I hope from prejudice to state the whole case, and frank enough to be inconsistent or even contradictory if the facts require it. I have no desire to run counter to established teachings, but simply to learn the lessons that are presented by our practice, and only wish that I were more adept in learning them.

I wish to again state that Colorado, owing to its size and position, presents a variety of conditions which many persons fail to properly consider. I have had no occasion to study the problems of the beet crop in the valleys of the Poudre, the Platte, the Uncompahgre or the Grand rivers, had I had and were I presenting the results of such a study they would in all probability be stated somewhat differently from the present ones.

This Station has published four Bulletins, 155, 160, 178 and 179, on the Fixation of Nitrogen in some Colorado Soils. The occurrence of very large amounts of nitrates in some of our soils is fully demonstrated, also that fixation takes place rapidly in them under favorable conditions and still further that nitrification takes place rapidly enough to account for very considerable quantities of nitrates in these soils.

Allusion has been made to the facts leading directly to this study, namely, the following questions which were propounded, why do not our beets ripen and keep better? Why have they fallen off in sugar content despite improvement in seed? Why do they produce so much molasses?

These questions represent facts serious enough in their importance to justify any effort to answer them and if we learn only a part of the truth we will have made some progress. The work done in the preparation of Bulletin 155 prepared me to believe it to be possible that nitrates might actually be developed on so large a scale as to account for the lengthened vegetative period of the beet; its green condition at the time of harvesting might easily account for its ready deterioration, and to this immaturity of the beet with the presence of nitrates might fairly be attributed the high percentage of molasses produced. I tested samples of Steffens waste water, molasses, and beets for nitric acid and found it present in such quantities as to be easily detected. This seemed to me more suggestive that not only the molassegenic action of the nitrates but the immaturity of the beet when harvested, due to the presence of the nitrates in the soil, might be largely accountable for the excessive quantity of molasses produced. With these facts in my possession I had no difficulty in interesting the representatives of the American Beet Sugar Company in Colorado. Mr. Winterhalter was already making experiments with artificial fertilizers, not with this phase of the problem in view but it offered me an opportunity to study it in this connection. We extended the line of experimentation to include the influence of nitrates when applied in medium quantities throughout the season upon the working or factory qualities of beets. There was placed at my disposal six acres of land, the most desirable in quality of all the lands available. It had been in beets in 1909, grown by a tenant and not manured; the soil was a sandy loam with two or three spots which were somewhat gravely. All of the land had received a dressing of ten tons of stockyard manure per acre which was plowed under to a depth of ten inches. The piece was divided into six plots of one acre each. All of which were planted with Original Kleinwanzlebener seed, crop of 1909, on April 1, 1910. One acre was chosen as a check plot, the other five acres each received a dressing of 250 pounds of Chile-saltpetre two days before the seed were planted. Beets were irrigated up April 9-11 and thinned May 23-26. On May 2 four of the fields each received a dressing of 250 pounds of nitrate; on June 1 three of the fields; June 22 two of the fields, and on July 27 one field received a dressing of 250 pounds. This gave us plots of one acre each which received the following quantities of nitrate: Field A, 250; B, 500; C, 750; D, 1,000; E, 1,250 pounds of nitrate distributed in applications of 250 pounds each at intervals of approximately four weeks, beginning March 28 and ending July 27. These fields were irrigated April 9, June 17, July 1, July 10, July 30, half of the fields on August 17 and the other half August 30. The dates given are those on which the irrigations were completed. All plots were thoroughly cultivated. In order to combat the leaf-spot, Fields A and B were sprayed with standard Bordeaux mixture, July 21, August 1, 13 and 21 and September 7; Field C was sprayed July 22, August 3, 13, 28 and September 8; Field D was sprayed July 22, August 16. 28 and September 8; Field E was sprayed July 23, August 16, 28 and September 9; Field F, the check, was sprayed July 23, August 16, 28 and September 9. The total rainfall during the season from March 28 till September 22 was 9.99 inches. One-half of each field was harvested October 6-8, the other half November 9-11. This constitutes the cultural data pertaining to these fields.

Another experiment was to see what effect, if any, the application of superphosphate, muriate of potash and sodic chlorid, used alone and in conjunction would have on beets growing in ground which was rich in nitre. I knew of a piece of land of this nature which was planted to beets, and through the kind offices of Mr. Winterhalter we obtained the permission of the owner to apply these fertilizers to test plots of about one-eighth of an acre each. The fertilizers were applied at the following rates: Superphosphate, 1,000 pounds per acre; Muriate of potash, 400 pounds per acre; Salt, sodic chlorid, 400 pounds per acre. The same quantity of each was used whether it was applied alone or in combination. . The fertilizers were applied July 5 by hand and so distributed that none of the fertilizer was nearer than four inches to the plants, as it would be worked closer to them by cultivation.

I had seen the crop of beets on this land in 1909 and it was poor. I expected to see a similar but poorer crop in 1910. I saw the field in late June and the promise was only fair. I saw it again in August when all my predictions of a poor crop were thoroughly discredited so far as the promise of a crop was concerned. I do not think that I have ever seen such a growth of beet leaves They stood easily thirty-eight inches high, and later when a very large amount of foliage had been killed by the leaf-spot the remaining foliage stood thirty inches high. It seemed ridiculous that we had ever entertained a thought of modifying the growth and character of such a crop by the addition of a thousand pounds of superphosphate or a few hundred pounds of muriate of potash to the acre. The crop of roots, however, was somewhat of a disappointment and the quality of the beets was of all sorts, from good to very poor, according to the part of the field from which they were gathered.

We have now stated the lines of experimental field work for 1910: First to determine the effects of nitrates upon the quality of the beets; second, to study the effects of fertilizers on the quality of beets; third, to see whether the addition of superphosphate, phosphoric acid, potash or ordinary salt would so hasten the maturity of the beet or otherwise modify its growth as to correct the effects of an excessive amount of nitre. There can be no question about the presence of an excessive amount of this salt in this field, even at the present time.

What I have said relative to the beets produced in the different districts of the Arkansas Valley applies with full force to other districts.

STANDARDS ADOPTED.

So far as the ordinary analysis is concerned I do not know what to take as standard. We certainly cannot take German results as standards for our beets. For some reason our beets are richer in ash constituents than the German beets, and also differ in other respects, but these differences will be stated in another place. It is very difficult to determine what we should adopt as a standard beet. This is a small matter so far as the percentage of sugar is concerned because the differences are so great and the average sugar content of the beet, as it now grows in the Arkansas Valley, is so much lower than it was six and ten years ago that all will agree that the beets are poor in this respect whatever standard may be adopted. The matter is not so easy when it comes to the question of composition. It is evident that, for my purposes, I can scarcely take Colorado grown beets, on the other hand foreign beets, viz: German beets, grown under entirely different conditions of cultivation, soil, and climate, can not safely be adopted, even though the beets may have been grown from the same strains of seed. We shall very largely use German data, because it is the best to which I have access, but this will not relieve me from the necessity of using certain beets as standards of comparison. I have chosen one sample of beets from Michigan, one from Montana and one from the Poudre Valley, Colorado, for this purpose. The latter probably represents the highest grade of Colorado beets.

The following German data are taken from an article by K. Andrlik, Zeitschrift des Vereins der Deutschen Zuckerindustrie for 1903, pp. 906-937. The analyses are of fresh cossettes.

ANALYSES OF GERMAN BEETS.

	I.	II.	III.	IV.	V.	VI.
Dry substance	25.450	25.250	23.360	34.400	22.800	25.020
Sugar	16.600	16.900	15.880	16.800	14.500	17.200
Crude ash	0.800	0.806	0.919	0.813	0.784	0.746
Fine ash	0.634	0.631	0.581	0.562	0.636	0.557
Injurious ash	0.386	0.391	0.315	0.297	0.400	03.35
Total nitrogen	0.257	0.252	0.210	0.199	0.306	0.186
Proteid nitrogen	0.113	0.112	0.110	0.107	0.120	0.109
Injurious Nitrogen	0.114	0.112	0.088	0.082	0.141	0.070
Potassic oxid (K_2O)	0.292	0.297	0.228	0.218	0.242	0.254
Sodic oxid (Na_2O)	0.047	0.043	0.046	0.044	0.076	0.043
Calcic oxid (CaO)	0.042	0.046	0.064	0.065	0.054	0.060
Magnesic oxid (MgO)	0.074	0.075	0.065	0.066	0.094	0.063
Iron and alumnic oxid $(FeAl)_2O_3$	0.030	0.026	0.054	0.049	0.036	0.090
Phosphoric acid (P_2O_5)	0.094	0.093	0.084	0.085	0.042	0.084
Sulfuric acid, SO_3	0.033	0.038	0.033	0.027	0.034	0.027
Chlorin (Cl)	0.014	0.013	0.008	0.008	0.038	0.011
Insoluble	0.098	0.099	0.344	0.241	0.037	0.125
Percentage Composition of the Ash.*						
Potassic oxid, K_2O	36.500	36.970	24.900	26.790	30.900	34.030
Sodic oxid, Na_2O	5.880	5.370	5.000	5.500	9.700	5.730
Calcic oxid, CaO	5.750	5.710	7.010	7.980	0.890	7.530
Magnesic oxid, MgO	9.270	9.300	7.110	8.180	12.000	8.520
Iron and aluminic oxid $(Fe\ Al)_2O_3$	3.840	3.240	5.920	6.110	4.630	4.020
Phosphoric acid, P_2O_5	11.760	11.500	8.660	10.290	5.330	11.200
Sulfuric acid, SO_3	3.840	4.700	3.520	3.260	4.340	3.800
Chlorin, Cl	1.770	1.630	0.890	0.800	4.590	1.400
Insoluble	12.260	12.230	37.480	29.640	4.690	16.850

*These percentages have evidently been calculated on the crude ash.—H.

These analyses present the fullest statement of the composition of German beets that I have found and they represent samples of cossettes from six factories. The details of the methods used are fortunately given with sufficient fullness to enable one to know on what basis the results may be compared with others.

As already stated, I have chosen as standards of comparison one sample of beets from Montana, one from Michigan, and one from Colorado, grown in this, the Poudre Valley, section. The German results may serve as guides to aid us in judging, but not as standards of comparison for our beets. The Montana beets were grown in a sandy loam soil, probably alkaline. The Michigan beets in a non-alkaline soil, and the Colorado beets in a soil which was probably alkaline but under favorable conditions. The history of the field in which the Colorado sample was grown was as follows: soil, sandy loam, fifth year in beets, no fertilizer of any kind had been used on it; plowed 25 March 1910, seed planted 15 April, plants blocked and thinned 15 June, irrigated 10 August and 1 Sept. The supply of water was small. The yield was ten tons per acre, and the percentage of sugar in the beets as they were delivered at the factory by the wagon load was from 16 to 20 percent.

The methods of analysis used were the same throughout the season and are sufficiently indicated by the statement of the analyses:

Owing to the fact that we have exceptionally large percentages of chlorin in some of our ashes, I have in stating the composition of the pure ash given, as a rule, the metallic sodium or sodium and potassium corresponding to the chlorin to avoid including the chlorin and its oxygen equivalent in the same statement, which would introduce too big an error in cases in which the chlorin in the carbonated ash equals from six to twelve or more percent, otherwise the statement of these analyses is the conventional one, giving the acids as anhydrids and the bases as oxids. The silicic acid has been omitted from the pure ash because I fear that the larger portion of it is derived from the fine sand due to fluxing.

Andrlik states that the amounts of injurious ash and nitrogen are safe criteria whereby to judge of the quality of beets. He defines injurious ash as the sum of the alkalis, sulfuric acid and chlorin, and injurious nitrogen as the difference between the total nitrogen and the sum of the albuminoid, ammonia and amid-nitrogen. In the six analyses quoted we observe that the injurious ash varies from 0.3 to 0.4 percent of the weight of the beet, while the injurious nitrogen varies from 0.07 to 0.14 percent of the beets. I have been unable to find any statement of the lowest amount of injurious ash which is to be considered as decidedly objectionable, or stated otherwise, the permissible amount of injurious ash. In regard to the injurious nitrogen, however, it is stated that the injurious nitrogen multiplied by ten gives approximately the amount of amido-acids and betain. It is further stated that on calculating these substances on one hundred parts of sugar that we obtain from 3.7 to 9.3 parts.

ANALYSES OF BEETS ADOPTED AS STANDARDS.

See Analyses CLXXXV and CLXXXVI, page 172 for analysis of Montana beets.

	VII.	VIII.
Where grown	Michigan	Ft. Collins, Colo.
Date of harvesting	2 Nov. 1910	3 Nov. 1910
Average weight, trimmed	813.0 grams	673.0 grams
	Percent	Percent
Sugar	15.30000	18.30000
Dry matter	22.00000	24.20000
Crude, carbonated ash in dry matter	3.23500	3.33900
Crude ash in beet	0.70170	0.82038
Pure ash in beet	0.49300	0.60887
Sulfuric acid	0.02930	0.02802
Phosphoric acid	0.06236	0.07620
Chlorin	0.00285	0.01941
Sodium	0.00185	0.01262
Potassic acid	0.26382	0.31690
Sodic oxid	....	0.02538
Calcic oxid	0.04550	0.04694
Magnesic oxid	0.07573	0.07932
Ferric oxid	0.00621	0.00182
Aluminic oxid	0.00236	0.00131
Manganic oxid	0.00170	0.00170
Total nitrogen	0.22915	0.20750
Proteid nitrogen (Stutzer)	0.12305	0.08710
Ammonic nitrogen	0.00596	0.00230
Amid nitrogen	0.02160	0.00290
Amino nitrogen	0.04794	0.07479
Nitric nitrogen	0.00320	0.00096
Injurious nitrogen in beet	0.07854	0.11520
Injurious ash per 100 sugar	1.94476	2.19672
Injurious nitrogen per 100 sugar	0.51287	0.62899
Press Juice According to Ruempler.		
Total nitrogen	0.19195	0.11675
Albumin nitrogen	0.05835	0.04230
Propeptone nitrogen	0.00030	0.00790
Peptone nitrogen	?	0.00350

Ash Analyses.

	IX. Crude	IX. Pure	X. Crude	X. Pure
Carbon	0.628	.....	0.480	.....
Sand	6.532	.....	2.115	.....
Silica	1.165	.....	0.112	.....
Sulfuric acid	4.117	5.944	3.415	4.602
Phosphoric acid	8.763	12.650	9.288	12.515
Chlorin	0.400	0.578	2.366	3.188
Sodium	.....	0.376	.....	2.073
Carbonic acid	20.233	.....	21.603	.....
Potassic oxid	37.055	53.496	38.627	52.053
Sodic oxid	0.255	.....	5.165	4.168
Calcic oxid	6.392	9.229	5.721	7.710
Magnesic oxid	10.641	15.361	9.656	13.011
Ferric oxid	0.873	1.260	0.214	0.295
Aluminic oxid	0.526	0.760	0.163	0.215
Manganic oxid	0.240	0.346	0.126	0.170
Loss, organic matter, etc.	(2.270)	.....	(0.603)	.....
Sum	100.090	.....	100.534	. .
Oxygen equi. to chlorin.	0.090	.....	0.534	... .
Total	100.000	100.000	100.000	100.000

"The former amount indicates a good, the latter a bad diffusion juice." It is further shown in the same article that 92.3 percent of the injurious nitrogen and from 70.9 to 80.3, usually 75.3 to 79.9 percent, of the injurious ash of the beet goes into the diffusate.

In 1910 I endeavored to obtain beets as standards for comparison with ours which we knew to be good beets and which worked well in the factory, for these reasons we chose a sample from Fort Collins with 18.3 percent sugar and one from Michigan with 15.3. We found the injurious ash in the former to equal 2.197 per 100 sugar, in the latter 1.945, the injurious nitrogen to equal 0.629 and 0.513 per 100 sugar respectively and the ratio of proteid to total nitrogen 41.9 percent and 53.7 percent. In the press juice we find the albumin nitrogen forming 36.2 and 32.0 percent respectively of the total nitrogen. The injurious nitrogen in the beet constitutes 55.5 and 34.3 percent of the total. The pure ash in the Michigan beet is approximately 83.33 percent of that in the Fort Collins beet. These are the principal feature in the composition of these beets, but it may be permissible in this place to state that the pure ash in these beets, 0.6088 and 0.4930, is quite within the range that I find given, especially by Andrlik, for Austrian or Bohemian beets. The points of interest in these ashes are that the phosphoric acid calculated on the fresh beet is fairly high, the potassic oxid is very high, which is the case with the magnesic oxid also, while the calcic oxid is low. The nitrogen is almost identical with the average found for German beets over a period of seven years by the Experiment Station of Lauchstaedt, but according to other figures I find that over 50.0 percent of the samples fall below 0.2 percent. The chlorin in these samples is quite low.

In 1911 a favorable year, I was fortunate enough to obtain through the kindness of Mr. Hans Mendelson of the Great Western Sugar Company a sample of beets grown by himself in Montana. The variety was a strain of his own production, No. 311, and had been siloed for three months or more before it was sent to me. Mr. Mendelson has kindly furnished me the following data relative to the cultivation of these beets. "The land is a sandy loam, had been planted to grain for eight years in succession up to 1909. In 1910 was planted to field peas, after harvest the field was disced, irrigated and sown to rape. This was pastured off in the fall by sheep and in the spring handled in the usual manner. The rows were 20 inches apart and the beets 8 inches apart in the rows. The growing crop showed every indication of a lack of nitrogen, still a fertilization with 200 pounds of nitrate did not produce the expected increase, indicating some other deficiency, in this case a lack of moisture in the subsoil."

These beets were of excellent shape and varied considerably in size. Their condition was perfect, they had been carefully packed and they were crisp, like freshly pulled beets. Apparently no drying out had taken place. The climatic conditions of the locality where these beets were grown are very favorable. The location was selected for this reason. There were eleven beets in the sample. The analysis follows:

ANALYSES OF MONTANA BEETS, SEASON 1911.

Fertilized with 200 Pounds Sodic Nitrate per Acre.

	CLXXXV.
Average weight of beets	566.3 grams
Av. wt. of beet trimmed	479.3 grams
	Percent
Sugar in beets	18.24000
Dry substance in beets	25.37000
Crude ash in dry substance	2.68000
Pure ash in dry substance	1.93500
Pure ash in fresh beet	0.49090
Sulfuric acid	0.01734
Phosphoric acid	0.08117
Chlorin	0.00761
Sodium	0.00495
Potassic oxid	0.25507
Sodic oxid	0.01312
Calcic oxid	0.03164
Magnesic oxid	0.07512
Ferric oxid	0.00224
Aluminic oxid	0.00086
Manganic oxid	0.00175
Total nitrogen	0.10494
Proteid nitrogen (Stutzer)	0.06995
Ammonic nitrogen	0.00199
Amid nitrogen	0.00251
Amino nitrogen	Not det.
Nitric nitrogen	None
Injurious nitrogen in beet	0.03050
Injurious ash per 100 of sugar	1.67240
Inj. nitrogen per 100 of sugar	0.16722

Press Juice According to Ruempler.

Total nitrogen	0.07797
Albumin nitrogen	0.04101
Propetone nitrogen	0.00172
Peptone nitrogen	0.00245

Ash Analysis.

	CLXXXVI. Crude	Pure
Sand	3.124	.....
Silicic acid	1.059	.....
Sulfuric acid	2.550	3.523
Phosphoric acid	11.939	16.536
Chlorin	1.119	1.550
Sodium	.....	1.008
Carbonic acid	21.225	.....
Potassic oxid	37.515	51.962
Sodic oxid	2.910	2.637
Calcic oxid	4.654	6.446
Magnesic oxid	11.049	15.304
Ferric oxid	0.330	0.457
Aluminic oxid	0.127	0.176
Manganic oxid	0.257	0.356
Loss	(2.394)	.....
Sum	100.252	.....
Oxyg. equi. to chlorin	0.252	.....
Total	100.000	100.000

These beets are, according to all the criteria whereby we judge beets, of the very best quality, the percentage of sugar is high, 18.24 percent, the injurious ash is low, 1.67 per 100 of sugar, the injurious nitrogen is only 0.16722 per 100 sugar, the ratio of proteid nitrogen based on Stutzer reagent is 66.68 percent and on the determination of albumin according to Ruempler is 52.6 of the total nitrogen in the juice. Andrlik in discussing the ratio of proteid nitrogen to the total nitrogen calls attention to the fact that the ratio of proteid nitrogen to total increases as the beet ripens and that the proteid nitrogen may reach 70 percent of the total in ripe beets with a low percentage of nitrogen. The pure ash in the fresh beet is not especially low, 0.4909 percent, but the phosphoric acid is as high as in German beets, which is not the case with Colorado beets, and there is no nitric nitrogen. In fact there are only two features in the composition of these beets which are common with those of Colorado, they are the amount of potassic oxid in the beet, 0.25507 percent in this and 0.25 to 0.56 in Colorado beets, and the ratio of the calcic to the magnesic oxid, this being about 1 to 2½. The Experiment Station at Lauchstaedt gives 0.17948 percent as the average percentage of potash for seven years for beets grown with complete fertilizers and it is essentially the same for beets grown without fertilization, 0.16959 percent. The sample from Michigan and also that from Fort Collins used as provisional standards show the same peculiarities of composition. The sugar content in these is 15.3 and 18.3, the pure ash in the beets 0.49300 and 0.60887, the phosphoric acid 0.062 and 0.076, potassic oxid 0.26382 and 0.31690, the nitric nitrogen 0.0030 and 0.0009, the injurious ash per 100 sugar 1.94476 and 2.19672, the ratio of the proteid nitrogen to the total is 53.7 and 41.9. The ratio of calcic to magnesic oxid is approximately 9:15 and 7:13.

According to these criteria our Montana sample alone equals or excells in quality No. VI of Andrlik's series. His No. VI contains for each 100 pounds of sugar 4.0 parts of injurious nitrogenous compounds (injurious nitrogen x 10) and 1.94 parts of injurious ash. The Montana sample contains 0.17 part injurious nitrogen and 1.67 parts of injurious ash per 100 of sugar, while the Michigan beets contain 5.13 parts injurious nitrogenous compounds and 1.94 parts injurious ash, and the Fort Collins beets contain 6.3 parts injurious nitrogenous compounds and 2.2 injurious ash. I do not know how much molasses these beets produced or any of the details of how they worked in the factory. We cannot, however, so far as I see, hope to obtain any better standards for our beets than these.

We took three sets of samples during the season of 1910, 23 Sept., 11 Oct., and 3 Nov., in order to follow the development of the beet so far as samples taken at such intervals might indicate it. Our battery experiments with these beets were made Nov. 10-16, 1910.

There are several classes of beets represented: First, such as were grown on ordinary, good soil, without the addition of any fertilizers; second, such as were grown on good soil with the addition of the ordinary fertilizers in various quantities and in different combinations; third, such as were grown on good soil with the application of different quantities of sodic nitrate; fourth, such as were grown on soil in which excessive quantities of nitrates had developed. As the land on which the fourth class was grown was known to us to be bad we made some experiments in the way of remedial measures. There were applied to different portions of it superphosphate, muriate of potash and sodic chlorid—so there are four sub-series under this one, i. e., one series corresponding to each of these fertilizers and a check series. Fifth: Beets grown with green manure; sixth, beets grown on College Farm at Fort Collins.

There are in addition to these, three series grown at Fort Collins in 1911.

The questions involved are unfortunately more complicated than even agricultural questions ordinarily are. We have, for instance, in the fourth class of beets, all of the questions which we have heretofore discussed. We have dry land and wet land with a comparatively low water plane, the presence of alkalis and, as the average man would judge, their absence. The presence of excessive quantities of nitrates in portions of the field and wholly different conditions in other portions. While leaf-spot was abundantly present, it was much worse in some portions of the field than in others.

The soil itself is not entirely uniform as it varies from a fine sandy loam to a more or less gravelly clay loam. These conditions undoubtedly produced their several effects and so modified one another. that it is impossible to analyze the results and correctly attribute a specific result in a given measure to each individual condition. We can only determine the extent to which for instance the application of 1,000 pounds superphosphate, 150 pounds of phosphoric acid per acre, affected the quality of this crop by means of check samples taken from the corresponding sections of adjoining rows.

It seems superfluous to state these facts, but on the other hand it is advisable in order that the reader may at least have our statement to show that we appreciate the difficulties of our problem, in some measure at least, and that we have duly considered the course that we have pursued in our work.

We have been compelled to take many samples, for the sake of confirming our observations and establishing their general validity under a variety of conditions. The difficulties presenting themselves in establishing what the composition of beets grown on unfertilized land is, are very great. The soils collected from beet fields in the Arkansas Valley at the end of the season and even those taken in January, 1910, to a depth of six inches, show by their varying quantities of nitric nitrogen how nearly impossible it is to judge of the amount of nitrates that may have been furnished to the beets during their growing period. Andrlik's experiment showed that the application of 528 pounds of Chile-saltpetre to the acre applied in three equal applications produced decidedly deleterious effects. The injurious nitrogenous substances amounted to 6.16 parts per 100 of sugar and the injurious ash to 1.89 parts per 100 of sugar in beets which had received this amount of saltpetre, against 2.36 parts injurious nitrogenous compounds, and 1.45 parts of injurious ash per 100 of sugar in beets grown without the addition of the nitrate. Apropos to these results Andrlik remarks that Chile-saltpetre applied in light and particularly in heavy applications acts unfavorably not only upon the quality of the beet, but also upon the harvest. The same author states that from 20 to 45 percent of the nitrogen and from 12 to 15 percent of the sodium oxid is appropriated by the roots. One would infer that the rest was used by the leaves or possibly remained in the soil. The former is much more possible than the latter. I have only a few determinations at my command to show how rapidly and completely the nitre applied to the soil may be appropriated by the plants. These results are very unsatisfactory but their general import is that both the rate and extent of the appropriation is rather great. Andrlik's results show that the increase of nitrogen recovered in the crop of beets was equal to 44.5 percent of the nitrogen applied as sodic nitrate in the case where the heavier application was made and 19.9 percent in the case of the lighter application. He did not consider the leaves except to mention the considerable increase in weight produced, from 2,000 to 2,400 pounds per acre. We shall, in the experiments of 1911, give some further data on this subject.

In collecting samples of beets grown without the application of fertilizers we are wholly unable to state how great or small a supply of nitrogen as nitrates they may have had during the season. The amount present at different times is variable and is influenced by so many causes that the aggregate supplied is difficult to estimate. We have among other conditions the influence of the crop itself as is shown by the work of Drs. Lyon & Bizzell, *Journal of Franklin Institute,* January-February, 1911. We made a number of determinations in 1910 to establish the different amounts of nitrates in the land cropped to beets and the same land not cropped. A single pair of these samples taken 18 October 1910 will show the difference that may be found. One of the samples was taken from a portion of a row where there were no beets; this was, then, a small spot within the patch which chanced to be without crop. Three samples were taken, the top two inches, the succeeding four inches and the succeeding six inches or twelve inches in all. The top two inches showed nitric nitrogen equivalent to 140 pounds of sodic nitrate per acre. The succeeding four inches gave 96 pounds of sodic nitrate, and the succeeding six inches gave 96 pounds sodic nitrate, or the top foot of this fallow spot which was small in area and surrounded by a luxuriantly growing crop, contained nitric nitrogen equivalent to 332 pounds of sodic nitrate per acre on this date Three other samples were taken in the same manner from a row of beets as near to this spot as was advisable with the following results. The top two inches gave 12.0 pounds, the succeeding four inches 1.7 pounds and the next six inches 2.6 pounds of sodic nitrate per acre. We have in this case a difference of 315.7 pounds between the amount of nitrate per acre in the fallow spot and that in the cropped land a few feet away. The questions in this case are: Was there as much nitrate formed in the cropped land as in the fallow land? Had the beet crop appropriated the 315.7 pounds? Or had the condition of being cropped prevented the formation of the nitrates, i. e., had the shading of the ground by a dense growth of leaves in some way retarded or prevented the formation of the nitrates or is there something in the roots of this crop which is inimical to these processes? The two sets of samples given above are not isolated ones. There are strips of land separating the series of experimental plots, and these gave, on the same date, essentially the same results; the surface foot of the fallow strip showed the presence of 321 pounds of sodic nitrate and the samples from the beet plot adjoining it 15.8 pounds. The preceding samples were taken at Fort Collins. I will give one set of samples taken at my request in the Arkansas Valley. This set of samples was taken to a depth of six inches, in the rows, between the rows and in the turn rows. The six inches of soil in the rows showed 180 pounds, that between the rows 360 pounds and that in the turn-rows 960 pounds of sodic nitrate per acre. These cases are not given for the specific purpose of raising questions relative to the formation and distribution of the nitrates in cropped and uncropped land, particularly to such as is cropped to beets, but to show that it is not safe to conclude that, because beets may have been grown without the application of fertilizers, particularly without the application of sodic nitrate, they have therefore had no abundant, perhaps prejudicial supply of nitrates. This may be true, but it is not proven by the fact that we did not add it. My fear is that the contrary is true, namely, that our beets often have a markedly prejudicial supply of nitrates furnished them during the season and that this is true in so large a percentage of beets grown for commercial purposes that the general result, in the Arkansas Valley and also elsewhere in the state, is a decided deterioration in the quality of the beets. The deterioration or the low quality of the beets in large sections is not seriously questioned but the cause thereof is not satisfactorily determined. I have considered some of the causes to which it has been attributed and have, as I believe, shown that whatever injury may be attributed to these causes, they are not sufficient to account for the facts as we find them and that there must be some other more generally applicable and at the same time sufficient cause for this deterioration.

The first class of beets to be considered is represented by beets grown on ordinarily good land without the application of any fertilizer. The sample of beets harvested 3 Nov. 1910, grown near Fort Collins, and an analysis of which has been given on page 37, has been given as a typical Colorado beet. The following samples have been taken from a variety of soils and should vary both on this account and also because they were taken from different localities. Eight of the samples were grown in 1910 and two of them in 1911.

It is a matter for general comment among the factory people that the beets grown in 1911 have worked much better than those of the past few years. I have had occasion to note that the whole development of the beet, especially in some sections, was entirely different from the usual development heretofore observed in these sections. I do not know the cause of this. It is difficult to believe it to be due to the water supply because it holds true that the development of the beets was very different in 1911 from that of previous years, for sections in which they had an abundance of water and also in some where there was a great scarcity of water.

The samples of this class have been taken from a variety of soils. Two of them were grown on virgin soil, sod land broken in the spring and planted shortly afterward to this crop. The water supply was very moderate, and while I do not know the rainfall and temperatures that they had during the season, the former may be safely assumed to be small and the latter high, as the locality was in the extreme eastern portion of the state and the land was up on the prairie far away from any flowing water. These are samples XI and XII. This field was harvested October 12-15 and averaged as delivered to the factory, 13.8 percent sugar, the separate loads ranged from 12.2 to 16.0 percent. The variety of the beets was not learned, but was probably a Kleinwanzlebener variety. Samples XIII and XIV were grown on the College Experiment Farm in 1911. No. XIII is Wohanka, richest in sugar, WZR—and No. XIV is Wohanka heaviest fielder, WER. Sample No. XV, a Kleinwanzlebener grown at Rocky Ford. Samples No. XVI and XVII, variety known only by number, College Experiment Farm. Samples No. XVIII, XIX and XX, Original Kleinwanzlebener, grown at Rocky Ford.

As we have a number of samples from this locality, I will give the rainfall for the growing season: April 2.57, May 2.14, June 0.33, July 2.99, August 1.52, September 0.03 inches. I have not the times and dates when each of the fields represented by my samples was irrigated but of some I have a complete statement of the treatment received. The importance of rainfall, i. e., the part played by rain water in our crop raising, depends upon the supply of irrigating water at our command throughout the season. In some sections this supply is always good, in others it is not. It would be too much of a digression to go into the question of the effects of water supply or irrigation at various periods of the growing season at this time. The subject has been discussed in several of the earlier bulletins of this Station. The observations recorded pertain to the crop and sugar content and not to the composition of the beet in greater detail. So far as our present purpose is concerned it may suffice to state that my observations do not justify me in making any positive assertions apropos to the subject. It is self-evident that plants must have at least a certain minimum quantity of water to keep them in a state of health and active growth. So long as this condition is fulfilled it seems that it would not matter whether this moisture is supplied by irrigating water or rainfall. This statement assumes that the condition of the soil is taken into consideration and is one of the factors determining the amount of water necessary to keep the beet in good condition and actively growing. The question of water-supply and its distribution during the growing season must be constantly considered in the study presented herewith.

ANALYSES OF BEETS, ORDINARILY GOOD SOIL.

	XI.	XII.	XIII.	XIV.
Date of harvesting	Sept. 23, 1910.		Oct. 12, 1911	
Average weight of beets	....	....	673.1 grams	788.4 grams
	Percent	Percent	Percent	Percent
Sugar	14.20000	12.40000	15.80000	15.30000
Dry substance	20.20000	19.20000	23.05400	23.07000
Soluble ash	3.25800	....	2.21250	2.29660
Insoluble ash	0.92200	....	1.18750	1.08700
Crude ash in dry substance	4.18000	....	3.40000	3.38360
Crude ash in beet	0.84436	....	0.78384	0.78060
Pure ash in beet	0.65529	....	0.55421	0.53066
Sulfuric acid	0.02460	....	0.02482	0.02281
Phosphoric acid	0.05786	....	0.06693	0.05260
Chlorin	0.09597	....	0.01129	0.01302
Sodium	0.02994	....	0.00734	0.00846
Potassium	0.05509	....	....	....
Potassic oxid	0.29559	....	0.28105	0.27639
Sodic oxid	....	....	0.05057	0.05235
Calcic oxid	0.02339	....	0.03131	0.03569
Magnesic oxid	0.05749	....	0.07010	0.06355
Ferric oxid	0.00337	....	0.00817	0.00343
Aluminic oxid	0.00108	....	0.00042	0.00263
Magnanic oxid	0.00201	....	0.00143	....
Total nitrogen	0.12530	0.13760	0.14388	0.14124
Proteid nitrogen (Stutzer)	0.06660	0.06830	0.07524	0.07154
Ammonic nitrogen	0.00200	0.00230	0.00224	0.00226
Amid nitrogen	0.00350	0.00630	0.00554	0.00564
Amino nitrogen	0.02575	0.04711	0.03817	0.04506
Nitric nitrogen	0.00358	0.00786	0.00870	0.00503
Injurious ash per 100 sugar	3.52950	....	2.37390	2.43820
Injurious nitrogen per 100 sug.	0.37440	0.48953	0.38529	0.40393
Press Juice According to Ruempler.				
Total nitrogen	....	....	0.12665	0.11869
Albumin nitrogen	....	....	0.04918	0.04772
Propetone nitrogen	....	....	0.00245	0.00564
Peptone nitrogen	....	....	0.00685	0.00537

Ash Analyses.

	XXI.		XXII.		XXIII.	
	Crude	Pure	Curde	Pure	Crude	Pure
Carbon	none	.....	none	.....	none	.....
Sand	1.391	.....	1.568	.....	1.429	.....
Silicic acid	0.217	.....	0.605	.....	1.164	.....
Sulfuric acid	2.912	3.754	3.166	4.479	2.939	4.299
Phosphoric acid	6.850	8.830	8.537	12.076	6.775	9.911
Chlorin	11.359	14.641	1.440	2.037	1.677	2.453
Sodium	.....	4.569	.....	1.324	.....	1.595
Potassium	.....	8.407	.....	.....	.....	.....
Carbonic acid	19.821	.....	24.052	.....	26.268	.....
Potassic oxid	42.852	45.109	35.851	50.712	35.601	52.080
Sodic oxid	4.776	.....	8.136	9.124	8.210	9.863
Calcic oxid	3.832	4.928	3.994	5.650	4.597	6.725
Magnesic oxid	6.803	8.773	8.941	12.648	8.186	11.975
Ferric oxid	0.410	0.517	1.042	1.474	0.421	0.615
Aluminic oxid	0.128	0.165	0.054	0.076	0.331	0.484
Manganic oxid	0.238	0.307	0.283	0.400	.....	.....
Loss	(0.969)	.....	(2.656)	.....	(2.780)	.....
Sum	102.561	.....	100.325	.....	100.378	.....
Oxygen equi. to chlorin	2.561	.....	.325	.....	.378	.....
Total	100.000	100.000	100.000	100.009	100.000	100.000

ANALYSES OF BEETS, ORDINARILY GOOD SOIL.

	XV.	XVI.	XVII.
Date of harvesting	Sept. 23, 1910.	Oct. 11, 1910.	Oct. 11,1910
Yield per acre	10.09 tons	7.0 tons	....
Average weight of beets	568.0 grams	368.24 grams	440.2 grams
	Percent	Percent	Percent
Sugar	14.40000	13.20000	13.30000
Dry substance	20.50000	20.30000	19.90000
Soluble ash	3.69100	3.70100	....
Insoluble ash	1.40700	0.87000	....
Crude ash in dry substance	5.09800	4.57100	....
Crude ash in beet	1.04509	0.92790	....
Pure ash in beet	0.88724	0.64629	....
Sulfuric acid	0.03030	0.02889	....
Phosphoric acid	0.04147	0.07342	....
Chlorin	0.13544	0.00484	....
Sodium	0.08800	0.00314	....
Potassic oxid	0.42640	0.28551	....
Sodic oxid	0.02557	0.12858	....
Calcic oxid	0.04150	0.03579	....
Magnesic oxid	0.08492	0.08122	....
Ferric oxid	0.00409	0.00217	....
Aluminic oxid	0.00324	0.00070	....
Manganic oxid	0.00475	0.00202	....
Total nitrogen	0.15630	0.18636	0.19810
Proteid nitrogen (Stutzer)	0.06600	0.09510	0.10030
Ammonic nitrogen	0.00277	0.00060	0.00280
Amid nitrogen	0.00563	0.00640	0.00797
Amino nitrogen	0.04125	0.03711	0.04154
Nitric nitrogen	0.01104	0.02138	0.02067
Injurious ash per 100 sugar	4.90010	3.41640	....
Injurious nitrogen per 100 sugar	0.56875	0.63840	0.65436

Press Juice According to Ruempler.

Total nitrogen	not done	not done	not done
Albumin nitrogen			
Propetone nitrogen			
Peptone nitrogen			

Ash Analyses.

	XXIV.		XXV.	
	Crude	Pure	Crude	Pure
Carbon	0.894	.....	0.553	.....
Sand	1.763	.....	1.792	.....
Silicic acid	1.652	.....	1.709	.....
Sulfuric acid	2.472	3.415	3.108	4.470
Phosphoric acid	3.383	4.674	7.895	11.360
Chlorin	11.042	15.256	0.521	0.749
Sodium	.....	9.918	.....	0.487
Carbonic acid	20.923	.....	24.941	.....
Potassic oxid	34.785	48.059	30.707	44.177
Sodic oxid	11.701	2.883	14.285	19.895
Calcic oxid	3.520	4.683	3.850	5.538
Magnesic oxid	6.928	9.571	8.736	12.567
Ferric oxid	0.334	0.461	0.255	0.336
Aluminic oxid	0.264	0.365	0.075	0.108
Manganic oxid	0.387	0.535	0.218	0.313
Loss	(2.387)	.....	(1.472)	.....
Sum	102.435	.....	100.117	.....
Oxygen equi. to chlorin.	2.435	.....	0.117	.....
Total	100.000	100.000	100.000	100.000

ANALYSES OF BEETS, ORDINARILY GOOD SOIL.

	XVIII.	XIX.	XX.
Date of sampling	3 Nov.	3 Nov.	3 Nov.
Yield tons per acre	11.6	11.6	....
Average weight of beets	497.0 grams	516.8 grams	575.1 grams
	Percent	Percent	Percent
Sugar in beet	14.30000	14.20000	12.70000
Dry substance in beet	19.90000	20.20000	20.00000
Crude ash in dry substance	4.51700	4.30200	4.99400
Crude ash in beet	0.89888	0.86900	0.99880
Pure ash in beet	0.63879	....	0.71760
Sulfuric acid	0.03130	....	0.03825
Phosphoric acid	0.04634	....	0.03342
Chlorin	0.04792	....	0.05755
Sodium	0.03276	....	0.03733
Potassic oxid	0.26374	....	0.23678
Sodic oxid	0.08661	....	0.17595
Calcic oxid	0.03533	....	0.03377
Magnesic oxid	0.09053	....	0.09956
Ferric oxid	0.00198	....	0.00247
Aluminic oxid	0.00155	....	0.00106
Manganic oxid	0.00082	....	0.00146
Total nitrogen	0.20605	0.21330	0.25215
Proteid nitrogen (Stutzer)	0.08070	0.07950	0.09045
Ammonic nitrogen	0.00290	0.00245	0.00535
Amid nitrogen	0.01495	0.01410	0.01966
Amino nitrogen	0.05231	0.05110	0.04794
Nitric nitrogen	0.01718	0.01984	0.04537
Injurious nitrogen in beet	0.10950	0.11725	0.13569
Injurious ash per 100 sugar	3.23300	....	3.70300
Injurious nitrogen per 100 sugar	0.75175	0.82571	1.07246

Press Juice According to Ruempler.

	XVIII.	XIX.	XX.
Total nitrogen	0.16775	0.18295	0.23855
Albumin nitrogen	0.04410	0.04070	0.04770
Propetone nitrogen	0.00175	0.00990	0.01350
Peptone nitrogen	0.00405	0.00030	....

Ash Analyses.

	XXVI.		XXVII.	
	Crude	Pure	Crude	Pure
Carbon	0.701	.....	Trace	.....
Sand	0.791	.....	0.918	.....
Silicic acid	0.744	.....	1.578	.....
Sulfuric acid	3.482	4.899	3.828	5.327
Phosphoric acid	5.155	7.254	3.348	4.659
Chlorin	5.332	7.503	5.750	8.002
Sodium	.....	4.867	.....	5.204
Carbonic acid	23.310	.....	25.500	.....
Potassic oxid	29.391	41.288	23.710	32.997
Sodic oxid	14.483	13.820	21.663	24.530
Calcic oxid	3.919	5.515	3.382	4.707
Magnesic oxid	10.072	14.173	9.970	13.875
Ferric oxid	0.220	0.310	0.248	0.345
Alumniic oxid	0.172	0.242	0.107	0.149
Manganic oxid	0.092	0.129	0.147	0.205
Loss	(3.389)	.....	(1.148)	.....
Sum	101.203	.....	101.297	.....
Oxygen equi. to chlorin	1.203	.....	1.297	.....
Total	100.000	100.000	100.000	100.000

Samples XI and XII were grown on a light, loamy, virgin soil with a scanty supply of either rain or irrigating water. The samples were gathered rather early in the season and the beets were still growing. The quality of these beets was, as the analyses show, really good; 14.2 percent sugar in sample XI and 13.8 percent as the average sugar content of the beets as harvested. The injurious ash per 100 parts of sugar was 3.53, which is perhaps a rather large amount, but I have been unable to find any statement relative to the permissible amount of injurious ash in beets or diffusion juices. The injurious nitrogenous substances, 3.74 parts per 100 of sugar, are quite low, in fact they are lower than in either the Michigan or Fort Collins beets which we tentatively adopted as standards of comparison, and as low as Andrlik's No. VI, which he judges as a good beet. An examination of the ash analysis shows the presence of a remarkably high percentage of chlorin; 14.641 percent in the pure ash. One might, perhaps, be justified in expecting to find a corresponding amount of sodic oxid but this constituent is quite low for our beets. In the ash of the Michigan beet both of these constituents are much lower but the soda in the ash of the Fort Collins beet is much higher. The soil on which these beets grew, like all of our semi-arid soils, is alkaline, but is not charged with alkali salts as we understand the term and as has been sufficiently explained in the preceding pages. We further observe that the ash, whether we consider the crude or the pure ash, is, compard with the figures given for foreign beets since 1890, higher by at least fifty percent than the figures given by Ruempler for beets grown without the application of kainite, and materially higher than the figures for those to which this salt was applied. They are also quite as much higher than the figures given by F. Strohmer and O. Fallada for Austrian beets grown with application of phosphoric acid, salt and sodic nitrate or ammonic sulfate and it is also materially higher than the Michigan and some of our Colorado beets. That our conditions are wholly different from Austrian conditions, for instance, is indicated by the fact that though the Austrian beets were grown on land to which an application of 9.2 pounds of salt per acre had been applied the chlorin in the pure ash of eleven samples, showed a maximum of 3.27 percent of chlorin, whereas the pure ash of these beets grown on virgin ground without the application of any fertilizer, shows the presence of 14.64 percent; on the other hand, the ashes of the Austrian beets show from 9.24 to 22.39 percent of sodic oxid, while the pure ash of these beets shows the presence of 6.15 percent which is calculated as metallic sodium in the statement of the analysis. The first thought is that sodic nitrate had been applied to the Austrian beets. This is true in the case of three out of eleven, and not true of the other eight; so the presence of such notable quantities of soda cannot be attributed to the action of the sodic nitrate. The chlorin in the ashes of the Austrian beets was not uniformally increased. We see that in six cases out of nine it was increased and in three it was not. These facts do not help us explain the large amount of chlorin which forms about 20.0 percent of the injurious ash in our samples.

The total nitrogen in these beets is low; 0.125 percent. The proteid nitrogen, precipitated by Stutzer's reagent, is relatively high for Colorado beets, the other forms of nitrogen, ammonic, amid, amino and nitric, are low. The nitric nitrogen, i. e., nitrogen present in the form of nitric acid, is present in many beets in traces only. Ruempler quotes Bresler as having found 0.0065 and 0.0039 percent in two samples of beets and states that Herzfeld found it only in traces. It is stated on the other hand that some French beets have been found to be relatively rich in it. This last fact has been attributed to their use of latrine as a manure.

The samples which we are discussing have been presented for the purpose of finding out as nearly as we may what kind of beets we are justified in expecting under our ordinary conditions of soil, climate and all the other things which constitute our agricultural conditions and one of these as I have shown in Bulletins 155, 160 and 178, is the frequent if not almost universal occurrence of very unusual amounts of nitrates in our soils.

In the case represented by analyses No. XI and XII we have beets grown on virgin soil under rather adverse cultural conditions, but the beets are very good in quality and the yield was 14 tons per acre.

Analyses XIII and XIV represent beets, varieties WZR and WER, grown on as good land as we have, with a good supply of water, good cultivation, and during a favorable season, 1911. We find the beets large in size, fairly rich in sugar, also in dry matter, low in ash, low in total nitrogen and low in injurious ash and injurious nitrogenous compounds; the former amounting to 2.37 and 2.44 and the latter to 3.85 and 4.04 parts per 100 parts of sugar. These are, according to the criteria adopted, excellent beets. The nitric nitrogen, however, is present in easily determinable quantities and is higher than that of the Michigan beets or those from Fort Collins grown in 1910. These are samples taken from the check plots of some experiments and we will return to them later and will discuss more fully the conditions under which they were grown.

Analysis XV represents beets grown in 1910 on an entirely different soil, a check plot in an experimental series. The soil is a calcareous clayey one somewhat difficult to manipulate. The water supply for this land is at all times abundant. The rainfall for the growing season, April to September, was 9.58 inches. The previous crop was beets. The attack of leaf-spot on the beets in this field was not more than mediumly severe. The reaction of this soil is alkaline, and the water-soluble in samples taken to represent the first, second and third foot of soil ranges from 0.1 to 3.655. The potash in the surface foot ranges from 0.68 to 0.95, in the second foot from 0.82 to 1.07, in the third foot from 0.48 to 0.93; the phosphoric acid ranges in the first foot from 0.11 to 0.82, in the second foot from 0.16 to 0.69, and in the third foot from 0.13 to 0.88. The humus nitrogen calculated on the soil was 0.073, 0.050 and 0.025 in the different samples of the surface foot, 0.040, 0.039 and 0.041 in the second foot, 0.051, 0.053 and 0.008 in the third foot. The lowest amount of lime in this soil was found in one of the samples from the third foot and was 4.18 percent. The magnesia amounts to about 1.5 percent, but in one sample representing the second foot it falls to 0.84 percent. The available potash exceeds 0.01 percent and the available phosphoric acid in the three surface samples taken one foot deep was 0.007, 0.003 and 0.010 percent. We have abbreviated these analyses, giving the essential chemical factors supposed to influence the growth of plants. It is usually assumed that, while the beet plant is a heavy feeder, its roots are not strong foragers, but unless we are led astray by our methods, there ought to be in this soil an ample supply of the chemical elements of plant food that they require, and I saw nothing in the crop to indicate the contrary.

This is the land on which the greater number of our fertilizer experiments were made and not being satisfied in regard to the results obtained the check plots were subsequently resampled in sections of one foot each to a depth of three feet. The samples were composite, each containing three sub-samples, and were submitted to the ordinary agricultural analysis with the following results:

ANALYSES OF SOIL EXPERIMENTAL PLOT, ROCKY FORD, COLO.

Plot 19—Sampled 20 July 1911.

	XXVIIa First foot Percent	XXVIIb Second foot Percent	XXVIIc Third foot Percent
Insoluble	59.035	56.078	52.436
Silicic acid	13.220	12.220	16.200
Sulfuric acid	0.108	0.173	0.477
Phosphoric acid	0.188	0.160	0.102
Chlorin	0.043	0.031	0.028
Carbonic acid	2.984	4.592	3.212
Potassic oxid	0.887	0.813	0.934
Sodic oxid	0.727	0.677	0.581
Calcic oxid	4.940	7.100	5.450
Magnesic oxid	1.436	1.257	1.630
Ferrous oxid	0.486	0.389	0.355
Ferric oxid	4.248	4.004	4.667
Aluminic oxid	5.228	5.787	6.366
Manganic oxid	0.100	0.100	0.150
Water at 100° C.	2.428	2.454	3.402
Ignition	3.628	3.464	3.446
Sum	99.686	99.299	99.436
Oxygen equi. to chlorin	0.009	0.007	0.006
Total	99.677	99.292	99.430
Total nitrogen	0.1080	0.0770	0.0630
Humus	0.9800	0.5920	0.5620
Humus nitrogen on soil	0.0530	0.0330	0.0370
Nitrogen in humus	5.4080	5.5740	7.0460
Humus N. on total N.	49.0750	42.8600	62.8600
Nitric nitrogen	0.0016	0.0002	0.0001
Water-soluble in soil	0.3590	0.3510	1.0500
Sulfuric acid in water soluble	Not det'd	Not det'd	46.5940
Calcic oxid in water soluble	Not det'd	Not det'd	24.6550

ANALYSES OF SOIL EXPERIMENTAL PLOT, ROCKY FORD, COLO.

Plot 38—Sampled 20 July 1911.

	XXVIId First foot Percent	XXVIIe Second foot Percent	XXVIIf Third foot Percent
Insoluble	58.983	47.486	48.168
Silicic acid	10.645	16.214	16.812
Sulfuric acid	0.213	1.826	1.689
Phosphoric acid	0.201	0.201	0.166
Chlorin	0.034	0.029	0.026
Carbonic acid	3.340	3.796	3.254
Potassic oxid	0.813	0.930	0.958
Sodic oxid	0.608	0.810	0.996
Calcic oxid	5.310	6.865	6.190
Magnesic oxid	1.619	1.693	1.708
Ferrous oxid	0.760	0.378	0.307
Ferric oxid	4.581	4.818	4.922
Aluminic oxid	6.100	6.037	7.080
Manganic oxid	0.155	0.265	0.255
Water at 100° C.	3.049	4.052	3.640
Ignition	2.938	3.956	3.146
Sum	99.349	99.384	99.317
Ogygen equi. to chlorin	0.008	0.007	0.006
Total	99.341	99.377	99.311
Total nitrogen	0.0960	0.0710	0.0480
Humus	0.9500	0.6500	0.5500
Humus nitrogen in soil	0.0460	0.0330	0.0360
Nitrogen in humus	4.8420	5.0770	6.5450
Humus N. in total N.	47.9200	46.4800	75.0000
Nitric nitrogen	0.0007	0.0001	0.0001
Water-soluble in soil	0.4180	3.3850	3.6550
Sulfuric acid in water-soluble	Not det'd	54.3100	53.8600
Calcic oxid in water-soluble	Not det'd	28.8400	25.3080

The analyses show an abundance of phosphoric acid, potash, lime and magnesia. The total nitrogen in the surface samples is just about the average for our soils. The ferrous oxid is very easily extracted with dilute hydric chlorid, but is wholly insoluble in water. It is probably present as a carbonate of iron. The ferrous salt is probably without effect on the character of the crop, for we find as much ferrous oxid in other soils which produce good beets under favorable conditions. The chlorin is not excessive, and the nitric nitrogen on the date of sampling was only moderately high, still there was the equivalent of 360 pounds of sodic nitrate in the surface foot of plot 19 on 20 July and 180 pounds in plot 38 taken to the same depth. While these quantities are comparatively small, they are, especially the 360 pounds, large enough to affect the quality of the beets. I mean by this, that if we should apply 360 pounds of sodic nitrate to an acre of beets on 20 July it would without doubt affect the quality of the crop. No attempt was made to study the variation of the amount of nitrates in this soil during the season but this was done for other fields by Mr. Zitkowski, whose results are given later.

The yield from this ground was not remarkable, 10.09 tons per acre, and the quality of the beet is fully shown by the analysis. The variety was the Fairfield. The sugar content was 14.4 percent, the injurious ash per 100 parts of sugar 4.9 parts, and the injurious nitrogenous compounds amounted to 5.69 parts. The total nitrogen is not particularly high but the ratio of injurious nitrogen is quite high, approximately 60.0 percent. The nitric nitrogen in these beets is decidedly higher than that in the Fort Collins standard beets. We have 0.01104 against 0.00096 percent. The ash of these beets shows a high percentage of chlorin, 15.25 percent of the pure ash or 0.13544 percent of the fresh beet. I leave the reader to classify such beets. I do not know, except in the most general way, how these beets worked in the factory, but we can safely assume that it was none too well.

Analyses XVI and XVII represent beets grown on the College Experiment Farm in 1910. The soil is to all appearances the same as that in which the samples of 1911 were grown. These samples show the maximum sugar content found during the season. The variety was given by number. The stand was good and the yield of roots was 7.0 tons per acre. The tops were frozen before the beets were harvested, about November 16, and their weight was not ascertained, but they were very heavy. The growth of the tops was luxuriant throughout the months of September, October and November till frozen. The accompanying photographs, Plate I, show the appearance of the field, also the size of the tops and the undesirable shape of the beets. If my information be correct, some of these

Plate I. Excessive foliage and small beet.

beets were irrigated once and some twice, but I could detect no difference at all in these plots. We observe that the dry matter is no more than average, if quite that, that the sugar is low, that the injurious nitrogen is high and that the nitric nitrogen was 0.02 percent of the fresh beet. The ash shows a rather large amount of both chlorin and soda. The land on which these beets grew is free from alkali and free from excessive water, it is, in short, excellent land, but the beets were poor in both crop and quality. Analyses XVIII, XIX and XX represent samples taken from check plots in other experiments of 1910. Analyses XVIII and XIX represent beets grown on the land chosen as a check plot for our experiments with nitrates. The samples taken from this plot throughout the season, however, were so erratic that I felt that it would be unwise to attach much, if any, importance to them, therefore, as a further check I took a sample from an adjacent piece of land which had not been fertilized at all. The land on which Nos. XVIII and XIX were grown had received a dressing of manure at the rate of 10 tons per acre, which had been plowed under to the depth of 10 inches. The previous crop on this land was beets without any fertilizer. This soil was submitted to a complete analysis, which will be given in another place. It contains potash 0.76, phosphoric acid 0.108, total nitrogen 0.11, which is fully an average for Colorado soils. The available plant food is quite sufficient, if not really abundant, for instance the available phosphoric acid in the samples taken the last of March amounted to 84 pounds per acre-foot, which is almost exactly one-fiftieth of the total. The soil is a light loam somewhat gravelly in spots. The soil on which the beets, represented by Analysis XX grew, was still lighter, almost sandy. Our analyses show that these samples are all poor in quality, not only is the sugar from medium to low in percentage, but the injurious nitrogen compounds are decidedly high, 7.5, 8.3 and 10.7 parts for each 100 parts of sugar.

In considering the quality of these beets as indicated by their composition it is not enough to consider them as samples grown on apparently good ground without the application of any fertilizer, but we must also bear in mind that they are grown in different sections of the state, some of them quite distant from one another. This happens to be the case with the pair XI and XII and the pair XIII and XIV. The former pair was grown about 172 miles south and 162 miles east or about 240 miles in a straight line southeast of the latter and at an elevation of almost 2,000 feet less. These factors added to the differences in soils, water-supply, preparation of ground and subsequent cultivation forbid that we should draw our conclusions with too great a degree of confidence; but, at the same time, they lend weight to those features of inferiority which are common to all of the samples and indicate their independence of these factors. It is for the purpose of avoiding misapprehensions that I have given, at the risk of being prolix, so many details. On the other hand, the number of samples and the various locations serve to give us a correct idea of the character of the beets that we are justified in expecting under favorable conditions and they show that these favorable conditions are not confined to the northern section of the state and the higher altitudes. While the sample of Fort Collins beets grown in 1910 with 18.3 percent sugar was undoubtedly an excellent beet as are also the College samples grown in 1911, they are no better beets than the samples grown on virgin soil in the extreme eastern portion of the Arkansas Valley, but still in Colorado, in fact, except in the percentage of sugar shown, the Arkansas Valley sample is somewhat the better, especially in regard to the amount of injurious nitrogenous substances present. Compared with the College samples of 1910 the Arkansas Valley sample is decidedly the superior one. The reader who is not familiar with the conditions in this section of the Arkansas Valley cannot appreciate the force of these facts. In this case we have samples of beets grown under very different conditions with the advantage, according to our universally accepted criteria, cultivation, supply of moisture, fertility of the soil, absence of hot drying winds, absence of fungus troubles, etc., in favor of the less advantageous returns in both crop and quality; to be specific the College crop in 1910 was 7.0 tons per acre and that on freshly broken sod land in the Arkansas Valley was 14 tons. The maximum sugar found in a field sample of the college beets was 13.3 percent, the average of the Arkansas Valley beets in load lots as delivered to the factory, was 13.8, with a maximum of 16.0 percent. The College samples show 5.7 and 6.4 parts of injurious nitrogenous substances to each 100 of sugar, while the Arkansas Valley sample shows 3.7 parts. Even two of the samples chosen as standards for our purposes, the Michigan and Colorado samples, show 0.51 and 0.63 parts injurious nitrogen. As we have given some College beets grown in 1911, it is perhaps of interest to state that the section of the Arkansas Valley under consideration produced in 1911 the best beets of any section of the state so far as my information goes. The tonnage was moderate but the sugar content averaged better than 17.5 percent and the beets worked exceptionally easily in the factory. The new lands in the Arkansas Valley produce now, as the lands about Rocky Ford did prior to 1905, excellent beets. If we consider in this connection the additional analyses XV, XVIII, XIX and XX, we find further suggestive facts. If we consider only the two factors, percentage of sugar and injurious nitrogenous compounds, these facts will become sufficiently evident. In analysis XV we have 14.4 percent sugar and 5.7 parts injurious nitrogenous compound per 100 parts sugar. While this is lower in sugar than our adopted standards with 15.3 and 18.3 it is almost as low as the lower one of them in injurious nitrogen. Analysis XVIII indicates a decidedly poor beet, while analyses XIX and XX are decidedly poorer still, particularly analysis XX, which is both low in sugar and rich in injurious nitrogenous substances, 10.7 parts per 100 sugar.

It appears from these samples that excellent beets can be produced in widely separated sections of the state but as a fact our soils do not uniformly, even under favorable conditions, produce beets of good quality, but on the contrary some of them are of decidedly bad quality. In regard to the different forms of nitrogen present we observe that the nitrogen precipitated by Stutzer's reagent, even though we know that it may carry down some amids, is low, whether we calculate it on the fresh beets or on the total nitrogen. The ammonic, amid and amino nitrogen appears to have very nearly the same ratio to the total nitrogen as I find given by others for German beets. The nitric nitrogen, however, is present in all of the analyses in noticeable quantities. As already stated this form of nitrogen has been found in some abundance in French beets. The maximum which I have found is in an analysis quoted from Ed. Urban by Ruempler in which 25.25 percent of the total nitrogen was present in this form. Ruempler further states that Bresler found only from 1.6 to 2.35 percent of the total nitrogen in the form of nitric nitrogen and that Herzfeld found in general only traces. We have in the Colorado and Michigan beets adopted as standards 0.46 and 1.4 percent of the total nitrogen present as nitrogen in the form of nitric acid; in analysis XI we have it corresponding to 2.8 percent of the total, in XIII we have 6.0 percent and we find it increasing in the series of samples till in analysis XX it amounts to 18.0 percent of the total. None of these samples were grown on manured or fertilized land except XVIII and XIX, these had received ten tons of stockyard manure per acre, which had been plowed under to a depth of ten inches. Analysis XIX shows the presence of nitric nitrogen equivalent to 9.3 percent of the total. Perhaps Analyses XVIII and XIX should have been omitted from this list, but they represent a check plot, in our experiments with nitrates of which they received none, but owing to the peculiar results obtained with samples from this ground, Sample No. XX was taken, as already explained as a further control.

We conclude that under favorable soil conditions the Colorado beet grown without the application of fertilizers is as good a beet as the beets of the other states or countries, that is that it contains as much sugar and as little injurious nitrogen. Concerning the injurious ash we are not so certain, for I have nowhere found any definite statement of the permissible amount in a good beet. In Andrlik's Sample No. V, which he indicates as a poor beet, the injurious ash amounts in the beet to 2.75 parts per 100 parts of sugar. Andrlik, however, appears to base his opinion of his beet wholly upon the amount of injurious nitrogen present. If this amount of injurious ash in the beet, 2.75 parts per 100 of sugar, be the permissible limit, our beets are as a rule too high in these ash constituents.

On the other hand I think that the relatively large amounts of injurious nitrogen compounds per 100 parts of sugar, shown by Analyses XV to XX indicate a tendency on the part of our soils to produce a low quality of beet. I further think that this tendency and its cause is indicated by the high percentage of nitrogen present as nitric acid.

THE EFFECTS OF FERTILIZERS.

We have already recorded the results obtained in a number of experiments with manure, sodic nitrate, superphosphate, potassic sulfate and two forms of lime, singly and in combination upon the sugar content and yield of beets. We were unable to determine that there was a sufficently uniform and favorable result produced to justify the use of any one or any combination of them. The question presented in the following paragraphs deals only with the composition of the beets grown irrespective of the yield of either beets or sugar.

In the preceding paragraphs we have shown that while our soil and climate may produce excellent beets we do not always harvest such, in fact, it is the decided deterioration of the general crop that has taken place in the Arkansas Valley since about 1904 that determined us to undertake this study in the hope of finding out the cause and discovering a remedy.

We have seen that some of our beets are decidedly low in quality and if this be due to the lack of proper plant food or the presence of plant food in improper ratios an investigation into the effects produced by the fertilizers mentioned may give us some hints at least how the crops may be bettered in quailty whether it is economically feasible or not.

ANALYSES BEETS GROWN WITH FERTILIZERS.

	XXVIII.	XXIX.	XXX.	XXXI.
Fertilizer per acre 1909	20 tons $CaCO_3$	250 P, 170 K	250 P, 170 K, 100 N	110 P, 130 K
Fertilizer per acre 1910	None	800 K	400 P	160 K, 100 N
Yield 1910	11.3 tons	10.11 tons	10.86 tons	11.70 tons
Date of sampling,	11 Oct.	11 Oct.	11 Oct.	11 Oct.
	Percent	Percent	Percent	Percent
Sugar in beet	14.60000	14.50000	14.10000	14.10000
Dry substance in fresh beets	20.90000	21.30000	19.70000	20.60000
Crude ash in dry substance	5.00900	4.96800	5.62600	6.49700
Crude ash in beet	1.04688	1.05718	1.10932	1.33838
Pure ash in beet	0.78047	0.81278	0.81556	1.05870
Sulfuric acid	0.02771	0.03257	0.03055	0.05118
Phosphoric acid	0.03477	0.06122	0.04848	0.10615
Chlorin	0.12746	0.14657	0.12489	0.24613
Sodium	0.08288	0.09520	0.08114	0.16004
Potassic oxid	0.37996	0.34494	0.39215	0.54874
Sodic oxid	0.00677	0.02517	0.01845	0.07745
Calcic oxid	0.03812	0.02822	0.03237	0.04873
Magnesic oxid	0.07073	0.07202	0.07642	0.09066
Ferric oxid	0.00489	0.00392	0.00491	0.00286
Aluminic oxid	0.00309	0.00073	0.00291	0.00445
Manganic oxid	0.00410	0.00213	0.00323	0.00203
Total nitrogen	0.12895	0.12320	0.10875†	0.21900
Proteid nitrogen (Stutzer)	0.07175	0.06660	0.06250	0.07495
Ammonic nitrogen	0.00100	0.00145	0.00560	0.00315
Amid nitrogen	0.00215	0.00320	0.00305	0.00620
Amino nitrogen	0.03700	0.03621	0.04071	0.03957
Nitric nitrogen	0.01034	0.00250	0.00987	0.01333
Injurious nitrogen in beet	0.05405	0.05195	0.03760	0.13470
Injurious ash per 100 sugar	4.27940	4.44450	4.59000	7.68430
Injurious nitrogen per 100 sug.	0.37020	0.35827	0.27288	0.95531

Ash Analyses.

	XXXVIII.		XXXIX.		XL.		XLI.	
	Crude	Pure	Crude	Pure	Crude	Pure	Crude	Pure
Carbon	0.809	.....	1.482	.....	1.295	.....	0.490	.....
Sand	1.041	.....	0.794	.....	1.612	.....	0.371	.....
Silicic acid	1.419	.....	1.208	.....	1.935	.....	0.630	.....
Sulfuric acid	2.647	3.551	3.081	4.008	2.754	3.755	3.025	3.824
Phosphoric acid	3.321	4.455	5.791	7.533	4.370	5.944	6.273	7.931
Chlorin	12.175	16.331	13.864	18.036	11.258	15.313	14.546	18.390
Sodium	.....	10.619	.....	11.714	.....	9.948	.....	11.958
Carbonic acid	19.678	.....	18.117	.....	18.865	.....	16.981	.....
Potassic oxid	36.294	48.683	32.628	42.445	35.350	48.084	32.429	40.999
Sodic oxid	11.310	0.868	14.525	3.097	11.524	2.262	17.318	5.786
Calcic oxid	3.641	4.884	2.669	3.472	2.918	3.969	2.880	3.641
Magnesic oxid	6.756	9.062	6.812	8.861	6.889	9.370	5.358	6.773
Ferric oxid	0.467	0.626	0.371	0.483	0.443	0.603	0.169	0.214
Aluminic oxid	0.295	0.395	0.061	0.090	0.262	0.356	0.263	0.332
Manganic oxid.	0.392	0.526	0.201	0.261	0.291	0.396	0.120	0.152
Loss	(2.502)	.....	(2.517)	.....	(2.775)	.....	(2.431)	.....
Sum	102.747	.....	103.129	.....	102.541	.....	103.283	.....
Oxygen equi. to chlorin	2.747	.....	3.129	.....	2.541	.....	3.283	.....
Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000

*$CaCO_3$ indicates factory waste lime and CaO burnt lime.
†Probably too low, though the duplicates agree very well.

ANALYSES BEETS GROWN WITH FERTILIZERS.

	XXXII.	XXXIII.	XXXIV.	XXXV.
Fertilizer per acre 1909	110 P 130 K 200 N	20 tons manure 110P, 200N	4 tons CaO 20 tons manure 110P, 130K, 200N	4 tons CaO 250P 170K 200N
Fertilizer per acre 1910	240P, 100N	220P, 400N	220 P, 260K	250P,170K,200N
Yield 1910	12.60 tons	14.57 tons	11.9 tons	11.59 tons
Date of sampling,	11 Oct.	11 Oct.	11 Oct.	11 Oct.
	Percent	Percent	Percent	Percent
Sugar in beet	12.40000	13.60000	14.70000	13.70000
Dry substance in fresh beet	18.80000	21.60000	22.00000	20.10000
Crude ash in dry substance	6.38600	5.66500	5.25400	6.32600
Crude ash in beet	1.20049	1.22364	1.15588	1.25344
Pure ash in beet	0.95270	0.93754	0.91227	0.93368
Sulfuric acid	0.02906	0.04297	0.04374	0.03690
Phosphoric acid	0.06469	0.09006	0.08181	0.04795
Chlorin	0.17743	0.13328	0.14213	0.14732
Sodium	0.11823	0.08666	0.09241	0.09579
Potassic oxid	0.43681	0.43050	0.41904	0.42362
Sodic oxid	....	0.02321	0.01593	0.04788
Calcic oxid	0.04255	0.03405	0.03231	0.04062
Magnesic oxid	0.07596	0.08873	0.07940	0.08284
Ferric oxid	0.00379	0.00261	0.00310	0.00647
Aluminic oxid	0.00265	0.00485	0.00175	0.00084
Manganic oxid	0.00152	0.00062	0.00103	0.00350
Total nitrogen	0.15345	0.23270	0.17150	0.17940
Proteid nitrogen (Stutzer)	0.07175	0.08040	0.08705	0.07000
Ammonic nitrogen	0.00315	0.00710	0.00275	0.00230
Amid nitrogen	0.00620	0.01650	0.00925	0.00935
Amino nitrogen	0.03957	0.02622	0.03421	0.04171
Nitric nitrogen	0.01333	0.00832	0.00865	0.01244
Injurious nitrogen in beet	0.07233	0.12870	0.07245	0.09775
Injurious ash per 100 sugar	6.14200	5.26920	4.85200	5.48550
Injurious nitrogen per 100 sug.	0.58334	0.94632	0.62047	0.71351

Ash Analyses.

	XLII.		XLIII.		XLIV.		XLV.	
	Crude	Pure	Crude	Pure	Crude	Pure	Crude	Pure
Carbon	0.500	.....	0.640	.....	0.355	.....	0.509	.....
Sand	0.582	.....	0.747	.....	0.727	.....	0.679	.....
Silicic acid	1.006	.....	1.391	.....	1.003	.....	1.507	.....
Sulfuric acid	2.421	3.051	3.512	4.584	3.748	4.794	2.944	3.952
Phosphoric acid	5.389	6.792	7.360	9.606	7.078	8.968	3.822	5.131
Chlorin	14.780	18.626	10.892	14.216	12.296	15.580	11.753	15.779
Sodium	.....	12.412*	.....	9.243	.....	10.130	.....	10.253
Carbonic acid	18.061	.....	17.890	.....	17.327	.....	20.572	.....
Potassic oxid	37.077	45.853	35.182	45.917	36.252	45.934	33.797	45.374
Sodic oxid	12.481	.....	12.437	2.476	12.117	1.706	14.115	5.128
Calcic oxid	3.544	4.466	2.783	3.632	2.795	3.541	3.241	4.351
Magnesic oxid	6.327	7.974	7.252	9.465	6.869	8.703	6.609	8.874
Ferric oxid	0.316	0.398	0.213	0.278	0.268	0.340	0.516	0.693
Aluminic oxid	0.221	0.278	0.396	0.517	0.151	0.191	0.067	0.090
Manganic oxid	0.127	0.160	0.051	0.066	0.089	0.113	0.279	0.375
Loss	(0.503)	.....	(1.712)	.....	(1.700)	.....	(2.243)	.....
Sum	103.335	.....	102.458	.....	102.775	.....	102.653	.....
Oxygen equi. to chlorin	3.335	.....	2.458	.....	2.775	.....	2.653	.....
Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000

*Includes 0.736 of potassium.

ANALYSES BEETS GROWN WITH FERTILIZERS.

	XXXVI.	XXXVII.
Fertilizer per acre 1909........	200 N 4 tons CaO, 200 N	200 N 200 N
Fertilizer, pound per acre 1910..............	400P, 300K, 200N	500P, 400K, 200N
Yield 1910	12.0 tons	13.16 tons
Date of sampling..............................	Oct. 11,1910	Oct. 11, 1910
	Percent	Percent
Sugar in the beet..........................	15.30000*	13.30000
Dry substance in fresh beet..................	21.00000	20.10000
Crude ash in dry substance..................	5.03700	6.55600
Crude ash in fresh beet......................	1.05777	1.31776
Pure ash in fresh beet......................	0.79850	1.04090
Sulfuric acid	0.03315	0.03345
Phosphoric acid	0.04286	0.07948
Chlorin	0.12475	0.19978
Sodium equi. to chlorin......................	0.08112	0.12990
Potassic oxid	0.36291	0.45641
Sodic oxid	0.03507	0.02261
Calcic oxid	0.03764	0.03447
Magnesic oxid	0.07399	0.07865
Ferric oxid	0.00042	0.00237
Aluminic oxid	0.00474	0.00372
Manganic oxid	0.00179	0.00000
Total nitrogen	0.13760	0.17770
Proteid nitrogen (Stutzer)..................	0.06745	0.08035
Ammonic nitrogen	0.00145	0.00290
Amid nitrogen	0.00320	0.00720
Amino nitrogen	0.03621	00.3141
Nitric nitrogen	0.00250	0.01846
Injurious nitrogen in beet..................	0.06550	0.08725
Injurious ash per 100 sugar................	4.16340	6.33200
Injurious nitrogen per 100 sugar............	0.42810	0.65603

Ash Analyses.

	XLVI.		XLVII.	
	Crude	Pure	Crude	Pure
Carbon	0.690	.....	5.254	.....
Sand	0.460	.....	0.446	.....
Silicic acid	1.111	.....	1.039	.....
Sulfuric acid	3.134	4.152	2.538	3.213
Phosphoric acid	4.052	5.369	6.031	7.635
Chlorin	11.794	15.624	15.161	19.195
Sodium	.....	10.159	.....	12.481
Potassium	.....	.....	.....	.....
Carbonic acid	20.147	.....	18.334	.....
Potassic oxid	34.309	45.451	34.635	43.850
Sodic oxid	13.646	4.393	14.995	2.173
Calcic oxid	3.526	4.714	2.616	3.312
Magnesic oxid	6.995	9.267	5.968	7.556
Ferric oxid	0.040	0.053	0.180	0.228
Aluminic oxid	0.448	0.593	0.282	0.357
Manganic oxid	0.170	0.225	.....	.....
Loss	(2.103)	.....	(0.942)	.....
Sum..................	102.661	.....	103.421	.....
Oxygen equi. to chlorin.	2.661	.....	3.421	.....
Total..............	100.000	100.000	100.000	100.000

*This is higher than the factory average by 1.2 percent and is the highest percentage of sugar found in beets from this field during the season. There were eight beets in the sample. The sample is probably not representative.

The effects of these fertilizers upon the weight of crops, the apparent coefficients of purity, and the amount of sugar produced have been given on page 19. These plots were harvested during the week or ten days subsequent to the taking of these samples and there is considerable evidence that marked changes took place in some of the plots. The samples from one of the plots, Number 24, from which the first sample was taken 6 Sept., showed a fairly uniform increase till 11 Oct., when they showed 13.2 and 13.6 percent sugar. Five days later a sample showed 15.5 percent. The plot was harvested and the beets delivered to the factory 18 Oct. and averaged 15.35 percent sugar, apparent purity 84.45. Other plots also showed increases, but no other one to such an extent as number 24. Our samples of 11 Oct. agreed with the factory averages, as well as samples of the size taken could be expected to agree, with two exceptions.

A set of eleven samples had already been taken 23 Sept. The results obtained by determining the injurious nitrogen in these are, with one exception, concordant in showing a great improvement in the quality of the beets. One sample shows a very surprising degree of improvement, but the determination of total nitrogen is apparently too low, which is mentioned in the tables. The following statement of the injurious nitrogenous compounds (injurious N x 10) in the beets on 23 Sept. and 11 Oct. may serve to indicate the changes that took place in the beets during this interval.

Injurious nitrogenous compounds per 100 of sugar in beets grown on the respective plots and sampled on the following dates:

	23 Sept. 1910	11 Oct. 1910
1	7.13	6.20
2	11.50	9.55
3	9.73	5.83
4	6.37	6.57
5	12.75	4.28
6	3.51	3.58
7	6.34	2.73
8	4.84	5.69
9	9.10	3.70
10	7.50	7.13

We see that in one case our results show an increase of 0.85 part injurious nitrogenous substances for each 100 pounds of sugar. This difference may be due to variation in the samples. We further see that in Number 5 of the table there was a remarkable improvement. This may be true, it may also be party due to the difference in the samples taken and also, which is less likely, to analytical errors.

The beets grown on this land are apparently high in injurious ash from 4.1 to 7.7 parts for each 100 of sugar, but this does not seem to be due to the action of the fertilizers though the highest amount, 7.7 parts, is found in the case of beets grown on a plot which had received 160 pounds of potassic sulfate and 100 pounds sodic nitrate per acre. On the other hand, beets from plots which had received heavier applications than this contained less than beets grown on plots which had received no fertilization. The irregularity of the results does not admit of any definite conclusion.

The apparent coefficient of purity for the beets from all of the plots ranged from 79.0 to 85.0 as they were harvested, and from 79.0 to 86.0 for the samples as taken on 11 Oct. excepting one sample which was very low. The plot on which this sample was grown had received a dressing of 120 pounds superphosphate and 50 pounds sodic nitrate.

The percentage of chlorin in the ash of the beets from these fertilized fields is high in comparison with the available data relative to the amount of chlorin in the sugar beet. According to Wolff quoted by Ruempler the average amount in beets prior to 1871 was 0.04000, ten years later it had fallen to 0.03060 percent. The average obtained at the Halle Experiment Station was nearly the same from 0.0260 to 0.0420. The maximum given by Ruempler for chlorin in fresh sugar beets is 0.242 percent, calculated on the basis of 80 percent water in the beet. In the six analyses previously quoted from Andrlik the maximum is 0.038 percent. In the Michigan beets we found 0.0029 and in our standard Fort Collins beets 0.0194 percent, but in the beets grown on this land we find the minimum to be 0.124 and the maximum 0.246 percent of the fresh beet.

The fact that our beets are apt to be rich in chlorin was shown by our earlier analyses, 1898, at which time mention was made of this fact. While manure in some experiments which we made clearly increased the amount of chlorin taken up by the beets, the high chlorin in these cases cannot be wholly attributed to the fertilizers used, for the beets from our check plot are as high in chlorin as those grown with fertilizers. The water soluble chlorin in this soil was, in the surface foot (three samples) 0.008, in the second foot 0.012, 0.013 and 0.014, and in the third foot 0.021 and 0.015 percent. These analytical results indicate not far from 1500 pounds of chlorin per acre taken to a depth of three feet, or about 2500 pounds of ordinary salt. The molassegenic properties of sodic chlorid seems to be beyond question. This quantity of salt, if it has any value as a fertilizer for beets, was perhaps more than sufficient to be of the highest advantage. The extent to which soda salts were appropriated by the by the plants shows very plainly when we consider the composition of the pure ash in which we see that sodic chloril makes up from 23. to 32. percent of the total.

The phosphoric acid in all of the samples except in the ash of the Michigan beet and in that of our standard Fort Collins beet is very low. This is exhibited plainly in the statement of the crude and even more so in that of the pure ash. The total phosphoric acid in this soil, not taking that applied to the various plots into account, was not far from 5,000 pounds per acre-foot, while the citric acid soluble for the three samples taken to represent the surface foot of soil gave 120, 280 and 400 pounds per acre foot and the succeeding two feet were well supplied. In addition to this natural supply, phosphoric acid was applied in quantities varying from zero to sixty-five pounds per acre. We cannot therefore attribute the low percentage of phosphoric acid in the ash to a lack of phosphoric acid in the soil nor to its being unavailable. We shall return to this subject briefly in a later paragraph.

We find that the injurious nitrogenous substances present in these beets are rather high. In twenty-four samples given by Andrlik, Jahres-Bericht der Zuckerfabrikation 1907 pp. 18-20 we find the range from 2.8 to 6.48 parts to 100 parts of sugar with only three samples with 6 parts or more. Of these twenty-four samples, eighteen were grown with application of farmyard manure and four with various amounts of superphosphate, potash salts, and Chile-saltpetre. Our samples show that the best ones in respect to the amount of injurious nitrogen, were those grown without any fertilizer or with potassic sulphate or superphosphate applied separately.

We have seen by the results on pages 17 and 19 that the general effects of fertilizers, applied in the quantities given, are decidedly disappointing. This is not due to the time or manner of application, for these were in accord with the practice which experience has approved as the best. Further it was not due to indifferent or insufficient cultivation, nor to a lack of water, nor to any untoward condition such as an unfavorable season or an attack of insects or of fungi. The leaf-spot was present, but its attack on these plots was not very severe. The data presented in the preceding paragraphs are intended to show a further and different purpose, i. e., to show whether any of these fertilizers or combinations of them have produced favorable effects upon the quality of the beets which is so decidedly beneficial that the interpretation is plain and beyond doubt. I think that we can safely conclude that they have not; on the contrary, it seems that we must conclude that the results obtained in these fertilizer experiments when compared with those obtained with beets grown without fertilizers, do not justify us in trying to ameliorate our conditions by these means. There are a number of things, it is true, to be taken into consideration in interpreting our results, some of which I have already stated, but which I repeat because of their importance. First: differences due to locality; this means that the localities are so remote from one another that the climatic conlitions are sufficiently different to constitute a factor in the results. Second: differences in soils. Third: differences in varieties of beets, or strains of seed used, and there are still others. While it is beyond my power to eliminate these factors, we can, I think, avoid attaching too much importance or too little importance to them, and also desist from making an excuse of them to explain things which we do not understand. We know that the climatic conditions of the Poudre Valley are very different from those of the Eastern part of the state, which lies in the Arkansas Valley, but we have already seen that this latter section of the state does produce excellent beets, not only in regard to high sugar content, but also in regard to their content of injurious ash and nitrogen. It has been proved that droughty conditions increase both the total and the injurious nitrogen in beets, but we have scarcely any better beets than have been grown in this section of the state and it follows that in considering our results, especially of 1910, we cannot justly appeal to climatic conditions as affording the explanation for adverse results which we cannot otherwise explain.

The chemical composition of the soil on which these experiments were made is given in full in connection with Analysis XV, which is a sample from one of the check plots in this series which received no fertilizer in either 1909 or 1910. The statements relative to the composition of this soil are based upon a series of fifteen analyses. I may state that this soil yields a solution with hydrochloric acid which shows the presence of ferrous salts, but not a trace when treated with water. On panning a portion of the soil no iron sulfids could be detected, only a black sand. No sulfuretted hydrogen could be detected on treatment with hydrochloric acid and lead paper. The coarse sand is composed of quartz and felspar. It seems probable that the ferrous compound present is a carbonate, siderite, possibly in combination with the calcic or magnesic carbonate, ankerite or mesitite. There is lime carbonate enough present to give a rather lively effervescence.

The available potash in 4,000,000 pounds of the surface foot of this soil was 400 pounds, of the second foot from 120 to 320 and of the third foot from 160 to 640 pounds. The phosphoric acid available in this amount of soil from the surface foot was 120, 280 and 400 pounds. The humus nitrogen calculated in like manner gives us from 1,000 to 2,000 pounds for the first foot, 1,600 pounds for the second foot and from 320 to 2,000 pounds for the third foot. Taking the average of available potash and phosphoric acid in the three sets of samples taken to a depth of three feet we obtain a supply, soluble in citric acid solution, of 773 pounds of potash and 796 pounds of phosphoric acid per acre. If we assume one-quarter of the humus nitrogen to be or to become available during the season, we have 980 pounds of nitrogen. The average yield of fresh beets for the ten plots was 11.98 tons per acre. The plant food necessary to grow 44 tons of fresh beets, practically four such crops as that actually harvested from these fields, is according to Hoffman, 320.5 pounds of potash, 157.8 pounds phosphoric acid and 345.2 pounds of nitrogen, and according to Strohmer, Briem and Fallada it is considerably less, 260.2 pounds potash, 79.4 pounds of phosphoric acid and 276.2 pounds of nitrogen. Wimmer found that about 98 pounds of soluble phosphoric acid produced this amount of beets most advantageously. It would be wholly without object to calculate how many crops the plant food in the surface three feet of this soil on the day of sampling would have sufficed to grow. All that the figures are presented for is to show that the land at the beginning of these experiments was sufficiently well supplied with plant food to have grown better crops. There is no reason that I know of to suppose that there was an injuriously large supply unless the amount of injurious ash for each 100 pounds of sugar be considered as indicating such a condition, but a comparison of Analyses XV and XXVIII with the analyses from XXXI to XXXVII inclusive, does not clearly justify such a conclusion. If anything is shown by these analyses, it is that the application of fertilizers other than potash and phosphoric applied separately has not only failed to consistently and materially increase the crop, but has actually decreased its quality so that we have a direct answer to our main inquiries. First: That the increase in crop is neither certain enough nor sufficient to justify the application of fertilizers experimented with. Second: That the quality of the beets was deleteriously rather than beneficially affected, except in two cases in which potash and phosphoric acid were applied separately.

These results are in harmony with others obtained in this state by previous experimenters, but we are not in harmony with results obtained in other states and countries. The important thing to us is that we would have little or no reason to hope for any improvement in volume and quality of our crops by the application of fertilizers even if they were at our command at prices which our people could afford.

Analysis XVIII represents beets grown with no fertilizer other than stockyard manure, 10 tons per acre, plowed under to a depth of 10 inches, while No. XX was grown on a sandy soil without any fertilizer. The water supply for this land was good in 1910. In addition to this there was a rainfall of more than 9 inches during the growing season, April to October. The quality of the beets in Analysis XX is decidedly bad so far as injurious nitrogen is concerned. It is a known fact that beets which have suffered from lack of water, drought, are poorer in quality than beets grown with plenty of water, and that beets grown on light and sandy lands are more susceptible to the influence of this condition than those grown on heavier lands. It is possible that the lightness of the land on which the beets of Analysis XX were grown may have detrimentally influenced their composition, but it was not due to a scarcity of water. The injurious nitrogenous substances for each 100 pounds of sugar in these samples were respectivey 7.5 and 10.72, the latter of which is a larger quantity than we find in the beets grown with fertilizers which show 9.46 and 9.55 parts as maxima. While the injurious nitrogen in the beets grown on the fertilized plots is undoubtedly high and was probably increased by the fertilizers used, it is not safe to conclude that these beets were lower in quality than beets grown on other lands without the application of fertilizers, for this seems not to be the case. The total nitrogen in the analyses so far given, made to include the nitric nitrogen, is not high. The total nitrogen in Analysis XXX may be considered as exceptionally low and neglected. still the total nitrogen in the other samples is not high. On the contrary it is lower than the analyses quoted from Andrlik and, as a rule, lower than the few determinations of total nitrogen that I have found given for beets in general. So far I have given twenty-one analyses of Colorado beets, in only five has the total nitrogen amounted to 0.2 percent and the maximum is 0.252 percent. Of the five samples showing 0.2 percent or more of nitrogen only one was a good beet, i. e., the one grown near Fort Collins, the others were all poor beets. These twenty-one samples of beets were grown both with and without the application of fertilizers. The total nitrogen in these samples is low rather than high and the ratio of the proteid nitrogen as determined by Stutzer's method, to the total nitrogen is often quite low, though the proteid nitrogen given by this method is apt to be too high. In the samples quoted from Andrlik, we find this ratio higher. It is as follows for the six samples given:

RATIO PROTEID TO TOTAL NITROGEN IN BEETS GIVEN BY ANDRLIK.

Number of Analysis	Total Nitrogen in Beet	Proteid Nitrogen	Ratio of Proteid to Total Nitrogen	Injurious Nitrogen per 100 Sugar
1.........	0.257	0.113	43.9	0.684
2.........	0.252	0.112	44.4	0.672
3.........	0.210	0.110	52.4	0.554
4.........	0.199	0.107	53.7	0.492
5.........	0.306	0.120	39.2	0.828
6.........	0.186	0.109	58.6	0.403

Andrlik makes no comment on the quality of these beets except to say that No. 5 is a bad beet while No. 6 is a good one. The data here given do not agree exactly with Andrlik's. He gives for the injurious nitrogen 0.930 instead of 0.828 and 0.37 instead of 0.409. Concerning the intermediate beets he makes no classification so we are left to determine where the dividing line between good and poor beets falls, so far as the injurious nitrogen per 100 of sugar is concerned. In other articles he apparently considers an amount of injurious nitrogen larger than 0.370 as objectionable as beets grown without the application of fertilizers contain as little as 0.280 injurious nitrogen per 100 sugar and when this was raised to 0.370 by the application of fertilizers he considered their influence deleterious. I therefore infer that we are safe in considering a beet carrying more than 0.450 injurious nitrogen per 100 of sugar as doubtful in quality and 0.9 or more as decidedly poor.

We will state these data in tabular form for the Colorado samples previously discussed.

RATIO PROTEID TO TOTAL NITROGEN IN COLORADO BEETS.

Number of Analysis	Total Nitrogen in Beet	Proteid Nitrogen	Ratio of Proteid to Total Nitrogen	Injurious Nitrogen per 100 Sugar
VIII	0.2075	0.0871	41.9	0.629
XI	0.1253	0.0666	53.1	0.374
XII	0.1376	0.0683	51.0	0.489
XIII	0.1439	0.0752	52.2	0.385
XIV	0.1412	0.0715	50.7	0.404
XV	0.1563	0.0660	43.0	0.569
XVI	0.1864	0.0951	51.1	0.638
XVII	0.1981	0.1003	50.6	0.654
XVIII ...	0.2061	0.0807	36.4	0.752
XIX	0.2133	0.0795	37.4	0.826
XX	0.2522	0.0905	36.0	1.073
XXVIII ..	0.1290	0.0718	55.0	0.370
XXIX ...	0.1232	0.0666	54.0	0.350
XXX	0.1088	0.0625	57.3	0.279
XXXI ...	0.2190	0.0750	34.2	0.955
XXXII ..	0.1538	0.0718	47.0	0.583
XXXIII ..	0.2330	0.0804	34.5	0.946
XXXIV ..	0.1715	0.0871	50.8	0.620
XXXV ...	0.1794	0.0700	39.0	0.714
XXXVI ..	0.1376	0.0675	49.0	0.428
XXXVII .	0.1778	0.0804	45.4	0.656

In considering the quality of these beets it is to be remembered that the injurious nitrogen is only one of the three criteria whereby we are to judge, the other two are the percentage of the sugar and the amount of injurious ash. Of these beets number VIII is the only one grown in 1910 that carries more than 15.3 percent sugar and less than 3.0 parts injurious ash per 100 of sugar, so while it is inferior to some of the other beets in respect to the injurious nitrogen contained, it is one of the best beets in the list. Of the remaining twenty samples, sixteen are from the Arkansas Valley and four from the College Experiment Farm at Fort Collins, two grown in 1910, which are decidedly poor beets, having one good quality in a moderate degree and two samples grown in 1911 which are of good quality. All of the Arkansas Valley samples were grown in 1910 and some of them are excellent beets, but some of them are very bad beets, for instance Number XX which had 12.7 percent sugar, 013669 percent injurious nitrogen in the fresh beet or 1.073 parts injurious nitrogen equal to 10.73 parts injurious nitrogenous matter per 100 parts of sugar.

I believe that the table faithfully represents the characteristics of the Arkansas Valley beets—i. e., low sugar, as a rule, low total nitrogen, a low ratio for the proteid nitrogen, a high content of injurious nitrogen, and a liberal amount of injurious ash. Our experiments with fertilizers do not give us much, if any, reason for expecting to either profitably increase the quantity or quality of our crops by their use. This is the important feature of our experiments. We may not be able to give a satisfactory explanation of the fact, but this is the finding of several independent experimenters. The only fertilizers claimed by any one to have produced good results are farmyard manure and nitrate of soda. I think that there is a general agreement in regard to the former but not in regard to the latter. It is altogether probable that favorable results have been obtaind by the use of sodic nitrate but this does not seem to have been the general result. The few favorable results obtained were probably due to conditions, which if known, were not mentioned. In the series of experiments given phosphoric acid and potash were combined with the nitrate, in the hope that we might obtain the good effects of the nitrate and neutralize its known bad effects. Our results have been given in detail and they are indifferent both in crop and quality The conviction has prevailed for a long time that sodic nitrate exercises an injurious action on the quality of the sugar beet, but this has been questioned as we will see later.

Up to the present, I have aimed to give beets grown under favorable conditions so that we might learn as far as possible what is a good crop and a good quality of beet with us. I think that the beets grown on the prairie land in the Arkansas Valley and the beets grown near Fort Collins in 1910 and also those grown on the College Farm in 1911 are good beets, the last being the best. They were taken 11 Oct. and showed 23.0 percent of dry matter, 15.8 percent sugar, 2.37 parts injurious ash and 3.85 of injurious nitrogenous matter per 100 sugar. But 1911 seems to have been an extremely favorable year. In 1910 the samples from the Arkansas Valley, taken 23 Sept. were also good though grown under somewhat adverse conditions. Dry matter 20.2, sugar 14.2, injurious ash 3.5 parts per 100 sugar and injurious nitrogenous matter 3.74 parts per 100 sugar. Our adopted standard grown in 1910 near Fort Collins gave us dry matter 24.2, sugar 18.3, injurious ash 2.197 parts per 100 sugar, injurious nitrogenous matter 6.29 parts per 100 sugar. Analyses XVIII, XIX and XX of beets grown under favorable conditions are indifferent or bad in quality, especially XX, which gave us dry matter 20.0, sugar 12.7, injurious ash per 100 sugar 3.7, injurious nitrogenous matter per 100 sugar 10.72 parts.

This is the poorest sample of beets grown on good land that we have analyzed, but we have others that are also decidedly poor, for instance our College samples grown in 1910 with dry matter 20.3, sugar 13.2, injurious ash per 100 sugar 3.42, injurious nitrogenous substances per 100 sugar 6.38. Some of the characteristics of these beets in regard to the relative quantities of the different nitrogenous groups have already been given, but there is another question which may be of importance in the general problem presented, i. e., why were the beets of the Arkansas Valley of such indiffernt or poor quality from 1904 to 1910 inclusive? They were very good prior to 1904. They were so far as our records show very good for a period of at least 8 years.

The nitrogen present in sugar beets in the form of nitric acid or nitrates is usually so small that its determination is attended with difficulty or is impracticable. What has been considered as exceptional quantities have been found in some French sugar beets. In the analyses already given we see that the nitric nitrogen varies from 0.00096 percent in the Fort Collins beets grown in 1910 to 0.04537 percent in a sample grown on good but unfertilized land in the Arkansas Valley.

While there are differences of opinion as to the effects of nitrates upon the sugar beet, I think that it is universally agreed that one effect is to prolong the vegetative period of the plant and retard its maturation, and if applied too late in the season to produce poor, green beets at harvest time. Until the last few years only general statements to this effect were made but in recent years investigations have gone further and ascertained that the nitrates increase the injurious nitrogen in beets and this is true in the case of an application of 525 pounds of sodic nitrate per acre, applied in three portions of 175 pounds each.

As elsewhere stated, the fact that I have found very large amounts of nitrates present in our soils and the further observation that the beets in the fields as they were harvested and taken to the factory appeared to be green, and further, because the juices in the factory indicated immaturity of the beets, I inferred that the presence of the nitrates in the soil was related to these facts as cause to effect. I arrived at this conclusion several years ago before the investigations of recent years had become available to me.

One of the most serious features of our problem is that it is not a question of a few pounds of nitrogen applied by or before the end of June or the early part of July, but of an unknown, often a large amount of nitrogen, furnished in July and August, of which fact we will adduce, in the proper place, what I believe to be conclusive evidence.

THE EFFECTS OF NITRATES.

We have already noticed that the nitric nitrogen in our beets is higher than that which we have found recorded except in the case of French beets, which showed the presence of 0.049 percent of nitric nitrogen as against 0.045 percent in Analysis XX. One question which we set ourselves was to ascertain on a larger scale what the effect of sodic nitrate is upon beets grown under our conditions and thus to find out whether the nitrates actually produce the conditions which we have found in our crops during the time given. To ascertain this, a piece of choice land was selected, land which was known to produce at least average crops of good beets. This land had been dressed with ten tons stockyard manure per acre. We selected six acres, five for the application of sodic nitrate and one to serve as a check plot. The unit quantity applied was 250 pounds. Each of the five plots received an application just before seeding, four weeks later four of the plots and four weeks later three of the plots received a dressing and so on till the fifth plot had received five dressings. Plot I received one application of 250 pounds 28 March; Plot 2 received two applications (500 lbs.) 28 March; and 1 June; Plot 3 received three applications (750 lbs.) 28 March, 1 June and 22 June; Plot 4 received four applications (1,000 lbs.) 28 March, 2 May, 1 June and 22 June; Plot 5 received five dressings (1,250 lbs.) 28 March, 2 May, 1 June, 22 June and 27 July. Irrigations applied 9 April, 16 June, 1 July, 9 July, 29 July, 17 August one-half of the land, and on 30 August the other half. All of the fields were sprayed with standard Bordeaux mixture to combat the leaf-spot. No. 1 as follows: 21 July, 1, 21 and 31 August and 7 September. No. 2 same as No. 1. No. 3, 22 July, 3, 13 and 28 August and 8 September. No. 4, 22 July, 16 and 28 August and 8 September. No. 5, 23 July, 16 and 28 August and 9 September. The total rainfall during the growing season was 9.9 inches. The beets received careful cultivation and the soil was kept in good condition.

The harvesting of these beets gave the following returns:

	Lbs. Sodic Nitrate	Tons Beets	Percent Sugar	Purity
Field 1........	250	16.85	14.50	83.7
Field 2........	500	15.52	14.25	82.0
Field 3........	750	14.94	13.18	79.5
Field 4........	1000	14.99	14.23	83.6
Field 5........	1250	15.96	13.83	82.2
Field 6........	None	14.47	14.90	84.5

These results do not agree throughout with the results obtained on the small samples taken for our laboratory purposes. The samples from Field 6 were anomalous throughout the season, so much so that the only object that I have in giving the results is for the sake of giving a complete record.

There were three series of samples taken of these beets, 23 September, 11 October and 3 November 1910. The third series was subjected to the fullest examination and is the most important, but the first two series will be given by themselves. They will enable us to obtain a better view of the development of the beet.

ANALYSES XLVIII TO LXIX, INCLUSIVE.

Samples Taken 23 Sept. 1910.

	Percent Sugar	% Dry Matter	Total Nitro.	Proteid Nitrogen	Ammonic Nitrogen	Amid Nitrogen	Amino Nitrogen	Nitric Nitrogen
Field 1...	14.5	19.7	0.19455	0.07345	0.01080	0.00915	0.03408	0.01820
	16.4	21.5	0.16930	0.07835	0.00460	0.01120	0.04165	0.00204
Field 2...	14.0	19.8	0.15855	0.07435	0.00645	0.00935	0.04880	0.00907
	13.7	19.7	0.20530	0.07900	0.00760	0.01258	0.02243	0.02201
Field 3...	13.8	19.4	0.25790	0.08157	0.00650	0.02245	0.04660	0.02798
	12.2	19.0	0.27810	0.08560	0.01130	0.01960	0.04228	0.04365
Field 4...	11.6	15.2	0.27573	0.08935	0.01225	0.02385	0.05755	0.03806
	12.3	17.1	0.28965	0.08270	0.00860	0.01240	0.04040	0.04110
Field 5...	12.3	17.6	0.21655	0.08155	0.00780	0.02005	0.03095	0.02500
	12.4	13.1	0.23180	0.07350	0.00895	0.02055	0.03893	0.02015
Field 6...	12.2	18.2	0.22475	0.08880	0.00780	0.02360	0.04198	0.01956
	14.4	19.7	0.15060	0.07690	0.00330	0.00555	0.03583	0.01096

ANALYSES LX TO LXXI, INCLUSIVE.

Samples Taken 11 Oct. 1910.

	Percent Sugar	% Dry Matter	Total Nitro.	Proteid Nitrogen	Ammonic Nitrogen	Amid Nitrogen	Amino Nitrogen	Nitric Nitrogen
Field 1...	16.5	17.5	0.16355	0.07465	0.00230	0.00890	0.07695	0.00925
	16.5	21.2	0.14915	0.06595	0.00155	0.00765	0.05414	0.00760
Field 2...	15.5	21.0	0.17133	0.08010	0.00275	0.00790	0.06478	0.00501
	16.3	22.6	0.22405	0.08900	0.00375	0.01285	0.05215	0.00941
Field 3...	15.8	22.1	0.25365	0.08790	0.00673	0.01960	0.06847	0.02026
	13.0	20.2	0.29395	0.09135	0.01120	0.02823	0.05366	0.04646
Field 4...	12.3	19.9	0.28390	0.09335	0.00680	0.02466	0.07186	0.04653
	12.4	19.8	0.25556	0.09395	0.00443	0.01920	0.07220	0.05051
Field 5...	12.6	18.6	0.28175	0.08590	0.00630	0.08030	0.03149	0.05404
	13.2	19.8	0.21180	0.09080	0.00345	0.01255	0.03504	0.03846
Field 6...	14.0	22.1	0.19740	0.07495	0.00245	0.00820	0.03670	0.02666
	15.4	22.2	0.19380	0.09450	0.00315	0.01165	0.04020	0.01800

Some of these beets, Fields 1 and 2, show that the beets had improved some during the 18 days between the two samplings. The sugar and dry substances had increased, the proteid nitrogen had increased, while the total nitrogen had decreased. Fields 3, 4 and 5, however, which had received respectively 750, 1,000 and 1,250 pounds of sodic nitrate per acre, showed no material improvement as measured by the percentage of injurious nitrogen in the beets on the respective dates.

	23 September	11 October
Field 3..................	0.15449	0.15180
Field 4..................	0.16811	0.14854
Field 5..................	0.11798	0.10713

The maximum decrease in injurious nitrogen in these three fields as represented by the averages of the six pairs of samples taken is only 0.02 percent. The maximum increase in the average percentage of sugar in any two pairs of samples is 1.2; which, considering that there were two pairs of samples from each field, is a very small maximum difference. The other two differences were 0.4 and 0.5 percent. On 23 Sept. the beets in Field 1 had already attained an average of 15.45 percent; those in Field 2 increased from 13.85 to 15.9 percent, an increase of 2.1 percent. These facts indicate that the beets in Field 1, to which 250 pounds of sodic nitrate had been applied, were well advanced toward maturity on 23 Sept., and as subsequent results showed, had reached their maximum by 11 Oct., while those in Field 2, to which 500 pounds of sodic nitrate had been applied in two equal portions, were later in maturing than the beets in field one, but had reached their maximum by 11 Oct. The beets in fields 3, 4 and 5 to which 750, 1,000 and 1,250 pounds in applications of 250 pounds each had been applied, were maturing only very slowly. The final laboratory samples were taken 3 Nov. and the results obtained with them are given in the following tables.

ANALYSES OF BEETS GROWN WITH APPLICATION OF NITRATES.

	LXXII	LXXIII	LXXIV	LXXV
	Field 1	Field 1	Field 2	Field 2
Date of sampling	3 Nov.	3 Nov.	3 Nov.	3 Nov.
Sodic nitrate per acre	250 lbs.	250 lbs.	500 lbs.	500 lbs.
Yield tons per acre	16.85	16.85	15.52	15.52
	Percent	Percent	Percent	Percent
Sugar in beets	15.70000	16.50000	15.30000	15.80000
Dry matter in fresh beets	21.30000	22.40000	21.40000	21.60000
Crude ash in dry matter	3.57200	3.33400	4.03700	4.75100
Crude ash fresh beet	0.76084	0.74682	0.86392	1.02622
Pure ash in fresh beet	....	0.51948	....	0.72592
Sulfuric acid	....	0.02595	....	0.03798
Phosphoric acid	....	0.03750	....	0.06096
Chlorin	....	0.02292	....	0.03099
Sodium	....	0.01490	....	0.02011
Potassic oxid	....	0.20800	....	0.30551
Sodic oxid	....	0.06222	....	0.11181
Calcic oxid	....	0.04301	....	0.04188
Magnesic oxid	....	0.09787	....	0.10766
Ferric oxid	....	0.00286	....	0.00301
Aluminic oxid	....	0.00226	....	0.00257
Manganic oxid (br.)	....	0.00199	....	0.00344
Total nitrogen	0.14470	0.14485	0.18225	0.20535
Proteid nitrogen (Stutzer)	0.06480	0.07465	0.07805	0.08010
Ammonic nitrogen	0.00190	0.00245	0.00200	0.00346
Amid nitrogen	0.00930	0.00765	0.01025	0.01500
Amino nitrogen	0.05103	0.04549	0.04613	0.02002
Nitric nitrogen	0.00181	0.00144	0.01658	0.01009
Injurious nitrogen in beet	0.06870	0.06010	0.09195	0.10679
Injurious ash per 100 sugar	....	2.12670	....	3.20500
Injurious nitrogen per 100 sug.	0.43758	0.36424	0.60051	0.68221
Press Juice According to Ruempler.				
Total nitrogen	0.11890	0.11905	0.16856	0.18690
Albumin nitrogen	0.03750	0.03750	0.04270	0.04270
Propeptone nitrogen	0.00275	0.00400	0.00035	0.00375
Peptone nitrogen	0.00185	0.00190	0.00480	0.00290

Ash Analyses.

	LXXXIV		LXXXV	
	Crude	Pure	Crude	Pure
Carbon	0.621	.....	0.345	.....
Sand	2.026	.....	1.375	.....
Silicic acid	1.804	.....	1.678	.....
Sulfuric acid	3.475	4.996	3.701	5.232
Phosphoric acid	5.021	7.218	5.940	8.397
Chlorine	3.069	4.412	3.020	4.269
Sodium	.....	2.868	.....	2.776
Carbonic acid	24.053	.....	24.178	.....
Potassic acid	27.852	40.042	29.770	42.083
Sodic oxid	11.020	11.978	13.440	15.401
Calcic oxid	5.759	8.279	4.081	5.769
Magnesic oxid	13.105	18.840	10.491	14.831
Ferric oxid	0.383	0.550	0.293	0.411
Aluminic oxid	0.303	0.435	0.250	0.353
Manganic oxid	0.266	0.382	0.335	0.474
Loss	(1.936)	.....	(1.784)	.....
Sum	100.693	.....	100.681	.....
Oxygen equi. to chlorin	0.693	.....	0.681	.....
Total	100.000	100.000	100.000	100.000

ANALYSES OF BEETS GROWN WITH APPLICATION OF NITRATES.

	LXXVI	LXXVII	LXXVIII	LXXIX
	Field 3	Field 3	Field 4	Field 4
Date of sampling	3 Nov.	3 Nov.	3 Nov.	3 Nov.
Sodic nitrate per acre	750 lbs.	750 lbs.	1,000 lbs.	1,000 lbs.
Yield, tons per acre	14.94	....	14.99	....
	Percent	Percent	Percent	Percent
Sugar in beets	15.30000	13.40000	13.40000	11.00000
Dry matter in fresh beets	20.80000	20.60000	20.00000	71.60000
Crude ash in dry matter	4.62400	5.82700	4.99200	6.23600
Crude ash in fresh beet	0.96179	1.20036	0.99840	1.10764
Pure ash in fresh beet	....	0.82238	....	0.74440
Sulfuric acid	....	0.03987	....	0.03435
Phosphoric acid	....	0.03588	....	0.02373
Chlorin	....	0.07050	....	0.06768
Sodium	....	0.04584	....	0.04401
Potassic oxid	....	0.30088	....	0.21865
Sodic oxid	....	0.18359	....	0.23728
Calcic oxid	....	0.03933	....	0.03273
Magnesic oxid	....	0.09951	....	0.08064
Ferric oxid	....	0.00496	....	0.00299
Aluminic oxid	....	Trace	....	0.00163
Manganic oxid (br)	....	0.00181	....	0.00058
Total nitrogen	0.22480	0.29610	0.26660	0.25505
Protein nitrogen (Stutzer)	0.08560	0.09080	0.07870	0.07525
Ammonic nitrogen	0.00420	0.00543	0.00590	0.00363
Amid nitrogen	0.01496	0.02666	0.02283	0.02186
Amino nitrogen	0.05176	0.07438	0.06110	0.04983
Nitric nitrogen	0.02006	0.04143	0.04008	0.06285
Injurious nitrogen in beet	0.12004	0.17321	0.16017	0.15431
Injurious ash per 100 sugar	....	4.78120	....	5.47180
Injurious nitrogen per 100 sug.	0.78456	1.29250	1.19561	1.40267

Press Juice According to Ruempler.

	LXXVI	LXXVII	LXXVIII	LXXIX
Total nitrogen	0.18600	0.27065	0.25740	0.24760
Albumin nitrogen	0.04085	0.04580	0.04365	0.04120
Propeptone nitrogen	0.00100	0.00560	0.00780	0.00870
Peptone nitrogen	0.00560	0.00400	0.00120	0.00210

Ash Analyses.

	LXXXVI		LXXXVII	
	Crude	Pure	Crude	Pure
Carbon	2.417	.....	0.537	.....
Sand	0.690	.....	1.798	.....
Silicic acid	1.911	.....	1.503	.....
Sulfuric acid	3.321	4.847	3.073	4.615
Phosphoric acid	2.989	4.363	2.123	3.188
Chlorin	5.873	8.572	6.055	9.092
Sodium	.....	5.574	.....	5.912
Carbonic acid	25.836	.....	28.199	.....
Potassic oxid	25.066	36.587	19.558	29.371
Sodic oxid	20.437	22.324	26.529	31.876
Calcic oxid	3.297	4.812	2.928	4.397
Magnesic oxid	8.290	12.100	7.214	10.833
Ferric oxid	0.413	0.602	0.268	0.402
Aluminic oxid	Trace	Trace	0.146	0.219
Manganic oxid	0.150	0.219	0.063	0.095
Loss	(0.689)	.....	(1.372)	.....
Sum	101.324	.....	101.366	.....
Ogygen equi. to chlorin	1.324	.....	1.366	.....
Total	100.000	100.000	100.000	100.000

ANALYSES OF BEETS GROWN WITH APPLICATION OF NITRATES.

	LXXX	LXXXI	LXXXII	LXXXIII
	Field 5	Field 5	Field 6	Field 6
Date of sampling	3 Nov.	3 Nov.	3 Nov.	3 Nov.
Sodic nitrate per acre	1250 lbs.	1250 lbs.	....	....
Yield, tons per acre	15.96	15.96	14.47	14.47
	Percent	Percent	Percent	Percent
Sugar in beets	12.80000	14.70000	14.20000	14.30000
Dry matter in fresh beet	19.80000	21.60000	20.20000	19.90000
Crude ash in dry beet	4.92800	3.97400	4.30200	4.51700
Crude ash in fresh beet	0.97574	0.85837	0.86900	0.89888
Pure ash in fresh beet	0.68028	0.58881	....	0.63879
Sulfuric acid	0.03147	0.03335	....	0.03130
Phosphoric acid	0.02434	0.02208	....	0.04634
Chlorin	0.04389	0.01953	....	0.04792
Sodium	0.02854	0.01269	....	0.03276
Potassic oxid	0.25473	0.22820	....	0.26374
Sodic oxid	0.15964	0.12244	....	0.08661
Calcic oxid	0.03838	0.04353	....	0.03533
Magnesic oxid	0.09282	0.09773	....	0.09053
Ferric oxid	0.00358	0.00423	....	0.00198
Aluminic oxid	0.00122	0.00334	....	0.00155
Manganic oxid (br)	0.00166	0.00169	....	0.00082
Total nitrogen	0.25360	0.19140	0.21330	0.20605
Proteid nitrogen (Stutzer)	0.08475	0.07980	0.07950	0.08070
Ammonic nitrogen	0.00366	0.00315	0.00245	0.00290
Amid nitrogen	0.02246	0.01726	0.01410	0.01495
Amino nitrogen	0.05241	0.05837	0.05110	0.05231
Nitric nitrogen	0.04225	0.00949	0.00949	0.01984
Injurious nitrogen in beet	0.14273	0.09719	0.11725	0.10750
Injurious ash per 100 sugar	4.04900	3.51170	....	3.10430
Injurious nitrogen per 100 sug.	1.11510	0.66115	0.82571	0.71591

Press Juice According to Ruempler.

Total nitrogen	0.23380	0.17820	0.18295	0.16775
Albumin nitrogen	0.04795	0.04005	0.04070	0.04410
Propetone nitrogen	0.01180	0.01060	0.00990	0.00170
Peptone nitrogen	....	0.00030	0.00030	0.00400

Ash Analyses.

	LXXXVIII		LXXXIX		XC	
	Crude	Pure	Crude	Pure	Crude	Pure
Carbon	0.540	.....	0.588	.....	0.701	.....
Sand	1.882	.....	3.418	.....	0.791	.....
Silicic acid	1.563	.....	1.460	.....	0.744	.....
Sulfuric acid	3.225	4.626	3.880	5.656	3.482	4.899
Phosphoric acid	2.495	3.579	2.572	3.750	5.155	7.254
Chlorin	4.498	6.452	2.275	3.317	5.332	7.503
Sodium	.....	4.196	.....	2.156	.....	4.867
Carbonic acid	26.052	.....	25.827	.....	23.310	.....
Potassic oxid	26.106	37.445	26.586	38.756	29.341	41.288
Sodic oxid	20.300	23.467	16.256	20.794	14.483	13.820
Calcic oxid	3.933	5.641	5.077	7.401	3.919	5.515
Magnesic oxid	9.513	13.645	11.386	16.598	10.072	14.173
Ferric oxid	0.367	0.526	0.492	0.718	0.220	0.310
Aluminic oxid	0.125	0.179	0.389	0.567	0.172	0.242
Manganic oxid (br)	0.170	0.244	0.197	0.287	0.092	0.129
Loss	(0.245)	.....	(0.110)	.....	(3.389)	.....
Sum	101.014	.....	100.513	.....	101.203	.....
Oxygen equi. to chlorin	1.014	.....	.513	.....	1.203	.....
Total	100.000	100.000	100.000	100.000	100.000	100.000

The samples already presented represent three classes of beets, all grown upon supposedly good ground. The first class was grown without fertilization of any sort. It is not hereby intimated that they are, because of this fact, to be considered as good beets. The second class was grown with application of various fertilizers to see if any combination used would materially improve the quantity and quality of the crop. In this place the quality alone is considered, the crop has already been stated. The third class was grown with the application of different quantities of sodic nitrate to determine what its effect upon the quality of the crop may be. The land chosen was the best available. The results obtained with the beets grown on the check plot in this case differed so little from those obtained with the application of nitrates that a sample was taken from an adjacent field, but this proved to be one of the poorest samples of all.

As we have given the nitrogen compounds precedence over the injurious ash, we will bring together the results obtained so far and it will make plain how the results stand. For this purpose we will give the total nitrogen, the nitric nitrogen, the injurious nitrogen in the beet and the injurious nitrogen per 100 parts of sugar.

FIELDS NOT FERTILIZED.

No. of Analysis	Total Nitrogen	Nitric Nitrogen	Injurious Nitrogen in Beet	Injurious Nitrogen per 100 of Sugar
VII	0.22915	0.00320	0.07854	0.51287
VIII	0.20750	0.00090	0.11520	0.62899
XI	0.12530	0.00358	0.05320	0.37440
XII	0.13760	0.00786	0.06070	0.48953
XIII	0.14388	0.00870	0.06086	0.38529
XIV	0.14128	0.00530	0.09180	0.40393
XV	0.15630	0.01104	0.08190	0.56875
XVI	0.18636	0.02138	0.08426	0.63840
XVII	0.19810	0.02067	0.08703	0.65436
XVIII	0.20605	0.01718	0.11725	0.82571
XIX	0.21330	0.01984	0.10750	0.75175
XX	0.25215	0.04537	0.13660	1.07246

EXPERIMENTS WITH FERTILIZERS.

	Fertilizers *used				
XV	None	0.15630	0.01104	0.08190	0.56875
XXVIII	None	0.12895	0.01034	0.05405	0.37020
XXIX	150 K	0.12320	0.00250	0.05195	0.35827
XXX	200 P	0.10875	0.00987	0.03760	0.27288
XXXI	160 K, 100 N	0.21900	0.01333	0.13470	0.95531
XXXII	240 P, 100 N	0.15345	0.01333	0.07233	0.58334
XXXIII	220 P, 400 N	0.23270	0.00832	0.12870	0.94632
XXXIV	220 P, 260 K	0.17150	0.00865	0.07245	0.62047
XXXV	400 P, 300 K, 200 N	0.13760	0.00250	0.06550	0.42810
XXXVII	500 P, 400 K, 200 N	0.17770	0.08725	0.08725	0.65603

*K indicates potassic sulfate 48.55 percent K_2O; P, superphosphate 13.19 P_2O_5; N. sodic nitrate 96.60 $NaNO_3$.

EXPERIMENTS WITH SODIC NITRATE.

No. of Analysis	Fertilizers *used	Total Nitrogen	Nitric Nitrogen	Injurious Nitrogen in Beet	Injurious Nitrogen per 100 of Sugar
	Samples Taken 11 Oct. 1910.				
LX	250 N	0.16355	0.00925	0.07770	0.46019
LXI	250 N	0.14915	0.00760	0.07400	0.44849
LXII	500 N	0.17133	0.00501	0.08058	0.51984
LXIII	500 N	0.22405	0.00941	0.11845	0.72668
LXIV	750 N	0.25365	0.02026	0.13942	0.88237
LXV	750 N	0.29395	0.04646	0.16317	1.25520
LXVI	1,000 N	0.28390	0.04653	0.15909	1.29340
LXVII	1,000 N	0.25556	0.05051	0.13798	1.11275
LXVIII	1,250 N	0.28175	0.05404	0.10925	0.86705
LXIX	1,250 N	0.21180	0.03846	0.10500	0.79543
LXX	• None	0.19740	0.02666	0.11180	0.79856
LXXI	None	0.19380	0.01800	0.08450	0.54905
	Samples Taken 3 Nov. 1910.				
LXXII	250 N	0.14470	0.00181	0.06870	0.43758
LXXIII	250 N	0.14485	0.00144	0.06010	0.36424
LXXIV	500 N	0.18225	0.01658	0.09195	0.60051
LXXV	500 N	0.20053	0.01009	0.10679	0.68221
LXXVI	750 N	0.22484	0.02006	0.12004	0.78456
LXXVII	750 N	0.29610	0.04143	0.17321	1.29250
LXXVIII	1,000 N	0.26660	0.04008	0.16017	1.19561
LXXIX	1,000 N	0.25505	0.06285	0.15431	1.40267
LXXX	1,250 N	0.25360	0.04225	01.4273	1.11510
LXXXI	1,250 N	0.19140	0.00949	0.09719	0.66115
LXXXII	None	0.21330	0.00949	0.11725	0.82571
LXXXIII	None	0.20605	0.01984	0.10750	0.71591
XX	None	0.25215	0.04537	0.13660	1.07246

Analysis XX represents beets grown on a favorably located piece of land, a rather light sandy loam. This land lies immediately west of that on which we made the experiments with sodic nitrate and the sample was taken less than 200 feet west of the west end of our experimental fields. The sample was taken, because the samples taken from our check field on 23 Sept. and 11 Oct. revealed the fact that they were not consistent with themselves and that our second sample from Field 5 and first sample from Field 6, though taken about 54 feet apart, agreed much more nearly than the two samples from Field 5, which were taken within 27 feet of one another and had received 1,250 pounds of sodic nitrate per acre, whereas Field 6 had received none.

We attempted to determine the nitric nitrogen in Field 6 at stated intervals throughout the season. The field was reported flooded on 6 July and so wet on 10 Aug., eleven days subsequent to the last preceding irrigation, that samples could not be taken. I feared that the results obtained with the samples from Field 6, which lay a little lower than Field 5, might have been due to accidental causes whereby the beets might have been supplied with nitrates carried from the adjacent, higher-lying portion of Field 5. This may not have been the case but the results led me to fear that it might be, so I took the sample represented by Analysis XX, which could not have been affectd in any way by the nitrate applied to our plots. The soil samples taken throughout the season were shallow ones and at no time showed an excessive amount of nitrates.

There are no data known to me definitely showing how much nitric nitrogen is usually present in a good beet, but judging from the amount of nitric nitrogen found in samples of Bohemian molasses there could not have been a determinable quantity in the beets themselves. This assumes of course that the whole of the nitric nitrogen passes into the diffusion juices and is not destroyed during their treatment. This is in accord with the observation of others in regard to nitrates in beets, except in regard to French beets which have been found to contain appreciable quantities of nitric nitrogen. The maximum that I have found given for French beets is 0.049 percent. The sample was taken on 30 Oct. and contained 16.97 percent sugar. This is different from our beets, for we find less sugar with such percentages of nitric nitrogen. No statement is made as to whether the beets were grown with or without fertilizers. We always determined the nitric nitrogen as nitric oxid and absorbed it in a solution of ferrous chlorid, so our results are not too high. In the beets grown without fertilizers we find the nitric nitrogen constituting in the different samples, 8.3, 9.3, 10.4, 11.6 and 18.0 percent of the total nitrogen. The lowest percentages shown by the table are 0.434 Fort Collins beets, 1.397 Michigan beets, and 2.857, beets grown on new sod land near Holly in the Arkansas Valley. The sample of Montana beets shows no nitric nitrogen.

The ratio of injurious nitrogen to the sugar falls in three instances to desirably low limits, in six it is moderately high and in three it is, I think we may say, decidedly objectionable. I know of no reason why Analysis XX should not be considered in this group though the sample is quite bad; sugar 12.7, proteid nitrogen 35.82 percent of the total, amino nitrogen 0.04794, nitric nitrogen 0.04537 percent of the beet, injurous ash 3.7 per 100 sugar and injurious nitrogen 1.07246 per 100 sugar, or the latter multiplied by 10 gives 10.7246 parts injurious nitrogenous substances for each 100 of sugar.

These results obtained with beets grown on good land without the application of fertilizers give us the range in the quality of the beets which we must expect to meet with under our best conditions.

The experiments with fertilizers were made in the Arkansas Valley on land which we have already described in connection with Analysis XV, wherewith we also gave its general composition. The available plant food in it is given in the discussion of Analyses XXVIII to XXXVII. The results as shown by this statement of the relations of the different nitrogen factors indicate that a slight improvement was effected by potassic sulfate and superphosphate when applied separately, for the beets grown with the application of these fertilizers are something better in quality than those grown without any fertilizer. I have elsewhere stated that results on contiguous half-acre parcels of this land varied so greatly, that one becomes doubtful as to the value of any result. Nevertheless this appears to be the fact, i. e., that phosphoric acid and potash applied separately improved the quality of the beets but the yield was not quite so good as on the plot which received 20 tons of lime per acre in 1909 and nothing in 1910 and only equal to the yield from the plot that had received no fertilizer either year. The two applied together, XXXIV, did not improve either the crop or the quality. The results with the sodic nitrate are fortunately, in the main, consistent in showing a slight increase in the yield and a depression of the quality. But these results are not without exceptions and other inconsistencies. It happens that Analyses XV, XXVIII, XXIX, and XXX represent four successive half-acre plots and from Analysis XXX we would infer a depression of the injurious nitrogen from 0.57 or 0.37 to 0.27 per 100 sugar caused by the application of 200 pounds of superphosphate per acre and from XXIX we would infer a slight depression or at least not an increase of the injurious nitrogen, but in XXXIV where we have the two applied together and in larger but not excessive quantities we find a decided increase in the injurious nitrogen. This is not due to climatic or cultural differences, nor to differences in the soil. In Analyses XXXV, XXXVI and XXXVII we have another group which is capable of various interpretations. If any conclusion be justified by the results of these experiments it is the one stated, i. e., that potash and phosphoric acid tend to improve the quality of the crop, but not to increase it, while sodic nitrate tends to increase the crop, but to lower the quality. The actual increase, however, in either crop or quality was so variable that no reliance can be placed in the use of these agents to increase the value of the crop, which was the purpose had in view. These features of our study agree with the gross results as heretofore stated. There were 28 experiments in this series but only these eleven samples were submitted to complete analysis. There is one point in which these analyses agree, i. e., in showing less amino nitrogen than the other samples which we have analyzed.

It is difficult to believe that the variations in half-acre pieces of land, apparently the same, may be so great as to account for the variations in the results observed in these cases, but I am convinced that this variation constitutes an important factor in our results. The effects of previous fertilization may play some part, but with mineral fertilizers this is very small.

The series of experiments with sodic nitrate was made with an entirely different object in view. It has generally been held that sodic nitrate affects the quality of the beet prejudicially. Whether this view, which has been almost universally held for a long time, was based upon definitely established data or was a general, but thoroughly well founded impression, I do not know. I have been able to find but one single series of experiments, this consisting of only two members, to definitely establish the injurious effects of sodic nitrate upon the factory qualities of beets. There may be others of very recent date but they have not come to my knowledge. The experiments to which I refer were made by Andrlik and consist of two experiments, one with about 27.0 pounds of nitrogen as sodic nitrate, the other with 81.0 pounds of nitrogen, or about 175 and 525 pounds of sodic nitrate per acre. His results were as follows: With 175 pounds of sodic nitrate per acre applied in three portions, average weight of beets 330 grams, sugar 17.2, total nitrogen 0.160, injurious nitrogen 0.040, injurious nitrogen per 100 sugar 0.233; with 525 pounds to the acre, beets 372 grams, sugar 16.4 percent, total nitrogen 0.234, injurious nitrogen 0.101, injurious nitrogen per 100 sugar 0.616. The check beets weighed 333 grams, sugar 17.8 percent, total nitrogen 0.138, injurious nitrogen 0.042, injurious nitrogen per 100 sugar 0.236. The injurious ash in the three samples was per 100 sugar, in the check 1.45, with 175 pounds saltpetre 1.57 and with 525 pounds saltpetre 1.89. Concerning these results Andrlik remarks, "The application of about 80 pounds of nitrogen per acre, 91.5 kg pro 1 ha, in the form of Chile-saltpetre acts very detrimentally." It brought about the following results: it lowered the sugar from 17.8 to 16.4, it increased the total nitrogen from 0.138 to 0.234, the injurious nitrogen per 100 sugar from 0.236 to 0.616 and the injurious ash per 100 sugar from 1.45 to 1.85. Andrlik does not say that these were bad beets, but that these changes in the beets were very detrimental. I infer from other statements that I have found, that 0.616 injurious nitrogen per 100 sugar is a decidedly objectionable quantity. This is the only intimation that I have found relative to the amount of injurious ash which may be permissible in an unobjectionable beet, and it is not clear that he intends this amount, 1.89 per 100 of sugar, to be so considered, but he specifies that the sodic oxid and injurious nitrogen in the roots have been increased three fold—the sodic oxid is given as 0.094 percent of the beet.

In regard to the effects of the sodic nitrate upon the nitrogenous constituents of the beets we have no good measure as our check samples failed us altogether, being quite as bad in quality as the beets to which we applied 750 or more pounds sodic nitrate per acre, and very decidedly poorer in quality than those to which we applied 250 pounds per acre. The fact is that the results of this experiment are not in agreement with what the results of the preceding series suggest. In the former series the application of 200 and 400 pounds of sodic nitrate in conjunction with potash and phosphoric acid which, it is agreed, tend to lessen or neutralize the bad effects of the nitrate, produced decidedly bad effects, but in this series we applied 250 pounds per acre alone and the results are favorable, but with 500 pounds per acre we have apparently passed the limits of beneficial action and with 1,000 pounds per acre applied in four equal portions at intervals of about four weeks beginning just before seeding time we reach the maximum of the deleterious effects as measured by these factors. Field 1 with 250 pounds of nitrate applied just before seeding gave us, according to our laboratory samples the best yield and the best beets, they are in fact better beets than the Michigan sample which we selected in an endeavor to obtain a standard for comparison in which we found 15.3 percent sugar, 0.229 percent total nitrogen and 0.51237 injurious nitrogen per 100 sugar. In the beets from Field 1, with 250 pounds of sodic nitrate we found 15.7 and 16.5 percent sugar, 0.14470 and 0.14485 percent total nitrogen and 0.43758 and 0.36424 part injurious nitrogen per 100 sugar. In respect to the ratio of injurious nitrogen to sugar, the beets from Field 1 were better than our Fort Collins beets which showed 0.62899 per 100 of sugar. The samples from Field 2 with 500 pounds per acre are not so good, but even these are better beets than those produced in our experiments with fertilizers and the total nitrogen is not particularly high, 0.18 and 0.20 percent, while the injurious nitrogen per 100 of sugar is 0.60054 and 0.68221 for the samples taken 3 Nov. In the other cases the total nitrogen was higher and the injurious nitrogen per 100 of sugar rose to a maximum of 1.40267. The amino nitrogen in this series rose to a maximum of 0.07438 and is above 0.045 in every case except one.

There was but little difference in the growth of the beets on Field 1 and of those on adjoining plots so far as the size of the tops and their color were concerned, they were all luxuriant and a deep green till the leaf-spot appeared. This was not the case with the three acres receiving the largest applications. On these one could easily distinguish the bigger and more abundant foliage. This difference may have been due to the larger quantity of nitrate, or to the time it was applied; be this as it may, the foliage was distinctly heavier and of a blue green color. No attempt was made to determine the weight of the tops, this would have been impossible owing to the destruction of leaves by the leaf-spot and by the wheels of the spraying outfit. There was a perceptible difference in the size and color of the fields that received the heavier applications of nitrates and the check field.

These amounts of nitrates exercised a very perceptible influence upon the physical condition of the soil, causing it to show a decided tendency to puddle and become hard. Whether this was due to the nitrate itself or to other salts formed from the nitrate as has been suggested I do not know. The number and size of the leaves on the nitre beets was larger than it is usual to find on sugar beets, besides, owing to the fulness of the foliage it was erect and not spreading or prone as we sometimes see it. The nitre beets did not seem to be so seriously attacked by the leaf-spot as the beets on adjacent land, but on counting the dead leaves on quite a number of beets to determine this point, I doubt whether there is any greater resistance shown toward the attack of the leaf-spot by nitre beets than by others. These beets were sprayed five times with standard Bordeaux mixture but I could see no conclusive evidence of benefit therefrom. The shape of the beets produced on these plots showed a decided modification of their form—as one effect of the nitrate. The beets became shorter and broader at the top as the nitrate applied increased. The photographs of some of the piles as they lay in the field at harvest time show this effect. I do not think that the shape of the beet was modified in this way by the hardness of the soil, for I have seen well shaped beets dug from harder soil than any of this, still the hardness of the soil may have had some influence, but I think that the full, excessive foliage and abnormal nutrition produced this effect. We have shown some photographs of beets grown on the College farm with excessive foliage and but seven tons of topped beets per acre. The following plates, Plates II and III, show some piles of beets as they lay on Field 2, 3, 5 and 6. The differences are evident without further description. Field 6 received no nitrate, fields 2, 3 and 5 received 500, 750 and 1,250 pounds respectively. These fields form one continuous piece of land. We shall discuss the ashes and juices of these beets in subsequent paragraphs.

The plates representing beets grown with and without the application of nitrates show very marked differences, but the beets as they were harvested and lay in the fields showed the differences even more markedly than the photographs of these piles. The variety of beets represented is the Original Kleinwanzlebener and there is no question of varietal differences. There were some variations in the quality of the soil but the differences in the shape of the beets varied with the amount of nitrogen applied and not with these. The cultivation, irrigation, spraying, etc., has been given in sufficient detail and as may be seen were essentially the same.

In order to present the extreme effects of nitre-impregnated land upon the shape of the beet I have introduced Plate IV. The lower photograph represents beets grown near Fort Collins, whose composition is given in Analysis VIII. The upper figure represents

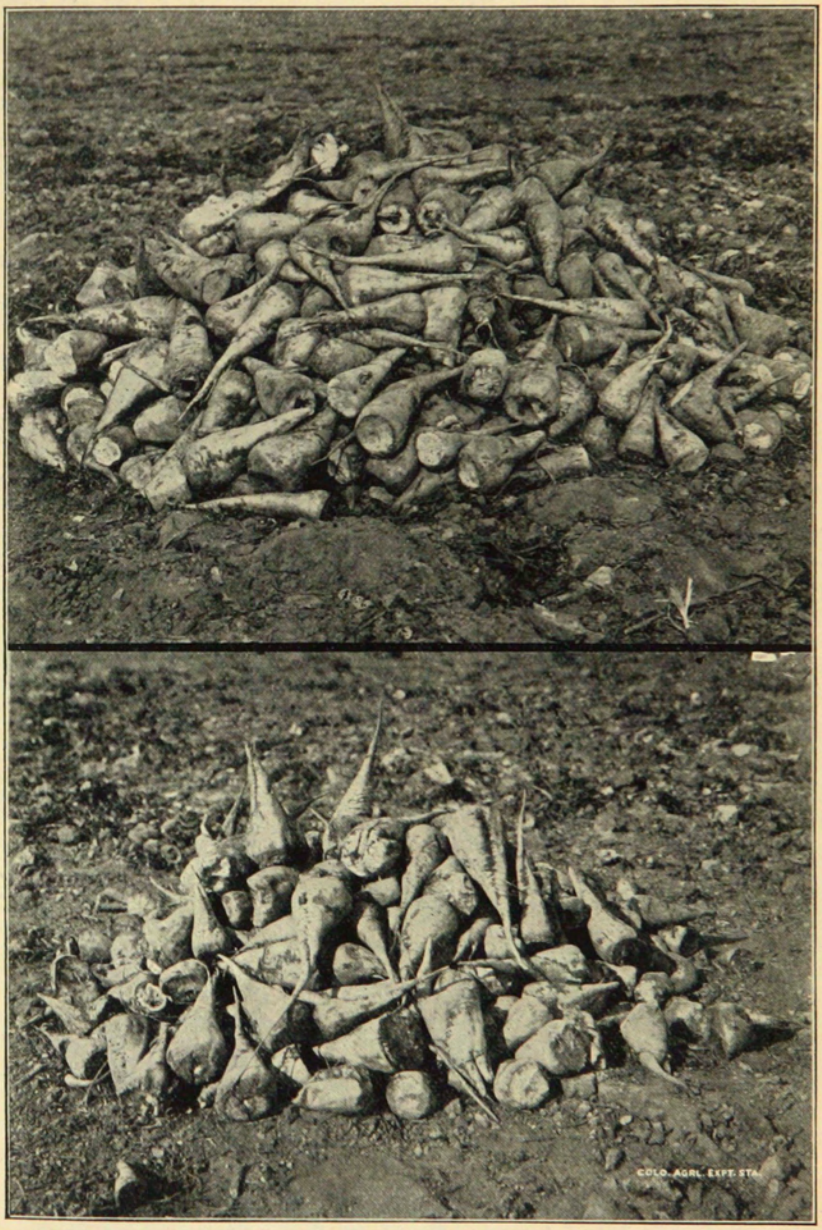

Plate II. Upper photograph represents beets grown without application of sodic nitrate, the lower one beets grown with 500 pounds per acre.

beets grown on land very rich in nitrates. The water plane at the point where these beets were grown was five feet below the surface but the ground was, as is very often the case, quite wet. The water *per se* probably had but little to do with the shape of the beets, for as

Plate III. The upper photograph represents beets grown with 1,000 pounds and the lower one beets grown with 1,250 pounds sodic nitrate per acre.

stated elsewhere we have grown well shaped beets on land in which the water plane at no time during the season fell to more than three and one-half feet below the surface and at times rose even to the surface. This land, too, was very rich in the ordinary alkali salts, a sample taken in one section of it to a depth of ten inches having yielded 2.5 percent soluble in water. This section of the field yielded, the third consecutive year that it was planted to beets, a

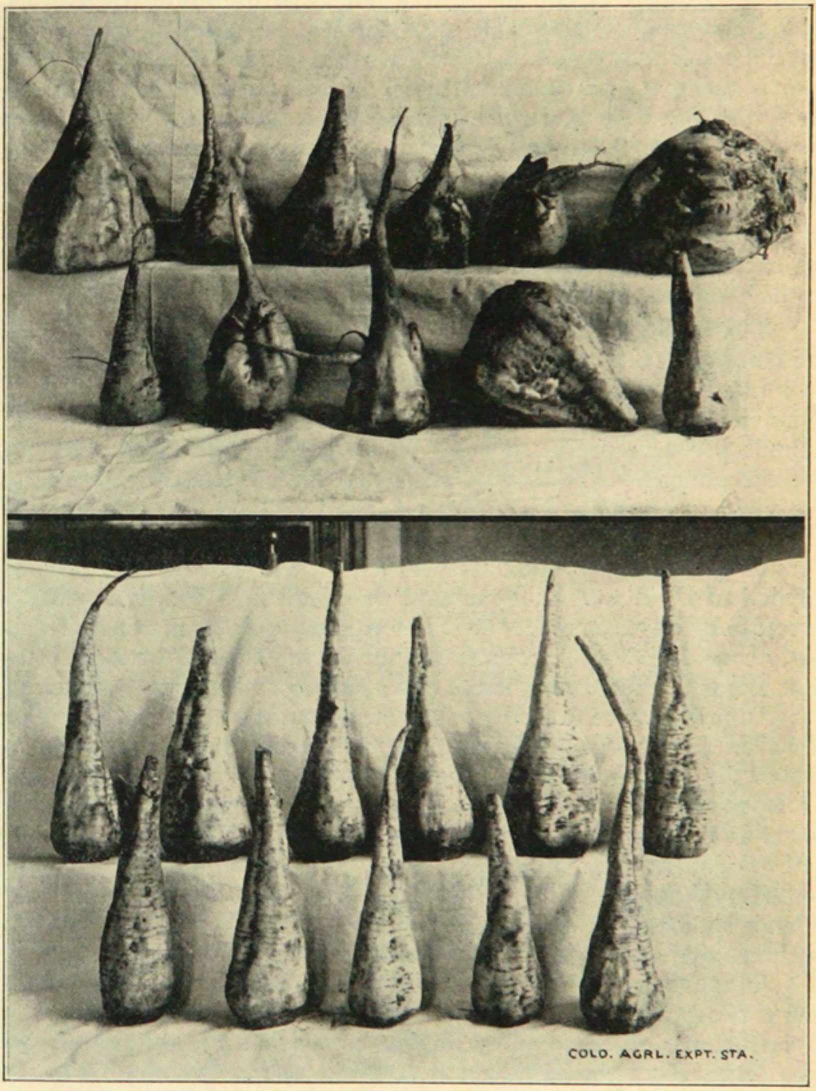

Plate IV. The upper photograph represents beets grown on land very rich in nitrates; the lower one beets grown on good land.

crop that would compare favorably in regard to shape, size and sugar content with the beets represented in Plate IV, lower figure. The beets represented in this plate grown in 1910 on a good, sandy loam, contained 18.3 percent sugar and had an apparent coefficient of purity of 83.2, while the beets grown in the undrained alkali land in 1898 contained 18.3 percent sugar and had an apparent coefficient of purity of 89.3. The shape and quality of the beets represented in Plate IV, upper figure, are undoubtedly the result of all the untoward conditions obtaining, but the chief, if not primarily the only one, is the presence of the nitrates. The analysis of these beets, Analysis No. CII, given on a subsequent page, shows that these beets had taken up a very remarkable amount of nitrogen, 0.345 percent total nitrogen with 0.0834 percent of nitric nitrogen. A knowledge of the conditions and the analytical results shown in the analyses of the beets and ash, leave no room for doubt but that the excessive quantity of nitrates in the soil was the principal cause in the production of such beets.

The results so far presented to show the effects of nitrates upon the composition of the sugar beet, agree with those of Andrlik except that in this case the application of larger amounts, 250 as against his 175 pounds, proved decidedly beneficial and even 500 pounds per acre produced results only a little less favorable than the 250 pounds. We may measure this for our present purpose by the yield of sugar as given for the beets delivered to the factory. Field 1, 250 pounds nitrate, produced 4,763 pounds and Field 2, 500 pounds nitrate, 4,377 pounds per acre. The second 250 pounds applied to Field 2 did not increase the yield, there being actually a decrease of 387 pounds. This is too small a difference to be seriously considered under our conditions, but we shall subsequently see that this is not the whole of the case. From this point, from 500 to 1,250 pounds, there was a decided deterioration of the beets, unquestionably due to the nitrates. The composition of these beets, in which the deterioration has been brought about by the application of 1,000 pounds of nitrate, is almost identical with the bad beets taken as a check and which of course, were grown without the application of nitrates or other fertilizers. These conditions are represented by Analyses LXXVIII and LXXIX, beets grown with 1,000 pounds sodic nitrate applied per acre, and Analysis XX, beets grown without nitrate. We have total nitrogen in LXXIX, 0.26660, in XX, 0.25215, nitric nitrogen 0.04008 and 0.04537, injurous ntrogen 0.16017 and 0.13660, injurious nitrogen per 100 sugar 1.19561 and 1.07246. These analyses agree better than the duplicate samples taken from the field which received 1,250 pounds of sodic nitrate. We cannot doubt the cause of the poor quality of the former beets, the high total nitrogen, the high nitric nitrogen and the high percentage of injurious nitrogen which is most clearly shown by the amount present for each 100 pounds of sugar, and especially so by converting the injurious nitrogen into its equivalent of nitrogenous substances, by multiplying it by 10—the factor 16.1 has also been suggested, we will use the lower factor—when we obtain for the two analyses in the order given, 11.96 and 10.72—amounts which are more than twice that which justifies us in classifying the beets as of poor quality. The sugar in these two samples of beets was 14.2 and 12.7 percent respectively and the injurious ash per 100 of sugar was, in LXXIX, 3.104 and in XX, 3.703 parts. As previously stated I have been unable to find a definite statement regarding the permissible amount of injurious ash in a beet. Of course a beet would not be judged by the amount of injurious ash alone, other factors are also to be taken into consideration. We do, however, find that Andrlik mentions the increase in the injurious ash from 1.45 to 1.89 parts or 0.44 part, in connection with an increase of 0.38 part of injurious nitrogen and a depression of 1.2 percent, from 17.8 to 16.4, in the sugar content as a very unfavorable action upon the quality of the beet. Again in the analyses of cossettes quoted from another article of Andrlik's, we find in Analysis VI which he says is a good beet, 1.947 parts injurious ash per 100 sugar and in V which he classifies as a poor beet, we find 2.759 parts, so in considering the injurious ash in our beets we may tentatively assume that 2.0 parts injurious ash per 100 of sugar in the beet is a reasonable limit for the permissible amount of injurious ash in an otherwise fairly good beet. Judged by this assumed standard our nitrate beets are quite bad, reaching a maximum quantity of 5.472 parts injurious ash per 100 of sugar—and our beets in general so far as they have been presented are indifferent or decidedly bad. We have presented but two samples and they were not from Colorado, in which the injurious ash is below 2.00 parts per 100 of sugar, and these have 1.67 and 1.9447 parts. Our best beets grown at Fort Collins approximate it with 2.2, 2.4 and 2.4 parts, but other Fort Collins beets are higher, 3.4 parts. The beets grown with the application of fertilizers are, in this respect, decidedly lower in quality as they show from 4.3 to 7.7 parts injurious ash per 100 of sugar. I have already called attention to the amount of chlorin in the ashes of these samples. In several of the analyses given the sodic chlorid amounts to 30 or even more percent of the pure ash and a still larger percentage of the injurious ash.

We have given the injurious nitrogen in Analyses LXXIX and XX. Analysis LXXIX is a sample of beets taken from the plot that had received 1,000 pounds of nitrate per acre in four equal applications. We find that the injurious introgen amounts to 1.403 parts per 100 of sugar. This sample shows the largest amount of nitric nitrogen of any of the samples taken from these fields and it amounts to 0.566 parts per 100 of sugar. More than one-third of the injurious nitrogen in this sample was present as nitric acid respectively as nitrates, or if we consider the nitrate to be sodic nitrate it gives us 3.4 pounds of sodic nitrate per each 100 pounds of sugar in these beets. The beets represented by Analysis XX were grown without the application of any kind of a fertilizer and we find the injurious nitrogen equal to 1.072 parts per 100 of sugar and the nitric nitrogn equal to 0.3555, almost exactly one-third of the injurious nitrogen and each 100 pounds of sugar in these beets was accompanied by 2.133 pounds of sodic nitrate. These are the maximum quantities found in these classes of beets, but they are very large, and we are certain that this was due in the one case to an application of 1,000 pounds of sodic nitrate per acre. The other also, though no nitrate was applied, must have had an excessive supply furnished by the soil itself as there is no evidence that the nitric acid is formed in the beet. An examination of our results shows our beets to contain from 0.032 which is our very lowest up to 3.4 parts of nitrates calculated as sodic nitrate for each 100 parts of sugar. The French beet previously mentioned as carrying 16.8 percent of sugar and 0.049 percent if nitric nitrigen, carried only 1.760 parts of sodic nitrate to 100 of sugar, which is only one-half as much as our maximum quantity. The sodic oxid in the ashes of these beets grown with nitre is very high, reaching a maximum of about 40.0 percent of the pure ash and nearly 0.25 percent of the weight of the fresh beet. It is lowest in the Michigan beet, of which it constitutes about 0.002 percent of the beet. It is likewise quite low in our Fort Collins standard beet and in those grown on new sod land at Holly, but is fairly high in those grown on the College Experiment Farm in 1911, 0.05 percent of the beet, and decidedly high in those grown in 1910, 0.129 percent. The chlorin in the beets grown on our plots with fertilizers is very high, constituting 15 to 19 percent of the pure ash, that this may have been the carrier of the sodium is probable, but whatever the cause the sodic oxid is quite high. The lands on which these beets were grown are, as repeatedly stated, good lands and not seeped, alkalized lands, surcharged with salts which may be considered injurious to vegetation. The maximum amount of chlorin found in the soil on which the experiments with fertilizers were made, was 0.038 percent for the total chlorin. The water soluble chlorin ranged from 0.008 to 0.021 percent, the latter was found in the third foot of soil. Beets grown with sodic nitrate are always relatively rich in chlorin.

The water-soluble in this soil is not exceptionally high for arid lands; the surface foot showed 0.10 and 0.18, the second foot 0.32 and 0.35 and the third foot 0.81 and 0.90 percent for two series of samples. These figures for the second and third foot, samples taken subsequently, were much higher. The water-soluble in this case is largely calcic sulfate. Our former studies of the sugar beet have shown that while the ash of beets grown on strongly alkalized land may contain considerable quantities of sodic oxid, it does not follow that it will contain more or even as much as that of beets grown on ordinary soil, in fact, we found it to contain less. The abundance of soluble salts alone does not determine this factor, nor do I intend to intimate what the cause of the taking up of the sodic oxid in our case is. The presence of sodic oxid in the beets grown with the application of sodic nitrate has been attributed to the nitrate. This may or may not be the controlling factor. In the cases so far given we have with a high nitric nitrogen content a large amount of sodic oxid above that necessary to furnish sodium to combine with the chlorin.

The magnesic oxid in the ashes of our beets is high and the lime low, as compared with the average data given, and both low compared with some recent data. The ratio of lime to magnesia in our beets is comparatively low, as it is usually 1:2 and sometimes 1:3. In the averages quoted from E. Wolff and others, this ratio is much more nearly 1:1. There are of course variations in this ratio in different analyses, but the observation is still true of the individual analyses that I find. Further, our beets are as a rule quite rich in ash constituents. The German beets seem to carry from 3 to 3.5 percent of crude ash or about 2.3 percent pure ash in the dry substance, whereas ours carry much larger percentages. It is rather exceptional to find a sample of beets showing less than 3.5 percent of crude ash and not at all uncommon to find from 5 to 6 percent. This is not due to the variety, to bad preparation or specifically to nitrates in the soil, at least, we do not find enough increase in the ash of beets grown with the application of nitre to justify such an inference. On the contrary, the application of 250 pounds per acre apparently produced a decided improvement in this respect, and while the crude ash in the beets grown with 750 and 1,000 pounds per acre is higher, it does not exceed the amount found in samples grown without fertilizers of any kind, so while it is very probable that the increase in ash was in part due to the action of the nitrate, it is not positive enough to remove the question beyond doubt. We have for example three samples grown without the addition of anything which show 4.3, 4.5 and 5.0 percent crude ash. We have also two samples grown with application of 750 pounds sodic nitrate, these have 4.6 and 5.8, also two with 1,000 pounds per acre and these show 5.0 and 6.2 percent. These samples are all from the same land. Samples from other land, beets grown without fertilizers, we have 5.1, 5.0 and 6.3 percent of crude ash. All that we are justified in stating is that the nitrate slightly increased the ash content of the beets, but that it can scarcely be considered the cause of the high ash content in general, unless we assume the presence of unusual amounts of nitrates in general.

The ratio between the sodic and potassic oxids varies greatly without such an apparent relation to other factors as to make it evident that this ratio is of itself an important one; for instance we have in the Michigan beets 15.3 percent of sugar, 0.70 percent of crude ash in the beet, 0.0032 percent nitric nitrogen in the beet and 0.5129 part injurious nitrogen per 100 of sugar and the ratio of sodic to potassic oxid is 1 :140. In Analysis XXXVI, one of our fertilized beets, we have also 15.3 percent sugar, 1.05 percent crude ash, 0.0025 percent nitric nitrogen, 0.428 injurious nitrogen per 100 sugar and the ratio of 1 :26 for the sodic to the potassic oxid. While the ratios in these samples are extreme, the quality of the beets is not very different. The amount of sugar is the same, 15.3 percent, the injurious nitrogen is less in the beets with 13.6 percent sodic oxid in the crude ash, against 0.255 percent in that of the other beet; the nitric nitrogen is also less and the injurious ash is 4.16 against 1.94 or 2.1 times as much. It is seldom in our beets that this ratio is less than 1 :9 and occasionally the sodic oxid is almost equal to the potassic oxid, in one sample given it is actually greater, but the beets in this case were very low in quality and they had been grown with a heavy application of nitrate.

BEETS GROWN ON BAD LAND.

The land chosen for the experiments and observations to follow, was one which I had been observing since 1909 and which I knew to be very rich in nitrates. The land slopes to the north and west so that the south end of the field is 17½ feet higher than the north end, and the southeast corner of the field is 22 feet higher than the southwest corner. The distance across this field from east to west was not measured. The rows ran north and south and were at this place 672 feet long. On the north and west of this land is a flat area through which runs a ditch. This drainage ditch is 650 feet beyond the north end of the cultivated land under consideration. The flat land is used as a pasture, but is partly bare and at times wet. We had borings made to determine the hight of the water plane at the end of September and found it to be five feet below the surface at the lowest point of the cultivated field and only one foot about the bottom of the open ditch. Samples of this soil were taken on 22 June 1910 because we wished to apply fertilizers to see whether they would produce any effects upon the crop in quantity or quality under these conditions. For this purpose thirty rows of beets were selected. The total length of the rows was 672 feet. The extreme north end of the cultivated portion was rejected as wholly unfit for our purpose. About 550 feet of the rows was taken. The width of the land selected was thirty rows of beets or from 45 to 50 feet and the length as stated. This was divided into three sections and composite samples representing the top and second two inches of soil taken. Each composite sample consisted of eight subordinate samples. The samples are numbered from the lower to the higher ground.

		Potash Percent	Phosphoric Acid Percent	Total Nitrogen Percent	Nitric Nitrogen Percent
I	Top 2 inches..............	1.163	0.0765	0.1480	0.0280
	Second 2 inches...........	1.275	0.1913	0.1305	0.0125
II	Top 2 inches..............	0.874	0.1244	0.0920	0.0050
	Second 2 inches...........	0.960	0.1626	0.0960	0.0030
III	Top 2 inches..............	1.024	0.1626	0.0970	0.0040
	Second 2 inches...........	0.893	0.1595	0.0850	0.0030

So far as this analytical data is concrned the soil is, according to our standards, well supplied with potash and phosphoric acid, but is lacking in nitrogen. There is no other indication or proof of this except our analyses. The nitrogen determinations here given were made by the plain Kjeldahl and I have added the nitric nitrogen found to obtain the total, this was all that remained for me to do. These determinations were made when the samples were taken and are the only ones that it is proper to use. The total nitrogen was recently redetermined in these samples now 20 months old, and there is an unquestionable increase in every instance. This increase is not uniform in amount, ranging from 80 to 500 p. p. m., but is sufficient to preclude the use of the recent determinations. These determinations were made with care, taking all usual precautions and in duplicate so that I am not inclined to consider this increase due to analytical errors. We observe that the nitric nitrogen varies from 3.13 to 18.93 percent of the total. These samples represent what we consider as soil of such quality and so conditioned that the owner was justified in cultivating it with the expectation of obtaining at least an average crop. The extreme northern edge of this field was very bad and was very noticeable because the owner was trying to cultivate it, which made its condition more evident. The surface became brown and mealy during the season. A surface sample of this soil showed that it was well provided with potash, 1.118 percent, and phosphoric acid, 0.380, and was very rich in nitrates and chlorids, about 30 percent of the water-soluble. The calcic oxid in this sample was 6.070 percent and the analysis of the water-soluble indicates that the sulfuric acid is wholly combined with lime. The citric acid soluble phosphoric acid amounted to 0.023 percent. The analytical data indicated a soil well provided with potash and phosphoric acid, but decidedly low in total nitrogen, at the same time we see that the highest section of this land contained on 22 June, 1910, 93.3 pounds of nitric nitrogen in the top four inches of the soil, the next lower section 106.2 pounds and the next lower 400 pounds, and this was all land in good cultivable condition. The beets on this date presented a good stand but were not particularly promising. I do not know the details of the cultivation received throughout the season. On 6 July there were applied to five rows, superphosphate at the rate of 1,000 pounds, to 5 rows potassic chlorid at the rate of 400 pounds, to 5 rows sodic chlorid at the rate of 400 pounds, to 5 rows superphosphate at the rate of 1,000 pounds and potassic chlorid 400 pounds per acre. and to 5 rows superphosphate 1,000 pounds and sodic chlorid 400 pounds per acre. The fertilizers were applied by hand. I visited this field on 8 Aug. and the condition of the field was very promising. The foliage was exceedingly heavy, the petioles were erect, stout and long, the blades were large but did not vary more in shape than usual; they were thick and heavy in substance and very brittle. The hight of the leaves was about 36 inches, the color was from a dark to a bluish green. No difference could be detected between the rows to which the fertilizers had been applied and the rest of the field. The yield of the beets at this time promised to be very heavy indeed, the yield at harvest time was 11.7 tons and the sugar according to the factory returns was 14.14 percent. We took three sets of samples 23 Sept., 11 Oct., and 3 Nov. The average weight of the beets was not determined except for the final, 3 Nov., samples. Owing to the number of samples to be handled, only the plots to which the fertilizers were separately applied, a check plot and the very bad portion of the field—39 samples in all—were taken. The samples are numbered 1, 2 and 3. Sample 1 is uniformly taken from the highest ground and corresponds to Sample III of the soil and 3 corresponds to Sample I of the soil.

BEETS GROWN ON BAD LAND—SAMPLES TAKEN 23 SEPT.

	Sugar	Dry Substance	Total Nitrogen	Protein Nitrogen	Ammonic Nitrogen	Amid Nitrogen	Amino Nitrogen	Nitric Nitrogen
Plot With Superphosphate.								
1....	10.2	15.8	0.2126	0.0761	0.00835	0.01825	0.04407	0.02446
2....	11.3	17.1	0.2577	0.0870	0.00830	0.01330	0.07141	0.03703
3....	9.4	15.0	0.2702	0.0730	0.00980	0.02040	0.01845	0.05258
Plot With Potassic Chlorid.								
1....	10.8	17.2	0.2255	0.0737	0.00830	0.01595	0.03832	0.03376
2....	8.9	14.1	0.2782	0.0741	0.00995	0.02720	0.05042	0.05098
3....	9.0	14.1	0.2169	0.0718	0.00865	0.01410	0.01611	0.04769
Plot With Sodic Chlorid.								
1....	12.6	18.8	0.2118	0.0769	0.00775	0.01355	0.04349	0.01705
2....	11.8	17.7	0.2543	0.0807	0.00980	0.01685	0.02785	0.04500
3....	9.8	16.1	0.2752	0.0830	0.00995	0.02290	0.03729	0.04146
Check Plot.								
1....	13.0	17.4	0.2687	0.0784	0.00400	0.01150	0.04015	0.01630
2....	12.4	18.5	0.2706	0.0793	0.01625	0.02045	0.04120	0.03480
3....	10.8	17.0	0.2630	0.0721	0.01640	0.01650	0.04205	0.02798
Very Bad Section.								
1....	7.8	14.4	0.2744	0.0827	0.00850	0.02350	0.03123	0.06493

BEETS GROWN ON BAD LAND—SAMPLES TAKEN 11 OCT. 1910.

	Sugar	Dry Substance	Total Nitrogen	Protein Nitrogen	Ammonic Nitrogen	Amid Nitrogen	Amino Nitrogen	Nitric Nitrogen
Plot With Superphosphate.								
1....	10.8	17.2	0.2413	0.0764	0.00230	0.02205	0.01786	0.05329
2....	11.3	18.2	0.2767	0.0873	0.00215	0.02805	0.01537	0.04351
3....	12.0	18.8	0.2527	0.0891	0.00275	0.02175	0.03114	0.03811
Plot With Potassic Chlorid.								
1....	11.4	18.8	0.3026	0.0891	0.01740	0.02620	0.02440	0.05745
2....	12.3	19.7	0.2687	0.0780	0.00530	0.02420	0.01256	0.03081
3....	13.2	18.3	0.1988	0.0868	0.00573	0.01213	0.05275	0.02537
Plot With Sodic Chlorid.								
1....	11.5	17.9	0.1945	0.0761	0.00313	0.01477	0.09680	0.02738
2....	13.1	19.6	0.2017	0.0792	0.00230	0.01580	0.12750	0.02854
3....	10.0	18.0	0.3214	0.0763	0.00855	0.02820	0.08932	0.07695
Check Plot.								
1....	11.5	17.0	0.1989	0.0850	0.00370	0.01180	0.04532	0.02853
2....	10.5	16.5	0.3070	0.0807	0.00475	0.02190	0.08209	0.06417
3....	9.0	15.5	0.2507	0.0678	0.00200	0.02205	0.06262	0.06955
Very Bad Section.								
1....	7.8	14.7	0.3301	0.0784	0.00840	0.02840	0.12559	0.09319

BEETS GROWN ON BAD LAND—SAMPLES TAKEN 3 NOV. 1910.

	Sugar	Dry Substance	Total Nitrogen	Protein Nitrogen	Ammonic Nitrogen	Amid Nitrogen	Amino Nitrogen	Nitric Nitrogen
Plot With Superphosphate.								
1....	10.9	17.6	0.25860	0.0777	0.00430	0.02260	0.03365	0.04982
2....	11.8	19.0	0.24350	0.0530	0.00356	0.02083	0.03142	0.04621
3....	10.2	18.0	0.30675	0.0879	0.00879	0.03470	0.03409	0.07260
Plot With Potassic Chlorid.								
1....	13.1	20.3	0.23700	0.07495	0.00360	0.02085	0.04295	0.02501
2....	11.8	19.4	0.24715	0.08125	0.00445	0.02245	0.04154	0.04111
3....	12.2	19.5	0.34510	0.09680	0.00526	0.04430	0.03483	0.05120
Plot With Sodic Chlorid.								
1....	13.0	20.0	0.19020	0.09685	0.00185	0.01340	0.03505	0.01558
2....	12.4	18.9	0.21445	0.10030	0.00245	0.02055	0.04908	0.03713
3....	10.4	18.3	0.33970	0.11385	0.00735	0.03260	0.02757	0.08743
Check Plot.								
1....	13.2	21.0	0.24930	0.08645	0.00545	0.02160	0.03514	0.01936
2....	11.3	17.6	0.15995	0.06740	0.00200	0.00690	0.03935	0.03249
3....	12.1	18.9	0.23345	0.08845	0.00350	0.01470	0.03470	0.05310
Very Bad Section.								
1....	8.6	16.5	0.34510	0.12389	0.00520	0.03985	0.03507	0.08337

BEETS GROWN ON BAD LAND.

Samples Taken 3 Nov. 1910. Superphosphate added at the rate of 1,000 pounds per acre.

	XCI	XCII	XCIII
Section	1	2	3
Average weight of beets	751.3 grams	725.0 grams	708.7 grams
	Percent	Percent	Percent
Sugar in beets	10.90000	11.80000	10.20000
Dry substance in beets	17.60000	19.00000	18.00000
Crude ash in dry substance	7.29200	6.46400	8.03700
Crude ash in fresh beet	1.28340	1.22820	1.44680
Pure ash in fresh beet	0.94071	0.93961	1.06440
Sulfuric acid	0.03615	0.03741	0.04285
Phosphoric acid	0.04816	0.03249	0.02732
Chlorin	0.12032	0.13660	0.20047
Sodium	0.07824	0.08882	0.13036
Potassic oxid	0.44601	0.42585	0.42708
Sodic oxid	0.09925	0.07759	0.12154
Calcic oxid	0.02773	0.02358	0.02627
Magnesic oxid	0.07581	0.10875	0.07807
Ferric oxid	0.00375	0.00204	0.00201
Aluminic oxid	0.00228	0.00341	0.00584
Manganic oxid	0.00304	0.00301	0.00252
Total nitrogen	0.25860	0.24350	0.30675
Proteid nitrogen (Stutzer)	0.07770	0.05300	0.08790
Ammonic nitrogen	0.00430	0.00356	0.00305
Amid nitrogen	0.02260	0.02083	0.03470
Amino nitrogen	0.03365	0.03142	0.03409
Nitric nitrogen	0.04982	0.04621	0.07260
Injurious nitrogen in beet	0.15400	0.16611	0.18110
Injurious ash per 100 sugar	7.15570	6.49390	9.04210
Injurious nitrogen per 100 sugar	1.41290	1.40770	1.78290
Press Juice According to Ruempler.			
Total nitrogen	0.24120	0.23640	0.28040
Albumin nitrogen	0.04600	0.05020	0.05580
Propetone nitrogen	0.00200	0.00090	0.00590
Peptone nitrogen	0.00730	0.00590	0.00380

Ash Analyses.

	CIV		CV		CVI	
	Crude	Pure	Crude	Pure	Crude	Pure
Carbon	0.373	.....	0.458	.....	0.624	.....
Sand	0.628	.....	0.600	.....	0.938	.....
Silicic acid	0.968	.....	1.224	.....	0.773	.....
Sulfuric acid	2.821	3.842	3.046	3.982	2.962	4.027
Phosphoric acid	3.758	5.119	2.645	3.458	1.890	2.567
Chlorin	9.390	12.790	11.122	14.539	13.866	18.835
Sodium	.....	8.317	.....	9.453	.....	12.246
Carbonic acid	23.616	.....	22.007	.....	20.539	.....
Potassic oxid	34.810	47.411	34.674	45.325	29.478	40.126
Sodic oxid	15.971	10.550	16.061	8.258	20.589	11.419
Calcic oxid	2.163	2.948	1.920	2.510	1.816	2.468
Magnesic oxid	5.917	8.059	6.804	11.575	5.381	7.335
Ferric oxid	0.293	0.399	0.166	0.217	0.139	0.189
Aluminic oxid	0.179	0.242	0.278	0.363	0.389	0.549
Manganic oxid	0.237	0.323	0.245	0.320	0.174	0.237
Loss	(1.017)	.....	(1.260)	.....	(3.671)	.....
Sum	102.119	.....	102.501	.....	103.129	.....
Oxygen equi. to chlorin	2.119	.....	2.501	.....	3.129	.....
Total	100.000	100.000	100.000	100.000	100.000	100.000

BEETS GROWN ON BAD LAND.

Sampled 3 Nov. 1910. Potassic chlorid applied at the rate of 400 pounds per acre

	XCIV	XCV	XCVI
Section	1	2	3
Average weight of beets	680.4 grams	640.7 grams	487.6 grams
	Percent	Percent	Percent
Sugar in beets	13.10000	11.80000	12.20000
Dry substance in beets	20.30000	19.40000	19.50000
Crude ash in dry substance	5.36100	6.51900	7.90900
Crude ash in beets	1.08828	1.26469	1.54226
Pure ash in beets	0.78546	0.91240	1.14930
Sulfuric acid	0.03722	0.03692	0.04269
Phosphoric acid	0.02831	0.02290	0.01624
Chlorin	0.09536	0.15944	0.23275
Sodium	0.06200	0.10368	0.15133
Potassic oxid	0.38575	0.41956	0.55650
Sodic oxid	0.05478	0.05424	0.02266
Calcic oxid	0.03981	0.02935	0.03028
Magnesic oxid	0.07570	0.08105	0.09096
Ferric oxid	0.00176	0.00143	0.00247
Aluminic oxid	0.00200	0.00100	0.00167
Manganic oxid	0.00270	0.00290	0.00177
Total nitrogen	0.23700	0.24715	0.34510
Proteid nitrogen	0.07495	0.08125	0.09680
Ammonic nitrogen	0.00360	0.00445	0.00526
Amid nitrogen	0.02085	0.02245	0.04430
Amino nitrogen	0.04295	0.04154	0.03483
Nitric nitrogen	0.02501	0.04111	0.05120
Injurious nitrogen in beets	0.12760	0.13900	0.19874
Injurious ash per 100 sugar	4.81140	6.55800	8.24530
Injurious nitrogen per 100 sugar	1.04240	1.17790	1.62910

Press Juice According to Ruempler.

Total nitrogen	0.21230	0.24550	0.32870
Albumin nitrogen	0.04250	0.04550	0.06260
Propetone nitrogen	0.00380	0.00380	0.00070
Peptone nitrogen	0.01410	0.01410	0.00820

Ash Analyses

	CVII		CVIII		CIX	
	Crude	Pure	Crude	Pure	Crude	Pure
Carbon	0.789	.....	0.909	.....	0.416	.....
Sand	0.943	.....	0.661	.....	0.615	.....
Silicic acid	0.978	.....	0.687	.....	0.983	.....
Sulfuric acid	3.420	4.739	2.919	4.046	2.768	3.715
Phosphoric acid	2.601	3.604	1.811	2.510	1.053	1.413
Chlorin	8.762	12.141	12.607	17.475	15.091	20.250
Sodium	.....	7.894	.....	11.363	.....	13.168
Carbonic acid	23.433	.....	21.995	.....	20.499	.....
Potassic oxid	35.445	49.116	33.175	45.984	36.083	48.421
Sodic oxid	13.575	6.974	15.332	5.945	14.688	1.917
Calcic oxid	3.658	5.069	2.321	3.217	1.963	2.364
Magnesic oxid	6.956	9.639	6.409	8.883	5.898	7.914
Ferric oxid	0.162	0.225	0.106	0.147	0.160	0.215
Aluminic oxid	0.184	0.255	0.081	0.112	0.108	0.145
Manganic oxid	0.248	0.344	0.229	0.318	0.115	0.154
Loss	(0.823)	.....	(3.603)	.....	(2.970)	.....
Sum	101.977	.....	102.845	.....	103.406	.....
Oxygen equi. to chlorin	1.977	.....	2.845	.....	3.406	.....
Total	100.000	100.000	100.000	100.000	100.000	100.000

BEETS GROWN ON BAD LAND.

Sampled 3 Nov. 1910. Sodic Chlorid was applied at the rate of 400 pounds per acre.

	XCVII	XCVIII	XCIX
Section	1	2	3
Average weight of beets	725.7 grams	705.9 grams	620.8 grams
	Percent	Percent	Percent
Sugar in beets	13.00000	12.40000	10.40000
Dry substance in beets	20.00000	18.90000	18.30000
Crude ash in dry substance	5.27400	6.06000	10.17400
Crude ash in fresh beet	1.05480	1.14530	1.86180
Pure ash in fresh beet	0.77680	0.86182	1.42470
Sulfuric acid	0.02921	0.03155	0.05344
Phosphoric acid	0.03448	0.03631	0.02831
Chlorin	0.11033	0.13697	0.31200
Sodium	0.07174	0.08893	0.20327
Potassic oxid	0.37902	0.39918	0.60811
Sodic oxid	0.03993	0.06132	0.07626
Calcic oxid	0.03945	0.03235	0.03042
Magnesic oxid	0.06701	0.06891	0.10247
Ferric oxid	0.00402	0.00196	0.00316
Aluminic oxid	0.00086	0.00259	0.00432
Manganic oxid	0.00082	0.00196	0.00284
Total nitrogen	0.19020	0.21545	0.33970
Proteid nitrogen (Stutzer)	0.09685	0.10030	0.11385
Ammonic nitrogen	0.00185	0.00245	0.00735
Amid nitrogen	0.01340	0.02055	0.03260
Amino nitrogen	0.03505	0.04908	0.02757
Nitric nitrogen	0.01558	0.03713	0.08743
Injurious nitrogen in beets	0.07810	0.09215	0.18590
Injurious ash per 100 sugar	4.84820	5.78850	12.04900
Injurious nitrogen per 100 sugar	0.60077	0.74315	1.78750

Press Juice According to Ruempler.

Total nitrogen	0.16160	0.20115	0.28823
Albumin nitrogen	0.04120	0.04560	0.04960
Propetone nitrogen	0.00650	0.00410	0.00570
Peptone nitrogen	0.00620	0.00375	0.00400

Ash Analyses

	CXI		CXII		CXIII	
	Crude	Pure	Crude	Pure	Crude	Pure
Carbon	Trace	.....	Trace	.....	Trace	.....
Sand	0.974	.....	0.461	.....	0.589	.....
Silicic acid	0.792	.....	0.969	.....	1.283	.....
Sulfuric acid	2.761	3.752	2.755	3.661	2.870	3.751
Phosphoric acid	3.266	4.438	3.170	4.213	1.520	1.987
Chlorin	10.452	14.204	11.944	15.871	16.755	21.900
Sodium	.....	9.235	.....	10.319	.....	14.268
Carbonic acid	23.020	.....	22.427	.....	20.574	.....
Potassic oxid	35.904	48.792	34.858	46.317	32.661	42.685
Sodic oxid	12.937	5.141	15.815	7.115	18.805	5.353
Calcic oxid	3.737	5.078	2.825	3.754	1.634	2.135
Magnesic oxid	6.343	8.262	6.071	7.996	5.503	7.192
Ferric oxid	0.381	0.517	0.167	0.227	0.170	0.222
Aluminic oxid	0.082	0.111	0.226	0.300	0.232	0.303
Manganic oxid (br.)	0.078	0.106	0.167	0.227	0.152	0.199
Loss	(1.626)	.....	(0.894)	.....	(1.035)	.....
Sum	102.358	.....	102.695	.....	103.783	.....
Oxygen equi. to chlorin	2.358	.....	2.695	.....	3.783	.....
Total	100.000	100.000	100.000	100.000	100.000	100.000

BEETS GROWN ON BAD LAND.

Sampled 3 Nov. 1910. Check Plot.

	C	CI	CII	CIII
Section	1	2	3	4
Average weight of beets	788.1 grams	603.8 grams	569.8 grams	663.4 gr.
	Percent	Percent	Percent	Percent
Sugar in beets	13.20000	11.30000	12.10000	8.60000
Dry substance in beets	21.00000	17.60000	18.90000	16.50000
Crude ash in dry substance	5.99100	6.79600	7.66700	10.14100
Crude ash in fresh beets	1.25811	1.19061	1.44906	1.67326
Pure ash in fresh beet	0.94227	0.89514	1.12218	1.32875
Sulfuric acid	0.03227	0.02945	0.04150	0.04483
Phosphoric acid	0.03875	0.02007	0.03109	0.03453
Chlorin	0.15188	0.16698	0.23134	0.30396
Sodium	0.09876	0.11110	0.15042	0.19741
Potassic oxid	0.42267	0.35496	0.43686	0.51664
Sodic oxid	0.06511	0.09887	0.09923	0.09159
Calcic oxid	0.03616	0.03159	0.03537	0.03485
Magnesic oxid	0.08958	0.07253	0.08845	0.09041
Ferric oxid	0.00310	0.00287	0.00224	0.00334
Aluminic oxid	0.00151	0.00081	0.00131	0.00691
Manganic oxid	0.00250	0.00154	0.00437	0.00478
Total nitrogen	0.24930	0.15995*	0.23345	0.34510
Proteid nitrogen (Stutzer)	0.08645	0.06740	0.08845	0.12389
Ammonic nitrogen	0.00545	0.00200	0.00350	0.00520
Amid nitrogen	0.02160	0.00690	0.01470	0.03985
Amino nitrogen	0.03514	0.03935	0.03470	0.03507
Nitric nitrogen	0.01936	0.03249	0.05310	0.08337
Injurious nitrogen in beets	0.13580	0.08365	0.12680	0.17616
Injurious ash per 100 of sugar	5.62920	6.73790	7.92850	13.43300
Injurious nitrogen per 100 sug.	1.02880	0.73900	1.04790	2.04840
Press Juice According to Ruempler.				
Total nitrogen†	0.19100	0.16450	0.23335	0.29800
Albumin nitrogen	0.04290	0.04015	0.04370	0.04255
Propetone nitrogen	0.00590	0.00435	0.00760	0.00250
Peptone nitrogen	0.00542	0.00670	0.00650	0.00430

Ash Analyses

	CXIV		CXV		CXVI		CXVII	
	Crude	Pure	Crude	Pure	Crude	Pure	Crude	Pure
Carbon	Trace	.....	Trace	.....	0.309	.....	Trace	.....
Sand	0.978	.....	0.976	.....	0.412	.....	0.874	.....
Silicic acid	0.872	.....	1.196	.....	1.230	.....	1.169	.....
Sulfuric acid	2.565	3.425	2.462	3.289	2.864	3.698	2.609	3.374
Phosphoric acid	3.080	4.112	1.717	2.294	2.140	2.763	2.010	2.599
Chlorin	12.072	16.119	14.286	19.089	15.966	20.617	17.695	22.875
Sodium	.....	10.481	.....	12.412	.....	13.405	.....	14.875
Carbonic acid	20.875	.....	21.806	.....	19.908	.....	19.064	.....
Potassic oxid	33.595	44.856	29.677	39.655	30.149	38.932	30.077	38.882
Sodic oxid	15.747	6.909	20.774	11.045	20.835	8.843	20.831	6.893
Calcic oxid	2.874	3.837	2.641	3.529	2.441	3.152	2.029	2.623
Magnesic oxid	7.120	9.507	6.064	8.103	6.104	7.882	5.263	6.804
Ferric oxid	0.246	0.328	0.240	0.321	0.155	0.200	0.194	0.251
Aluminic oxid	0.120	0.160	0.068	0.091	0.091	0.118	0.402	0.520
Manganic oxid	0.199	0.266	0.129	0.172	0.302	0.390	0.237	0.306
Loss	(2.379)	.....	(1.183)	.....	(0.697)	.....	(1.539)	.....
Sum	102.722	.....	103.219	.....	103.603	.....	103.993	.....
Ogygen equi. to chlorin	2.722	.....	3.219	.....	3.603	.....	3.993	.....
Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000

*The nitrogen is remarkably low, but the duplicate determinations agree within 0.0029 percent and while the nitrogen in the juice of the siloed sample

As no ash analyses were made on the first two sets of samples, I have given the statement of the sugar, dry substance and nitrogen for the three sets in one table for the easier comparison of these data.

The essential points in the composition of the soil have been given in previous paragraphs and attention has been called to the low percentage of total nitrogen and the high ratio of the nitric nitrogen to the total, from 3.13 to 18.93 percent.

The amount of foliage and its color and the size of the beets, which averaged for all the samples taken, 3 Nov. 665.7 grams, indicate an abundant supply of nitrogen, though the average of the six composite samples taken is only 0.108 percent. The growth and color of the foliage and the total nitrogen in the beets indicate a decided excess of this element. The total nitrogen in the first beets, 38 out of the 39 samples analyzed ranged from 0.1902 to 0.3451 percent with four below 0.2000 percent. One sample fell to 0.15995 percent. The nitric nitrogen ranged from 0.0163 to 0.09319 percent. The last set of samples was submitted to an even more extended investigation, which emphasizes the very bad quality of these beets. The samples taken from the check plot show that the injurious ash ranges from 5.63 to 13.43 parts for each 100 parts of sugar and that the injurious nitrogenous substances (injurious nitrogen x 10) ranged from 7.39 to 20.48 parts per 100 of sugar. There can be no question but that these bad properties are mainly due to the excessive nitrates in the soil which in the section corresponding to the third sample of beets in each series showed on the 22 June nitric nitrogen equal to 3,240 pounds of sodic nitrate in the top four inches of soil per acre, and in the section designated as very bad land we found in soil gathered from beneath the leaves of a beet and close to the root, 8 October 1910, ntric acid corresponding to sodic nitrate equal to 0.823 percent of the air dried soil or 5,468 pounds in the top two inches of the soil.

There were only three experiments with fertilizers in which we sampled the beets, i. e., with phosphoric acid, superphosphate 1,000 pounds; potassic and sodic chlorid at the rate of 400 pounds per acre. The heavy application of superphosphate was made with the idea that the phosphoric acid thus added might cause an earlier ripening of the beets and consequently materially improve the quality of the beets. The others, potassic and sodic chlorid, were added to see if they would produce any effect upon the beets under these conditions and, if so, what. I have previously stated that in regard to the growth and appearance of the plants no difference whatsoever

is 0.00455 percent higher than in these beets it is still low, the lowest with one exception, of the thirteen samples given.

†These samples had been siloed for four weeks before the juices were analyzed.

could be observed between the rows to which these fertilizers had been applied, either singly or in conjunction, and the rest of the field. The growth was alike luxuriant over the whole piece of ground. The phosphoric acid did not affect the ripening in the least, so far as we could see. The samples taken at different periods, 23 Sept., 11 Oct., and 3 Nov. 1910, do not show any differences in favor of the beets grown with the application of phosphoric acid and those grown without it. We may take any single factor in the composition of the beets or all of them and there is no positive evidence of any beneficial effects accruing from the application of this amount of phosphoric acid. The amount of superphosphate added was as large as we deemed feasible and was so chosen in order ot make the ratio of phosphoric acid to the potash and nitrogen available to the crop as high as possible.

The effects produced by the other fertilizers are no more positive than those of the phosphoric acid. We must conclude, so far as these samples go, that these fertilizers have neither positively benefited nor injured the beets

Owing to a number of features in the beets grown upon such land which no one could fail to notice, questions concerning the physiological effects of these conditions necessarily presented themselves. In order to afford opportunity to study this point 100 samples were prepared in 1910, but owing to the fact that the Department of Botany had too much other work to do these samples were not examined. In 1911 I again took up this question and Mr. W. W. Robbins was kind enough to undertake to study the subject to such extent as his other duties permitted. I furnished him samples of beets grown on the bad land used for our experiments in 1910 as examples of beets grown with excess of nitre, and good beets grown on a field which, according to samples of soil tested, contained no excess of nitrates. His report is given in full as follows:

"The researches of a number of European investigators have shown that the anatomical structure of the sugar beet is correlated with sugar content. In general, beets with a high percentage of sugar have a finer structure than those with a low percentage. A cross or lengthwise section of a beet shows it to be made up, for the most part, of a ground tissue, penetrated by groups of vessels. In a cross section, these groups of vessels take a circular form, being separated from each other by parenchyma tissue. At the center of the beet the bundles are close together, forming the so-called "star." The tissue separating vessels is composed of two kinds of parenchyma cells—small cells surrounding the vessels and large ones further removed. The smaller parenchyma cells are rich in sugar, while the larger ones are principally water storage calls, poor in sugar. Hence, beets having a predominance of small celled parenchyma are richer in sugar than those in which large water storage cells predominate.

It must not be assumed from this that it would be possible to find conspicuous differences in the anatomical structure of beets varying one or two percent in sugar. Furthermore, a certain microscopical appearance is not to be associated with a given sugar content.

The question here is, "What is the effect of excessive nitrates in the soil upon the structure of the beet? Beets grown in a nitre-rich soil were compared, part for part, with beets grown in an ordinary soil. Microscopic sections of material imbedded in paraffin were cut to a thickness of about 10 microns. It was found very essential that corresponding parts of the abnormal and normal beets be compared. The most consistent and marked differences were shown by sections of the star, for here the bundles are closer together. Inasmuch as the niter beets have their sugar content depressed, as shown by chemical analysis, it was anticipated that this condition would modify their anatomy in the way mentioned above. Such was found to be the case.

A glance at the cut surfaces of a nitre and normal beet shows marked differences; the nitre beet has a glassy, watery appearance; the normal beet is yellower and not so watery. Hand razor sections of the abnormal beet slice off readily; while with the normal beet, there is a tendency for the sections to be shreddy and roll up under the razor edge. Examination with the naked eye of a normal beet cut in cross-section shows the star to be solid and compact; the small-celled parenchyma tissue forms an unbroken whitish band on either side of each ring of vessels; this band is wider on the outside of the circle of vessels than on the inner side.

In comparing this section with one from a corresponding part of a nitre beet, it will be seen that in the abnormal individual, the star is not as compact; the rays of vessels of the star are longer and further apart, being separated by large parenchyma cells. The band of whitish tissue, formed of small parenchyma cells, is not as wide in proportion to water cells; furthermore, this band is not as solid, but is broken by strips of large water-storing cells. (See Plate V.) This means that the amount of sugar storing tissue about each group of vessels is reduced, comparatively. It is very evident to one examining with the naked eye, cross sections of two beets, one abnormal—a nitre beet—the other normal, that the latter has a finer anatomy; that the ratio of small sugar-storing cells to large water-storing cells is higher; that it has more the structure of a beet rich in sugar.

Comparative microscopic examination of the beets bear out the facts as above stated. The normal beet has a greater proportion of

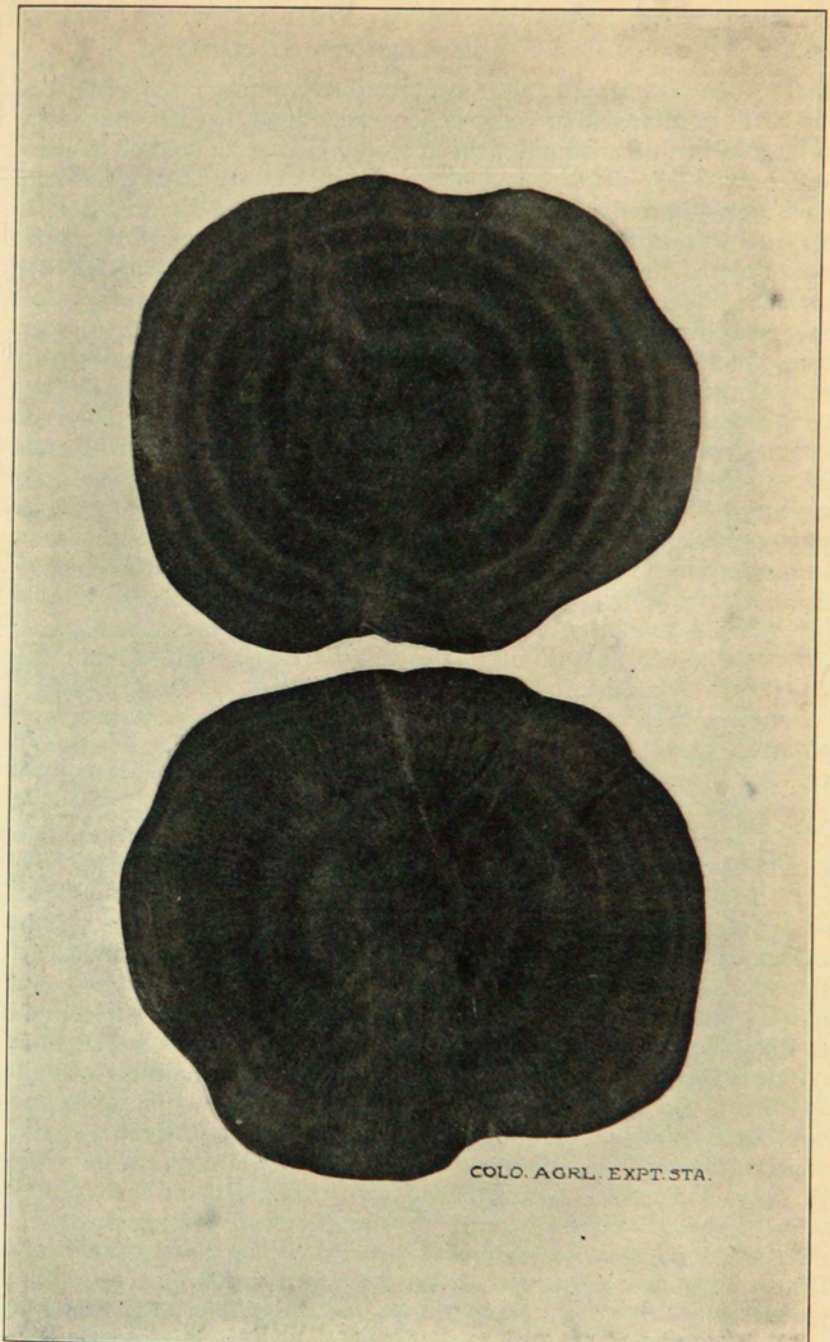

Plate V. Upper figure represents a section of a normal beet, the lower one a section of a nitric beet. Note the watery appearance of the latter and the fine-grained white rings in the former.

small celled parenchyma; the star is more compact; the groups of vessels in the star and any ring are not separated by such wide strips of large-celled parenchyma: the anatomy is finer and closer in every respect."

We will briefly consider the classes of beets so far presented in regard to the nitrogen compounds present, their general character and some of the effects produced which may be attributed to the presence of nitrates whether added to or produced in the soil. We have sought to find good beets produced in Colorado and to determine their composition. The beets grown in 1910 were evidently of medium quality, but much better in 1911, as indicated by the two samples given as representative of this year. The best Colorado samples taken in 1910 are from widely separated districts, Holly and Fort Collins, where the conditions were very dissimilar. The Holly sample was grown on newly broken sod land with a very moderate supply of water, a condition tending to lower the quality of the beets. We restate in the following table a few of the best samples:

BEST BEETS ANALYZED IN 1910.

No.	Date Harvested	Locality	Fertilizer	Av. wt, grams	Sugar, percent	Total N, percent	Nitric N, percent	Inj. N per 100 Sugar	Inj. Ash per 100 Sugar
1....	23 Sept.	Holly	None	.....	14.2	0.1253	0.00358	0.3744	3.5295
2....	3 Nov.	Fort Collins	None	673.0	18.3	0.2075	0.00090	0.6290	2.1960
3....	3 Nov.	Rocky Ford	250 lbs. $NaNO_3$	690.0	16.5	0.1449	0.00144	0.3642	2.1267
4....	3 Nov.	Rocky Ford	500 lbs. $NaNO_3$	872.0	15.8	0.2054	0.01009	0.68221	3.2050
5....	11 Oct.	Rocky Ford	None	.....	14.6	0.1290	0.01034	0.37020	4.2794
6....	2 Nov.	Michigan	....	813.0	15.3	0.2292	0.00320	0.51287	1.9446

These samples were all grown on good land, some with and others without fertilizers. Two of these samples were grown with the application of sodic nitrate, one with 250 pounds per acre, the other with 500 pounds, the latter in two portions. The first sample in the table was grown on new land, the other samples were grown on land which had been cultivated for years. The second sample represents the fifth consecutive crop of beets grown on the same land without fertilizers. The third and fourth samples were the second consecutive crop of beets on this soil. The first crop was not fertilized. This soil is well supplied with potash, 0.762 percent, also with phosphoric acid, 0.106 percent, and had an average supply of nitrogen for Colorado soils, 0.11 percent. The third, fourth and fifth samples were also the second consecutive crop of beets. The plot on which the fifth sample was grown received no fertilization of any kind either year. The soil in this case contained potash 0.95 percent, 0.012 available, phosphoric acid 0.17 percent, 0.007 available; total nitrogen, average of two samples done in duplicate, 0.10230 percent. I know nothing about the composition of the Michigan soil. This sample was obtained and submitted to examination because I was informed by men who had handled the juices in Michigan factories and also in factories in the Arkansas Valley that the Michigan juices worked much more easily than the juices from fresh beets, not frozen, thawed,, rotten or otherwise deteriorated beets, in the Arkansas Valley.

The beneficial effects of sodic nitrate apparent in the third and fourth samples of this table are not in harmony with the results obtained in our other experiments with this fertilizer. Other observers, however, have found that Chile-saltpetre applied in quantities up to 340 pounds per acre may affect the quality of the beets beneficially, especially in regard to the sugar content, provided that the soil is not itself already super-saturated with nitrogen, a phrase used in the Jahresbericht der Zuckerfabrikation, 1910, p. 7, but the percentage of nitrogen in the soil experimented with and thus designated is not given. The soils on which our experiments were made would certainly not be considered, according to ordinary standards, as supersaturated, carrying a total of not more than 0.11, practically the amount considered as an adequate percentage, while the humus nitrogen amounts to 0.072 percent of the soil, showing that in this case almost two-thirds of the total nitrogen was soluble in ammonia. Another investigator, Kiehl, found as the result of his observations on 29 localities an increase in the sugar content of from 1.2 to 1.99 percent., due to the use of sodic nitrate. The conditions under which these experiments were made were not given in the abstract at my disposal. On the other hand, all the data given relative to the total nitrogen in beets grown with the addition of sodic nitrate show that it is increased, which in general is true, but in the case of the third sample, with 250 pounds of sodic nitrate, this cannot justly be asserted. The most that one can do is to hold the point as questionable, for the result actually indicates that there has been a decrease. The fourth, fifth, and sixth samples cannot be considered as checks, for the samples were not grown on the same land. This is the case in which our check plots failed us completely. The same may be said regarding the injurious nitrogen and ash. So that if we consider the third sample only, it appears that the application of 250 pounds of sodic nitrate per acre was in all respects beneficial. These favorable conclusions cannot be drawn in the case of the fourth sample, for while we have no usable check samples with which to compart it, the effects of the 500 pounds or the second 250 pounds depressed the yield by 1.3 tons per acre and the sugar by 0.7 percent. On the other hand it increased the total nitrogen from 0.14 to 0.20 percent, the nitric nitrogen practically seven-fold, the injurious nitrogen per 100 sugar 90.0 percent, and the injurious ash per 100 sugar, 50.0 percent. As I have elsewhere stated, we have, with the application of 500 pounds of sodic nitrate per acre, clearly reached the limit of its beneficial action and probably passed it and as clearly passed the limit of profit. I have made this digression from the orderly presentation of our results because of the exceptional results obtained by the application of 250 pounds of sodic nitrate per acre to this land

While the table presents our best samples of beets for 1910, it will be recognized that they show a strong tendency toward low percentages of sugar, high percentages of nitric nitrogen and high ratios for the injurious nitrogen and injurious ash per 100 of sugar. Some of them, moreover, are reasonably high in total nitrogen, and the ratio of the total nitrogen to the injurious nitrogen per 100 of sugar varies from 2.5 in the best Colorado sample to about 3.0 in the others. It is clearly stated in the table that these best samples include some grown with fertilizers, but those grown with fertilizers are not better than those grown without them, sample No. 3 excepted, for which reason I have ventured to include these best samples in one table, which exhibits the best results obtained in 1910 without fertilizers on well conditioned land from both the physical and chemical standpoints, as well as the best results obtained with fertilizers on the same kind of land.

The following table presents some further results obtained with combinations of potash, phosphoric acid, and nitrogen. The tables previously given state these results more in detail but the data here given serve our present purpose better. All of these experiments were carried out at Rocky Ford in co-operation with the American Beet Sugar Company and all of these samples were harvested 11 Oct. 1910.

There was no plot in this series to which sodic nitrate alone had been applied. None of these samples shows any betterment in quality due to the fertilizers used and neither the yield nor the percentage of sugar was improved. On the contrary, it was, in the main, depressed. The total nitrogen in two cases is rather high, in the other cases it is only moderately so. The nitric nitrogen, the injurious nitrogen and the injurious ash are quite high. The nitric nitrogen is lower in four cases than in the check sample, which is No. 5 in the preceding table. The injurious ash has been decidedly increased and while the potash and phosphoric acid applied separately seem to have depressed the injurious nitrogen, it was increased in all of the other samples. I have already stated that I believe that variations in the properties of the soils of these half-acre plots is a factor which ought not to be left wholly out of our reckoning.

We have given among our best beets two samples grown with the application of sodic nitrate 250 and 500 pounds respectively.

BEETS GROWN WITH FERTILIZERS.

	Fertilizers Used per Acre	Sugar Percent	Total Nitrogen Percent	Nitric Nitrogen Percent	Injurious N per 100 Sugar	Injurious Ash per 100 Sug.
1.....	300 pounds K*	14.5	0.12320	0.00250	0.35827	4.4445
2.....	400 pounds P	14.1	0.10875†	0.00987	0.27288	4.5900
3.....	160 pounds K					
	100 pounds N	14.1	0.21900	0.01333	0.95531	7.6843
4.....	240 pounds P					
	100 pounds N	12.4	0.15345	0.01333	0.58334	6.4200
5.....	220 pounds P					
	440 pounds N	13.6	0.23270	0.00832	0.94632	5.2692
6.....	220 pounds P					
	260 pounds K	14.7	0.17150	0.00865	0.62047	4.8520
7.....	250 pounds P					
	170 pounds K					
	200 pounds N	13.7	0.17940	0.01244	0.71351	5.4855
8.....	440 pounds P					
	300 pounds K					
	200 pounds N	15.3‡	0.13760	0.00250	0.42810	4.1634
9.....	500 pounds P					
	300 pounds K					
	200 pounds N	13.3	0.17770	0.01846	0.65603	6.3320

The 250 pounds per acre produced favorable results in all respects, yield, percentage of sugar, injurious nitrogen and injurious ash. The application of 500—or the second application of 250 pounds—depressed the crop and the percentage of sugar and increased the percentage of nitrogen and also that of the nitric nitrogen. Further, it increased the injurious nitrogen and the injurious ash per 100 of sugar. The results presented by the fertilizer experiments in which sodic nitrate was added permits the inference that this is the usual effect of the nitrate. The following tabular statement presents the results of our further experiments to study this point. The supply of plant food and water were abundant, but we furnished an over-supply of nitrates. The samples were harvested 3 Nov. 1910.

Amount of Sodic Nitrate per Acre	Sugar Percent	Total Nitrogen Percent	Nitric Nitrogen Percent	Injurious N per 100 Sugar	Injurious Ash per 100 Sug.
250 pounds...........	16.5	0.14485	0.00144	0.36424	2.1267
500 pounds...........	15.8	0.20535	0.01009	0.68221	3.2050
750 pounds...........	13.4	0.29610	0.04143	1.29250	4.7812
1,000 pounds...........	11.0	0.25505	0.04983	1.40267	5.4718
1,250 pounds...........	12.8	0.25360	0.04225	1.11500	4.0490

There can be no question about the quality of these beets nor the direct effects of the nitrate when present in these quantities. Whatever variations of soil in these acre plots may have existed to

*P stands for superphosphate 13.19% P_2O_5, K for potassic sulphate 48.55% K_2O, N for sodic nitrate 96.60% $NaNO_3$.

†See note in full statement of Analysis XXX.

‡This was a sample of eight beets. The sugar is 1.2 percent higher than the factory returns.

modify the action of the nitrates, this action has not been obliterated or so far modified as to be rendered in the least doubtful. It will be noticed that the maximum effect was produced by the application of 1,000 pounds per acre, which is a small quantity compared with the quantities which we have found in many of our soils. We will support these analytical data in subsequent paragraphs by experiments showing the factory quality of these and other beets grown on bad ground and sold to the factory, in other words, commercial beets. We will, however, next consider the analytical results obtained with beets grown on bad ground. These results, like the preceding, have already been presented in detail. The first group of results presented the effects of the soil itself without any attempt to modify them by fertilizers. This soil was already known to me as one rich in nitrates and further, one in which the nitrates were not only spreading but the accumulation had already become so great in portions of it as to exterminate the Azotobacter. The order of these samples proceeds from the best to the worst portion of the field. The samples were harvested 3 Nov. 1910.

No.	Sugar Percent	Total Nitrogen Percent	Nitric Nitrogen Percent	Injurious N per 100 Sugar	Injurious Ash per 100 Sug.
1....................	13.2	0.24930	0.01936	1.02880	5.6292
2....................	11.3	0.15995*	0.03249	0.73900	6.7379
3....................	12.1	0.23345	0.05370	1.04790	7.9285
4....................	8.6	0.34510	0.08337	2.04840	13.4330

The next group presents the results produced by superphosphate applied at the rate of 1,000 pounds per acre. The order of the samples has the same significance as in the preceding group and represent corresponding sections as is the case with the succeeding table. No experiments were made with section four.

No.	Sugar Percent	Total Nitrogen Percent	Nitric Nitrogen Percent	Injurious N per 100 Sugar	Injurious Ash per 100 Sug.
1....................	10.9	0.25860	0.04982	1.41290	7.1557
2....................	11.8	0.24350	0.04621	1.40770	6.4939
3....................	10.2	0.30675	0.07260	1.78290	9.0421

The superphosphate has under the conditions obtaining in this soil produced decidedly bad results. The contrary to what we had expected. If the check rows had been separated from those treated with superphosphate by a space of even thirty feet we would try to believe that the action of the phosphate was in this case just what it has proven to be in many other experiments, but that some other factor had brought about the results. We have, however, no explanation, not even the size of the samples, to modify the conclusion that the action of the phosphoric acid was decidedly bad. All of the beets suffered from attack by leaf-spot, but all suffered alike and the

*Other samples representing this section of the field taken 23 Sept. and 11 Oct. gave for total nitrogen 0.2706 and 0.3070 and nitric nitrogen 0.03480 and 0.06417. The figure should probably be 0.25995.

foliage was so abundant that the loss of a considerable number of leaves did not make a great difference in the appearance of the field.

The results produced by the potassic chlorid, 400 pounds per acre, are presented in the following statements:

No.	Sugar Percent	Total Nitrogen Percent	Nitric Nitrogen Percent	Injurious N per 100 Sugar	Injurious Ash per 100 Sug.
1	13.1	0.23700	0.02510	1.04240	4.8114
2	11.8	0.24715	0.04111	1.17790	6.5580
3	12.2	0.34510	0.05120	1.62910	8.2453

This amount of potassic chlorid may possibly have produced a little effect upon the quality of the beets but all the samples are still so bad that there is no reason at all for entertaining a hope that it will be feasible to profitably produce good beets by its use.

The next fertilizer used was salt, sodic chlorid. I knew that this soil was very rich in chlorin, but I also knew that it was rich in potash and used the salt just as I used the potash to determine whether it would have any effect or not, though it seemed to be a case of "carrying coals to Newcastle."

No.	Sugar Percent	Total Nitrogen Percent	Nitric Nitrogen Percent	Injurious N per 100 Sugar	Injurious Ash per 100 Sug.
1	13.0	0.19020	0.01558	0.60077	4.8482
2	12.4	0.21545	0.03713	0.74315	5.7885
3	10.4	0.33970	0.08743	1.78750	12.0490

The results are not decisive enough under the circumstances to justify any conclusions, but if, with a knowledge of all the conditions, one had to express an opinion, it would be that salt, sodic chlorid, gives more promise of producing good results than the other fertilizers used.

This restatement of some of the salient features in the composition of our beets gives us not only a clearer view of their quality and the characteristics of their composition, but justifies us in comparing the established quality and composition of beets grown with the application of saltpetre with the quality and composition of those grown on nitre-infected ground. For this purpose we will use first, the sample grown on newly broken sod land at Holly, Colorado, and in the extreme eastern part of the Arkansas Valley as representative of a fairly good quality of beets grown in this section; second, the sample of beets grown on desirable land with the application of 1,000 pounds Chile-saltpetre per acre, and third, the sample grown on the third section of our bad land without the application of any fertilizers.

No.	Amount of Sodic Nitrate per Acre	Sugar Percent	Total Nitrogen Percent	Nitric Nitrogen Percent	Injurious N per 100 Sugar	Injurious Ash per 100 Sug.
1	Virgin soil	14.2	0.12530	0.00358	0.37440	3.5295
2	1,000 pounds	11.0	0.25505	0.04983	1.40267	5.4718
3	Abundant in soil	12.1	0.23345	0.05370	1.04790	7.9285

The following effects of the nitrates are so patent that they are beyond question. The sugar has been depressed by at least 2.0 percent. The total nitrogen has been doubled. The nitric nitrogen has been increased from ten to fourteen times. The injurious nitrogen per 100 of sugar has been increased between three and four times and the injurious ash about twice. The same effects can be traced in our fertilizer experiments, though not so plainly. Further, these effects are so pronounced that no questions of water supply, cultivation, variety or strain of seed, the effect of leaf-spot, insect injury, climatic conditions, or the general conditions prevailing in our soils can in any way obscure them. How and to what extent these factors may have modified them is not a part of our present problem. These factors must be assumed to exist and to be operative.

We may now consider a few of our results obtained on samples grown on good ground without the addition of fertilizers of any kind and which may be assumed to represent beets as they are actually grown for the factories. The beets designated as grown on bad land was such a crop and they were delivered to the factory. I wish to state emphatically that the following analyses do not represent the quality of all of the crops delivered to the factories in 1910, for that would be absurd, as there are some excellent beets grown every year. If it were not so we would have more justification to attribute the low quality of our beets to climatic conditions or to some other cause acting uniformly throughout the country, which is not true. These samples do, however, represent very many crops which are actually delivered to the factories.

No.	Locality	Sugar Percent	Total Nitrogen Percent	Nitric Nitrogen Percent	Injurious N per 100 Sugar	Injurious Ash per 100 Sug.
1......	Rocky Ford	14.3	0.20605	0.01984	0.71591	3.1043
2......	Fort Collins	13.2	0.18636	0.02138	0.63840	3.4164
3......	Rocky Ford	12.7	0.25215	0.04537	1.07246	3.7030

The average percentage of sugar for these three samples is 13.7 while the average for the Arkansas Valley for the same year, 1910, was approximately 14.2 so that they are only a little below the average for the Valley. The low sugar, the high total nitrogen, the high nitric nitrogen, the large amounts of injurious nitrogen per 100 sugar, and the relatively high injurious ash per 100 sugar can scarcely be attributed to any other cause than to an excessive supply of nitrates during the season, especially in view of the results just presented as having been definitely produced by nitrates either applied to or formed in the soil. The Fort Collins sample was grown on the College Experimental Farm in the surface two inches of which we found in October nitric nitrogen equivalent to 160 pounds per acre. These samples were taken from fallow spots among the beets. Again we found in the same tract of land but not in the same place in April nitric nitrogen equivalent to 1,000 pounds of sodic nitrate in the surface two inches. We showed in Bulletin 155 that at the end of the season and even in the early part of the winter that our lands, especially the beet fields of the Arkansas Valley, contained in 1909 quantities of nitrates reaching 1,902 pounds in the surface six inches of soil. The presence at times of sufficient quantities of nitrates in our soils to produce these effects cannot be doubted, and the effects are those who are produced by excessive quantities of nitrates.

We have not heretofore laid any special stress upon the presence of nitric nitrogen in all of the samples of our Colorado beets but the results show plainly that an excess of nitrates increases the amount of this form of nitrogen in the beet from 0.0009 percent, the minimum found in a Colorado beet, to 0.04983 percent for beets grown with the application of 1,000 pounds of Chile-saltpetre and a maximum of 0.08743 percent in beets grown in very bad ground. There are other very striking effects shown by the composition of the ash, but we will take these up later.

It has been shown that the beet plant draws upon the nitrogen of the soil most heavily in June and July. Professor Remy has shown that to produce a crop of 44 tons, together with the tops per hectare (2½ acres) requires 455.4 pounds of nitrogen. The nitrogen appropriation is distributed as follows in respect to times: May, 4.4 pounds; June, 112.0 pounds; July, 212.2 pounds; August, 48.0 pounds; September 44.0 pounds, and October 35.2 pounds. In our experiments with sodic nitrate the last 250 pounds were applied on 27 July. This would appear to be too late to produce any decided effect upon the crop, and we find the maximum effect produced by the application of 1,000 pounds per acre, the last portion of which was applied on 22 June. The condition of an early supply of nitre may or may not be met in the field as it has not yet been determined during what period the most liberal amount of nitrates may be furnished to the beets by the soil, i. e., without artificial applications. It is almost certain that this will differ in various pieces of land. Our highest figures for beet fields have been obtained in early winter or spring, but we have not as yet made any systematic study of this point. In subsequent paragraphs, however, we will give the results obtained by applying nitrates to beets beginning 1 August and continuing at intervals of 14 days, till the plots had received a total corresponding to 750 pounds per acre.

The experiments with sodic nitrate in 1910 were inaugurated with the intention of running the beets thus produced in an experimental plant to see whether we actually produced the bad working qualities in these beets which had been observed in the beets grown in the Valley during the past eight years. This was carried out on a sufficiently large scale to show what we had actually accomplished in this direction. The beets were treated in all respects just as they are in any factory, sliced, subjected to diffusion, a thin juice produced, which was treated with milk of lime, carbonated, etc., and finally evaporated to a thick juice; but none of the samples were carried farther than this point except as will be given later. The dried cossettes and these thick juices were subjected to examination with the following results, which were kindly furnished me by Mr. W. H. Baird, at that time the General Superintendent of the American Beet Sugar Company. The analytical work was done by Dr. Potvliet. The designation of the fields is the same as in the preceding tables.

ANALYSES OF BEETS USED IN EXPERIMENTAL RUN.

DRIED COSSETTES.

Field	1	2	3	4	5	6	7
Sodium nitrate appl'd, lbs.	250	500	750	1,000	1,250	None	Bad L'd
Sodic nitrate in cossettes	0.5628	0.5203	0.9005	1.1483	1.4595	0.5719	2.4320
Sodic nitrate per 100 dry substance	0.5739	0.5239	0.9126	1.1544	1.4797	0.5789	2.4870
Total nitrogen	0.9163	0.9346	1.2617	1.3673	1.5968	0.9879	1.9223
Total nitrogen per 100 dry substance	0.9342	0.9412	1.2788	1.3746	1.6167	1.0001	1.9569
Nitrate nitrogen in total nitrogen	10.1000	8.1000	11.8000	13.8000	15.0000	9.5000	20.9000
Dry substance	98.0800	99.3000	98.6700	99.4700	98.7700	98.7800	98.2300

ANALYSES OF THICK JUICES PRODUCED.

Field	1	2	3	4	5	6	7*
Sodic nitrate applied, lbs.	250	500	750	1,000	1,250	None	Bad L'd
Actual D. S.	59.1500	59.9100	46.5000	48.5100	51.6000	50.8700	46.5800
Sodium nitrate	0.3176	0.2888	0.4927	0.6422	0.7909	0.4510	2.2170
$NaNO_3$ per 100 D. S.	0.5369	0.4720	1.0595	1.3239	1.5327	0.8866	4.7590
$NaNO_3$ per 100 sugar	0.6107	0.5346	1.2226	1.5327	1.7733	1.0044	6.8420
Total nitrogen	0.3902	0.3517	0.4083	0.4472	0.5004	0.3620	0.8770
Nitrogen in 100 D. S.	0.6599	0.5870	0.8780	0.9219	0.9699	0.7116	1.8828
Nitrogen in 100 sugar	0.7506	0.6648	1.0131	1.0687	1.1219	0.8062	2.7068
Percent N. reduced	29.3000	37.6000	31.3000	32.9000	40.0000	28.8000	29.3000
Nitrate N. in total N.	13.4000	13.2000	19.9000	23.6000	26.0000	20.5000	34.2000
Sugar, per 100 D. S.	87.9100	88.2900	86.6600	86.3700	86.4300	88.2600	69.5600

These thick juices were further examined by us with the following results:

Field	1	2	3	4	5	6	7
Specific gravity	1.29900	1.28900	1.21800	1.22900	1.24200	1.24200	1.25100
Total nitrogen	0.35235	0.36885	0.37710	0.43440	0.41565	0.33427	0.99710
Ammonic nitrogen	0.00613	0.00690	0.00735	0.00760	0.00813	0.00605	0.03010
Amid nitrogen	0.00817	0.00765	0.01105	0.01190	0.01498	0.00965	0.04870
Amino nitrogen	....	0.17814	0.20386	0.21560	0.19483	0.28616	....
Nitric nitrogen	0.06034	0.05085	0.09302	0.11210	0.13430	0.08289	0.49313

The technical results agree very well with those obtained by the analysis of our field samples. Field No. 6 was intended to be a check field but as elsewhere stated it failed us. The technical re-

*These beets were taken from the very bad portion of the field and correspond to the section of the field designated by the number 4, see page 99.

sults corroborate the observations previously made upon the samples of this field for the real coefficient of the thick juice from these beets is 88.26, which is at least one point too low for beets grown on such land and in the perfect condition that these beets appeared to be at the time that they were sliced. We concluded from our analytical data that the beets grown with 250 and 500 pounds of sodic nitrate per acre were our best beets and that those grown with 1,000 pounds per acre were the poorest beets and that the excess of sodic nitrate had producd this effect. We see in considering the real coefficients of purity of these thick juices, probably the best measure of these effects, that by the application of 750, 1,000 and 1,250 pounds of sodic nitrate to the acre we have depressed it 1.89 points below a field sample grown as a check but which itself is at least 1.25 points below what the coefficient of a reasonably good thick juice should be. The lowest coefficient is found for the beets grown with 1,000 pounds sodic nitrate per acre. The beets grown in Field 7, elsewhere designated as bad land, gave a thick juice of only 69.56 coefficient of purity, which is scarcely 3.5 points above the conventional limit for molasses. The amino and nitric nitrogen in these juices present the same facts with still greater emphasis, the nitric nitrogen ranging from 13.38 percent in the best sample to 49.45 percent of the total nitrogen in the worst sample.

I stated in an earlier paragraph that our beets, specifically the beets of the Arkansas Valley, produced too much molasses. I think that the sugar technologist will agree that a thick juice with a real coefficient of purity of 87 or 86 will produce a large amount of molasses and concerning a coefficient of 69.6 there can be no question. None of these juices were boiled, so we did not study the properties of the filmasses produced from such beets but Mr. H. E. Zitkowski, the Chief Chemist at the factory, told me that he tried the thick juice of No. 7 on a small scale and that it was all that the coefficient of purity indicated, very bad.

The amount of molasses that sound beets of good quality should produce is somewhat difficult to ascertain. The statements made concerning German beets often pertain to houses producing only raw sugar which carries some of the molasses. In others, where the various green syrups are boiled several times and the saccharate is used in liming the thin juice, it is difficult to tell how much molasses the beets are producing, but in non-Steffens houses, producing granulated sugar, we can obtain a very fair approximation to a correct answer. For our purposes, I will assume that beets with 16.0 percent sugar and of good quality ought not to produce more than 5.5 percent of their weight of molasses. While this is to the best of of my knowledge, a fair estimate, it does not matter in this case whether the estimate is a point too high or a half point too low, because some of the beets in the Arkansas Valley have in years past produced from 7 to 9 percent and even more, which is clearly a very large amount, too much in fact by several percent. The explanation that I offer for this fact is evident and has already been formulated, i. e., that the soils furnish too large an aggregate amount of nitrates which effect a late maturation of the beet, which may or may not explain all of the bad qualities observed in them. Whether it does or not we have shown that the nitrates will depress the sugar content, this has long been established, increases the injurious nitrogen and the injurious ash and renders the beets rich in nitric acid. I have made ths fact evident by giving in all of the analyses presented, the nitric nitrogen present. If this be true, then the molasses should be rich in nitric nitrogen. I have never examined the saccharate for nitric nitrogen. It is probably very small in amount or entirely absent, as the Steffens waste waters are rich in it and it should not be carried down with the saccharate to any considerable extent; so that the nitric nitrogen present in molasses even in Steffens houses, would owe its origin to the beets worked and not to the saccharate. I have the determinations of the total and nitric nitrogen in a number of molasses. Some of these were furnished me by Mr. Baird and made in the laboratory of the Rocky Ford factory in connection with this work, but others of them were made in our Station laboratory. The following is a statement of the results:

TOTAL AND NITRIC NITROGEN IN MOLASSES.

		Nitrogen Total	Nitrogen Nitric	Percent of Total Nitrogen
1..........	Bohemia	2.4000	0.0067	0.28
2..........	Bohemia	2.3000	0.0032	0.14
3..........	Bohemia	2.4200	0.0042	0.19
4..........	Bohemia	2.2600	0.0082	0.37
5..........	Michigan	2.5200	0.0470	1.85
6..........	California	1.9000	0.0920	4.80
7..........	Colorado	2.1100	0.3200	15.30
8..........	Colorado	2.0700	0.4000	19.30
9..........	Colorado	1.8038	0.3715	20.60
10..........	Colorado	1.5253	0.3146	20.63
11..........	Colorado	1.8364	0.3830	20.86
12..........	Colorado	1.6999	0.3560	21.09
13..........	Colorado	2.0900	0.4400	21.20
14..........	Colorado	2.0500	0.4700	23.00
15..........	Colorado	1.5638	0.4516	28.88
16..........	Colorado	1.2798	0.1839	14.37
17..........	Colorado	1.7082	0.2737	16.04
18..........	Colorado	1.3241	0.2584	19.51
19..........	Colorado	1.8595	0.4225	22.71
20..........	Colorado	1.8699	0.1196	10.66
21..........	Colorado	1.3433	0.1560	11.62

The Colorado molasses are all lower in total nitrogen than the Bohemian and Michigan samples, but are without exception higher in their nitric nitrogen. If we compare the lowest percentage of nitric nitrogen found in the Bohemian with the highest found in a

Colorado analysis we find that the Colorado molasses contains 147 times as much. If we compare the lowest ratio for the nitric to the total nitrogen in the Bohemian samples with the highest ratio for the Colorado samples, we find the latter 206 times the former. The Colorado beets here represented produced from 5.5 to 7.5 percent of molasses, calculated on the beets cut while the Bohemian beets produced, according to the best information that I can obtain, certainly not more than 5.5 percent. Molasses Nos. 7 to 15 inclusive and also No. 20 are molasses from the seasons of 1909 and 1910, but samples 16, 17, 18, 19 and 21 are molasses from the season of 1911. Only four of the 1911 samples are from factories from which I obtained samples in 1910. It will be observed that these samples are in the main lower in nitric nitrogen than the Colorado samples of 1910 and the factories were producing less molasses calculated on the beets cut than in 1910, some of them two percent less. Two of the samples were taken at the end of the campaign and the beets being worked at that time were in bad condition and the production of molasses was on this account a little heavier than earler in the season. These molasses are a little lower in nitric nitrogen than those obtained earlier in the season, which is quite natural.

Subsequent experiments show that defoliation in early September causes the retention of the nitric nitrogen in the beets and it may be argued by some, if they know the facts, that the leaf-spot may have caused this abundance of nitric nitrogen in the molasses by having destroyed the foliage to so large an extent. The first consideration is that beets do not normally contain such quantities of nitric nitrogen and it was not produced in the beets by the leaf-spot. A second consideration is that some of the Colorado samples rich in nitric nitrogen were produced from beets free from leaf-spot.*

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*NOTE—As beet molasses has become a considerable factor in fattening cattle, we are sometimes asked about the value of the nitrogen present in the molasses. It is not a part of our purpose to go into this question to any extent. It is just to state that no representation is made by he Colorado factories, so far as I know, that the molasses has any value because of its nitrogen content, but only because of its sugar or carbohydrate content. The following analyses show the forms in which the nitrogen is present or permit us to infer in what form it is present.

No.	Total Nitrogen	Ammonic Nitrogen	Amido Nitrogen	Amino Nitrogen	Nitric Nitrogen	Proteid Stutzer
1........	1.0802	0.01557	0.02323	0.22256	0.15520	0.05570
2........	1.0674	0.01478	0.02508	0.23354	.....".	0.05570
3........	1.2597	0.01584	0.02349	0.12332	0.02190	0.04593
4........	1.0495	0.02138	0.02191	0.14034	0.20480	0.04805
5........	1.3832	0.02033	0.03352	0.28690	0.32170	0.05306
6........	1.4372	0.02085	0.03934	0.21377	0.15320	0.05807
7.... ...	1.0495	0.01663	0.02877	0.22941	0.12180	0.03168

As the methods of treatment in the defecation of the juices tend to remove the proteids the small amount of nitrogen indicated as present in this form by Stutzer reagent was chceked by precipitation with acetic acid and alcohol and washing with water to determine albumin which gave us from zero to 0.014 percent nitrogen in this form, a wholly negligible quantity at best. These molasses are all from the 1911 campaign and show that from one-tenth to one-quarter of all the nitrogen present in these samples was in the form of amino compounds and the rest was probably present in the form of betain. The nitrates have no food value and the other compounds are not generally believed to have much if any food value, certainly not more than an equal weight of carbohydrates.

Three samples of Steffens waste water which had been concentrated showed the presence of from 0.15 to 0.61 percent of nitric nitrogen. These figures indicate that large quantities of nitrogen as nitrates go into the waste water. I have not sufficient data relative to the individual samples to justify me in making any attempt to present the amount, either relative or absolute, thus eliminated. This amount relative to the total present must be very high, practically 100 percent. The nitric nitrogen in the Colorado molasses examined averaged in 1910 0.34 and if we assume the yield of molasses as 7.5 percent, which may be too high for some factories, but not for others, we will obtain for the average percentage of nitric nitrogen in the crop, 0.0212, whch is not far from the average indicated by the samples grown on good soils without fertilizers, 0.0229 percent. In Landw. Vers. Stat., 1900, p. 118, are given nine analyses of German molasses, four of which seem comparable to our Colorado samples. The percentages are on molasses, not on dry substance.

	Total Nitrogen	Nitric Nitrogen	Percent of Total Nitrogen Present as Nitric Nitrogen
1	1.942	0.04157	2.14
2	2.131	0.04252	2.00
3	2.229	0.03637	1.63
4	2.162	0.04157	1.93

The nitric nitrogen is given in the analyses as "nitric acid," which I have assumed to mean N_2O_5 and have calculated the elemental nitrogen on this assumption. The rest of the samples analyzed contain considerably smaller amounts of nitric acid, but they were produced from juices to which raw sugar had been added, or were the products of other methods. We do not know the percentage of the molasses calculated on the beets from which it was produced, but its weight was probably less than five percent that of the beets and even if it were much more than this the amount of nitric nitrogen would still be very much less than we meet with in the Colorado product, from one-tenth to one-twentieth as much.

These nitrates in our Colorado beets may contribute directly to

Ware, Cattle Feeding with Sugar Beets, Sugar and Molasses, p. 236, says, "Briem says molasses contains 8 percent digestible proteid, apparently excessive as Beyer found 1.47 percent nitrogen of which 5.3 percent was protein, 29.3 percent betain, glutamin and asparagin and 48.3 percent amid compounds. Kuehn gives from 22.7 to 75.7 or an average of 34.4 percent of the nitrogen as amids. Albuminoids are entirely absent. Authorities, such as Kuehn, Ramm and Moussen assert that these nitric substances have a very doubtful nutritive value, certainly not greater than that of carbohydrates as their use for flesh and milk production is infinitesimally small. They are mainly thrown out in the urine.

Weiske and Schulze declare that they are without nutritive value and are simply acid amids, hence it is argued that no allowance should be made for them in the calculation of rations.

Voeltz, Naehrwert der Amide der Melasse, Zeitschrift des Vereins der Deutschen Zucker Industrie 1907 p. 681, concludes "That the amid compounds of sugar beet molasses can completely play the role of the proteids in the metabolism of mature ruminates."

It does not seem probable that the nitrogen of sugar beet molasses has any considerable feeding value.

the production of molasses but I think that they are much more significant of the condition of the beets at harvest time and of the fact that the whole crop, represented by these samples of molasses, is very rich in nitric nitrogen.

In a preceding paragraph reference was made to the results obtained by Prof. Remy in regard to the amount of nitrogen required to grow 44 tons of beets with their tops, together with the distribution of this requirement in regard to time, I stated that I have made no adequate study of the amount of nitric nitrogen furnished by the soil at various times during the season. Mr. Zitkowski, however, made a study of this question in two fields and kindly placed his results at my disposal. Both fields were planted to beets and each had an abundant supply of irrigating water. The beets grown on Field A averaged 16.2 percent sugar, sampled 18 Sept., and those from Field B, sampled on the same date, averaged 12.6 percent. The soil of Field A was very "alkaline," 1.5 percent of the air-dried soil was soluble in water. The beets on 3 Oct. showed the presence of 16.0 to 17.0 percent of sugar. These fields were divided into sections and sampled to a depth of one foot from time to time. The results are given in the following table in parts per million. These data were obtained in the season of 1911.

NITRIC NITROGEN IN SOIL ON VARIOUS DATES.

Field A.

Sampled..	4 Mar.	2 June	20 June	27 June	19 July	9 Aug.	25 Aug.
I	4.9	1.2	12.5	17.0	8.5	5.4	2.5
II	3.8	37.0	27.5	28.0	30.0	22.2	12.0
III	5.8	52.8	15.0	37.0	34.0	9.0	6.2
IV	4.6	3.2	30.0	19.0	11.5	9.5	2.7
V	7.6	4.8	36.0	15.0	40.0	35.5	...
VI	3.8	8.8	31.5	27.0	35.0	11.1	...
VII	10.8	7.5	12.0	130.0	15.5	67.0	9.2

Field B.

Sampled..	4 Mar.	2 June	20 June	27 June	19 July	9 Aug.	25 Aug.
I	10.9	112.0	23.0	20.0	59.0	52.0	105.0
II	10.1	32.0	22.0	16.0	40.0	6.5	101.0
III	10.7	87.0	136.0	141.0	6.0	16.0	103.0
IV	10.6	109.0	24.0	130.0	8.0	3.1	47.0
V	20.5	69.0	14.0	96.0	8.0	6.5	333.0
VI	...	...	...	...	...	...	286.0
VII	6.1	4.1	15.0	43.0	52.0	10.5	251.0
VIII	15.3	6.7	87.0	90.0	15.0	30.5	....

I have no detailed statement of the meteorological conditions preceding the taking of the samples nor am I certain that the beets were of the same variety, though it is probable that they were. Be this as it may, it is certain that no variety with a normal sugar content of 12.6 percent was used. The object in stating these facts, however, is primarily to show how large the quantities of nitric nitrogen in our beet fields under good cultivation may be and how it varies from time to time. These fields were not examined further so far as I now know, nor were the beets. Mr. Zitkowski was fully aware of the surprising nature of the results obtained, especially of those obtained in the samples from Field B, taken 25 Aug., and had the work checked by taking a sample and determining the nitric nitrogen by the colorimetric method and as nitric oxid and obtained an agreement within one part per million, so we may feel confident that the figures gven are essentially correct. Adopting Prof. Remy's figures and giving them in terms of tons and pounds per acre, we find that to produce 17.6 tons of beets together with their tops there would be required 182 pounds of nitrogen per acre. We have further seen that approximately three-fourths of this is appropriated by the beets in June and July or such a crop at the end of the season will have used during these months 138 pounds of nitrogen. There were 21 samples from Field B examined for nitric nitrogen during the month of June. If the average of the 7 samples taken in March and that of the 25 samples taken in June show the amount of nitric nitrogen in this acre-foot of soil on these respective dates, their difference will give us an approximate idea of the gain during this period, which is 49 parts per million or taking the weight of an acre-foot of this soil at 3½ million pounds we have an actual gain of nitric nitrogen quite sufficient to furnish all of the nitrogen for a 17.5 ton crop of beets with their tops. In July and early August a very sharp decline took place, but in the latter part of August there was a very great increase, giving an average for the seven samples taken 27 Aug. of 195 p. p. m., showing the presence of nitric acid equivalent to 4,104 pounds of sodic nitrate in the acre-foot of soil sampled.

We were so situated that we could not well analyze these beets, but the facts that those grown on this field carried only 12.6 percent sugar, which is almost as low as the lowest of our nitre beets and the presence of such an abundant supply of nitrates in June and again in August justify us in assigning to the nitre a causal relation to the low percentage of sugar, and also in assuming that the other properties of these beets were those of our nitre beets. These latter beets with 12.6 percent sugar are representative of a larger portion of the crop than the former with 16 to 17 percent, for the average for the whole crop will, in some years, scarcely reach 14.0 percent, though in 1911, an admittedly good year, the average was nearer 14.5 percent.

GREEN MANURING.

We have previously given the results obtained with various fertilizers upon the tonnage of beets, the yield of sugar and the quality of beets, and have found that they do not justify us in stating that they can be applied with any hope of profit or material improvement in the quality of the crop produced. The problem is not solved to such an extent that one is justified in assigning reasons for these results except tentatively, which we will not do. We will merely state the view which has been suggested or tacitly assumed throughout, that the quality of our beets, which is the principal object of this study, is not poor or even bad because of any lack of plant food, nor because of lack of water, nor of fungus diseases, nor of attack of insects. nor of alkali, nor of excessive water, but more probably because of the bacterial flora of the soil. I have for a long time held the view that if it were possible for us to bring about different biological conditions, we would find a way to produce beets of a good quality. I am still of the opinion that a very liberal green manuring which will produce putrefactive changes in our soils gives us the most promise of success under our conditions. It was with this view in mind that the following experiments were made. These experiments were only partially successful, particularly in regard to the quantity of green crop produced. Mr. Winterhalter had previously tried green manuring and was aware of the fact that we were likely to be disappointed in this respect and so expressed himself. We planted mustard on one plot and took a piece of winter wheat for the second one. The land chosen was an adobe, a little heavier than that on which the experiments with potash, phosphoric acid and nitrogen were made and is a part of the same general tract. The stand obtained was good but the mustard came into bloom when the plants were only a few inches high and the total weight of the green matter plowed under was disappointingly small, estimated at 5½ tons per acre. The beets on both the mustard and wheat plots were planted 13 June. The stand considering the character of the soil was excellent. The variety used was the Original Kleinwanzlebener. The irrigation and cultivation was adequate, and though the beets were harvested 9 Nov., the plot on which mustard had been grown, yielded 7.9 tons of beets with 16.04 percent sugar, 84.96 purity, the wheat plot yielded 9.1 tons, 15.83 percent sugar, 83.3 purity. These are factory returns. The shape of these beets was all that could be wished though the ground was excessively hard at harvest time. The following analyses present the analytical results obtained with these beets in our laboratory.

BEETS GROWN WITH GREEN MANURE.

Harvested 9 Nov. 1911.

	CXVIII Wheat	CXIX Wheat	CXX Mustard	CXXI Mustard
Average weight of beets	437.4 grams	505.5 grams	482.8 grams	491.3 grams
	Percent	Percent	Percent	Percent
Sugar in beets	18.50000	14.60000	17.30000	16.10000
Dry substance in beets	24.40000	21.20000	24.40000	22.90000
Crude ash in dry substance	3.48400	4.89800	3.82300	3.94000
Crude ash in beets	0.85009	1.08376	0.93281	0.90226
Pure ash in beets	0.62400	....	0.69871	....
Sulfuric acid	0.02650	....	0.03249	....
Phosphoric acid	0.06711	....	0.07439	....
Chlorin	0.04062	....	0.06542	....
Sodium	0.02641	....	0.04254	....
Potassic oxid	0.32652	....	0.34521	....
Sodic oxid	0.02747	....	0.01208	....
Calcic oxid	0.02596	....	0.02478	....
Magnesic oxid	0.07580	....	0.09391	....
Ferric oxid	0.00252	....	0.00422	....
Aluminic oxid	0.00277	....	0.00093	....
Manganic oxid	0.00230	....	0.00276	....
Total nitrogen	0.17940	0.18660	0.15270	0.15490
Proteid nitrogen (Stutzer)	0.08995	0.08385	0.08500	0.08415
Ammonic nitrogen	0.00230	0.00300	0.00155	0.00170
Amid nitrogen	0.00530	0.00865	0.00345	0.00490
Amino nitrogen	0.07791	0.06306	0.03362	0.04366
Nitric nitrogen	0.00348	0.01064	0.00141	0.00332
Injurious nitrogen in beets	0.08185	0.09110	0.06000	0.06415
Injurious ash per 100 sugar	2.41900	....	2.87730	....
Injurious nitrogen per 100 sug.	0.44243	0.62398	0.34711	0.39845

Press Juice According to Ruempler.

	CXVIII	CXIX	CXX	CXXI
Total nitrogen	0.14400	0.16505	0.12245	0.11980
Albumin nitrogen	0.05100	0.04730	0.04710	0.04540
Propetone nitrogen	0.00440	0.00340	0.00340	0.00360
Peptone nitrogen	0.00460	0.00830	0.00300	0.00450

Ash Analysis.

	CXXII		CXXIII	
	Crude	Pure	Crude	Pure
Carbon	0.177	.....	0.433	.....
Sand	0.993	.....	0.852	.....
Silicic acid	1.012	.....	0.891	.....
Sulfuric acid	3.117	4.247	3.483	4.650
Phosphoric acid	7.894	10.755	7.975	10.647
Chlorin	4.778	6.510	7.013	9.362
Sodium	.....	4.233	.....	6.088
Carbonic acid	20.583	.....	18.889	.....
Potassic oxid	38.410	52.328	37.007	49.406
Sodic oxid	7.416	4.402	7.438	1.729
Calcic oxid	3.054	4.161	2.656	3.546
Magnesic oxid	8.917	12.148	10.067	13.440
Ferric oxid	0.296	0.403	0.452	0.603
Aluminic oxid	0.326	0.444	0.100	0.134
Manganic oxid	0.271	0.369	0.296	0.395
Loss	(3.834)	.....	(4.031)	.....
Sum	101.078	.....	101.583	.....
Oxygen equi. to chlorin	1.078	.....	1.583	.....
Total	100.000	100.000	100.000	100.000

The analyses indicate that these beets are very good ones, in fact there is but one factor in this crop that we could wish were better, that is the weight of the crop. The beets are high in sugar and comparatively low in total nitrogen. The ratio of proteid nitrogen to the total, is much higher than in a great many of our beets. The ratios for the injurious ash and injurious nitrogen per 100 of sugar are low. The pure ash is also lower than we usually find it in our beets. At first sight it seems proper to attribute these improved qualities to the green manure. I am not at all disposed to draw any conclusions from these results. They would have to be extended and corroborated before it would be proper to do so.

In presenting the results of our attempt to find out whether there was such a marked difference in the yield, sugar content and coefficient of purity of beets attacked by the leaf-spot in varying degrees of severity that we might be justified in asserting the nature and extent of the injury due to this cause, I remarked, that there seemed to be a relation between a small yield and a high sugar content rather than between any other recognizable factors. It is not evident that this is equivalent to saying that this relation exists between the size of the beets and the sugar content, though such may be the fact, for though the average weight of the beets analyzed was not far from one pound each, the yield of about 8.2 tons per acre with a stand of 32,000 beets per acre shows that many of the beets were small, less than one-half pound in weight. I have the record of three other fields planted to Z. Z. Klinewanzlebener seed and to which burnt lime, 6 tons, waste lime, 30 tons, and stockyard manure, 30 tons per acre had been applied, and we have low yields and high sugar percentages for the year of application and also for the succeeding year. These beets were not analyzed but the sugar content as shown by the factory returns, especially for the second year, 17.2, 17.9 and 16.0 leave no room for doubt but that they were good beets. It is for such reasons that I am not inclined to attach much importance to the good results obtained in the green manuring experiments. The profit on such a crop of beets is too small to make it desirable for us to try to raise such crops simply because the beets are good, but it is not clear why these crops are not larger. Thirty tons waste lime or the same quantity of stockyard manure furnishes a heavy dressing of phosphoric acid, in the former, 528 pounds, and of both phosphoric acid and nitrogen in the latter case, 492 pounds of phosphoric acid and 360 pounds of the nitrogen, which ought to bring about the production of more than 6 or 8 tons of beets per acre. It is, however, true that these beets, grown with the application of green manure and on ground that was in a bad physical condition, are among the best, if not the very best, beets which we sampled in 1910.

EXPERIMENTS OF 1911.

In 1910 we added Chile-saltpetre up to 1,250 pounds per acre, making the last, the fifth application of 250 pounds on 27 July. It seems to have been established that the beet plant appropriates about three-fourths of the total amount of nitrogen used during the season in June and July and consequently only smaller amounts after 1 Aug. Our results in 1910 indicated that 1,000 pounds per acre, the fourth portion of 250 pounds applied 22 June, produced the maximum effect. This is at a time when the beet is appropriating nitrogen most actively. Our examination of soil samples shows the presence of large amounts of nitric nitrogen in our cultivated fields, especially in fallow spots later in the season. If this nitric nitrogen in the soil be, as I believe it is, primarily due to fixation there is no reason why the supply should not occur later or perhaps continue throughout the season. For this reason, and further to study the effect of large amounts of nitrates upon the ash content of the beet and particularly upon the amount of phosphoric acid appropriated, further experiments were instituted. In these we made our first application of nitrates at the rate of 250 pounds per acre 4 Aug. 1911, and three subsequent ones at the rate of 125 pounds per acre at intervals of 14 days, making the last application 28 Sept. The beets were already well developed when these experiments were begun, the tops were exceedingly heavy and very dark green in color. The varieties used were Wohanka Erntereichste and Zuckerreichste. One-tenth acre was used in each case and check plots of like size. All plots were irrigated five days after the first application of nitre. There were light showers on 1 and 2 September, about 0.14 inch of rain. On 11 September the plots were again irrigated. Cultivation was out of the question owing to the heavy, very brittle foliage. The first samples were taken from the check plots 8 Aug. All samples taken from these plots consisted of at least 18 beets each, of which a composite sample was made. The second set of samples was taken 18 Aug. and every 14 days thereafter till the beets were harvested 8 Nov., the latest possible date, because there was great danger of their being frozen in the ground. The effects of the nitre were very evident in less than a fortnight in the increased growth and deepened color of the foliage. This difference continued to become more evident till about 10 Oct. when the check plots showed unmistakable evidences of ripening while the treated plots were still in the full vigor of their growth. During the night between 20 and 21 Oct. the temperature fell to 13.6° F. and the tops were of no further use to us. The beets, however, were effectively protected by the heavy foliage and the fact that they had grown well below the surface of the ground.

Samples of these beets were photographed 15 Aug. to show the

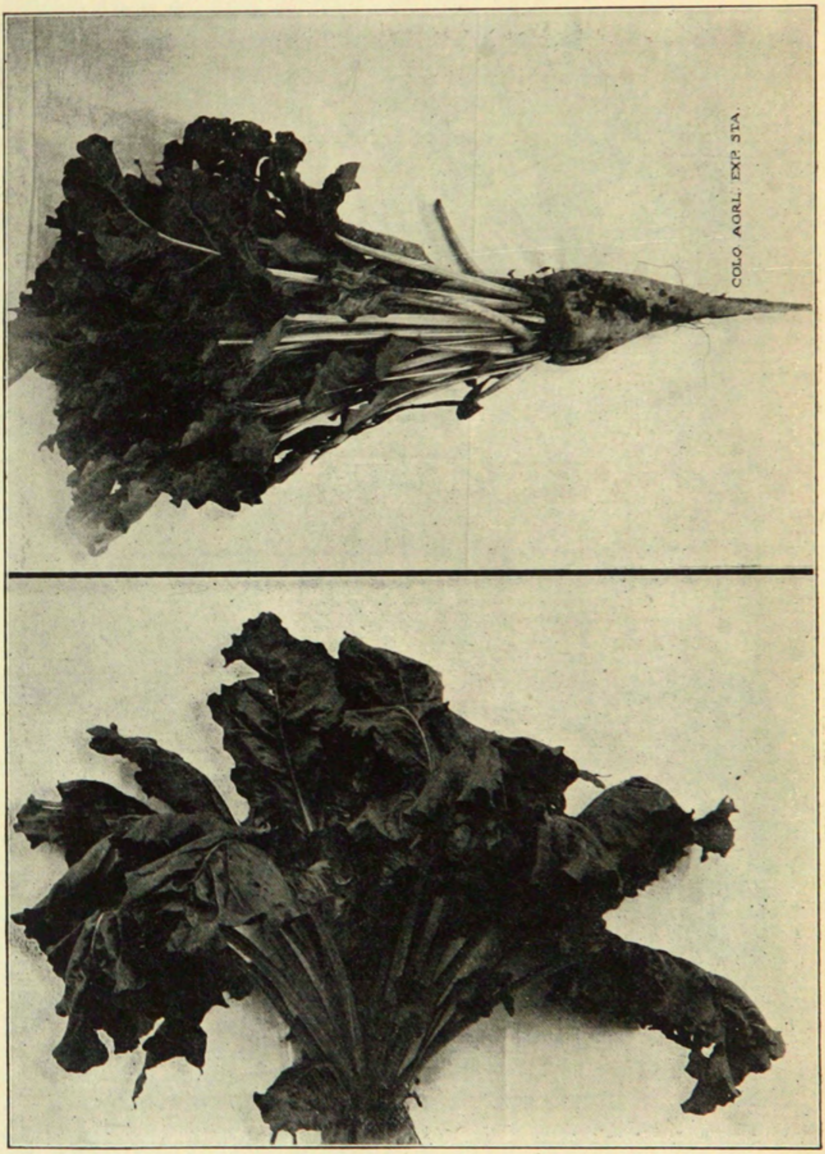

Plate VI. This plate shows development of foliage on beets 15 Aug. 1911.

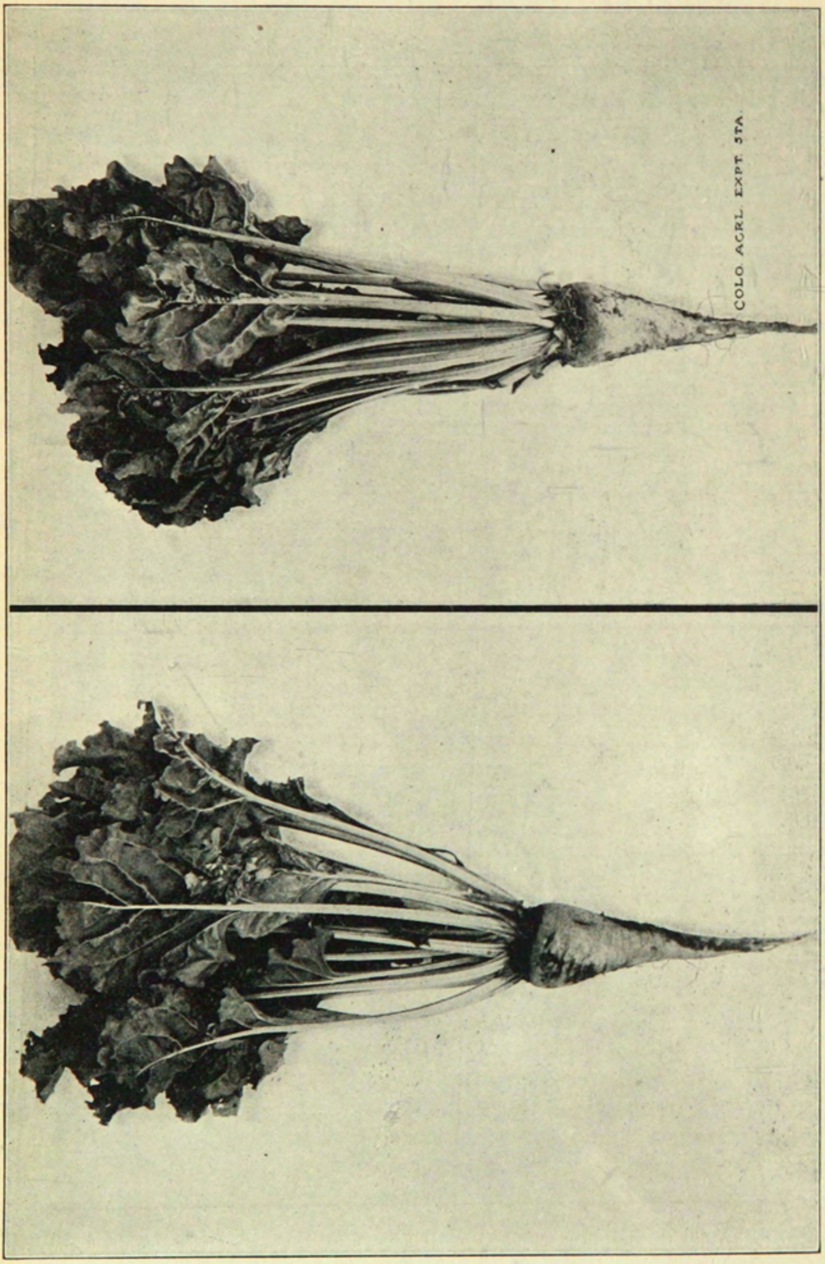

Plate VII. These beets weighed 2½ and 3 pounds each, while the tops weighed 4 pounds each.

whole plant on this date; in order to give a correct notion of the luxuriance of the tops. There are two plants of each variety. Plate VI represents Z R and Plate VII E R. Plate VI, lower figure, shows the top only of an individual of the Z R variety.

The land on which these beets were grown is abundantly supplied with nitric nitrogen, at least the samples taken in 1910 from the beet plots showed considerable quantities, fallow strips giving nitric acid equivalent to 306 pounds of sodic nitrate in the top six inches of soil on 18 Oct. 1910.

In 1911 the divisions of the farm were designated as sections and plots. The section immediately west of the beet plots, section 1700, was partly fallow, but had been cultivated throughout the season though not irrigated. It was covered with a fine soil mulch. This fallow portion was divided into three portions for the purpose of determining the nitric nitrogen in it and sixteen samples taken to the depth of two inches, and a like number to a depth of four inches from each section; these were united to form composite samples representing the respective depths. There were four samples taken from each section from the fourth to the seventh inch inclusive and united to form a composite sample. These samples were taken 14 Sept. 1911. The beets in the adjoining section were growing rapidly at this time. The nitrates, calculated as sodic nitrate, amounted to 670 pounds in the top seven inches of the south section, 517 pounds in the top seven inches of the middle section and 320 pounds in the top four inches of the north section. These determinations were made by the phenol-sulfonic acid method. We have done this, however, with other samples of the soil and found that they agreed very well with the Schloesing method. These amounts of nitrates, provided like amounts were formed in the sections occupied by the beets, are quite sufficient to account for the extraordinarily vigorous growth of tops in those sections to which we applied no nitrate. We were aware of the fact that this land furnishes many hundreds of pounds of nitrates per acre-foot of soil under favorable conditions. The deportment of the beets in 1910 as well as our analytical results had fully apprised us of this fact. The luxuriant growth of tops and their blue-green color on 1 Aug. 1911 showed it almost as certainly as our subsequent determinations.

It may be well in this connection to restate our purpose in applying sodic nitrate under such conditions. It has been shown by Prof. Remy that the greatest consumption of nitrogen by beets takes place during the months of June and July. The growth and color of the tops in July admitted of no question but that these beets had been well supplied with nitrogen during this period. Our results in 1910 showed that the application of from 250 to 750 pounds per acre, applied subsequent to 1 April and in addition to 250 pounds applied on ths date was decidedly prejudicial. The application of 250 pounds 1 May produced only a small depreciation in the value of the beets, but further applications of this amount, made at intervals of four weeks, up to 27 July, produced very bad results. The supply of nitrates furnished by our soils continues, as shown by samples taken from beet fields throughout the season, even into early winter. We wished to demonstrate what the effects of an excessive supply of nitrates late in the season may actually be.

The choice of the land known to be already well supplied with this form of nitrogen may be considered ill-advised. This was the most accessible and practically the only available land at our disposal and there are some advantages in using such land for the large supply in the check plots, in a measure protected us against exaggerated results due to the nitrate added, which might have been produced had we used land which was only moderately well supplied with or was even in need of nitrogen.

The details of the cultivation received have already been given in sufficient fullness.

The first samples were taken 8 Aug. from plots of the same varieties to which no nitrates had been applied. The data obtained from these samples will show the condition of the beets at the time we made the first application, 4 Aug., with reasonable accuracy as only four days had elapsed.

The 1911 series of experiments differ in the following essential particulars from those of 1910, the seasons though favorable were different, the soils were both productive but not alike in character, in 1910 the nitrate was all applied before 1 Aug., in 1911 none was applied until after this date. In 1910 the beets grown in the Arkansas Valley were quite severely attacked by the leaf-spot, the 1911 samples grown at Fort Collins were not affected at all, a few leaves could be found here and there showing this fungus, but they were scarce and the disease was wholly negligible, but while the varieties were standard ones in both cases, they were not the same. I regretted this but I could not help it. In 1910 our experiments were made with Original Kleinwanzlebener, in 1911 with Wokanka heaviest yielders, "ER" and richest in sugar, "Z R." There is no question but that these strains differ in some respects, among which may be included their susceptibility to varied conditions. Our results are so positive and consistent, however, that these differences in the strains of beets do not conceal them, though some differences do find expression in our results.

The land used in 1911 was part of the same field on which the college beets of 1910 were grown. This land is level, well located and the soil productive. It contains according to older analyses of general samples, potash soluble in hydrochloric acid 0.87, phosphoric acid 0.12, total nitrogen 0.147 and humus 0.426 percent. The ratio of nitric nitrogen to the total will be given in a subsequent paragraph. Composite samples of soil and subsoil were taken from these plots. Four samples each of soil and subsoil were united to form composite samples. The results were as follows:

ANALYSES OF SOIL ON WHICH EXPERIMENTS OF 1911 WERE MADE.

	CXXIV Soil	CXXV Subsoil
Insoluble	63.489	63.547
Silicic acid (soluble in sodium carbonate)	9.866	8.557
Sulfuric acid	0.094	0.069
Chlorin	0.025	0.035
Phosphoric acid	0.175	0.160
Carbonic acid	2.976	4.942
Potassic oxid	0.715	0.573
Sodic oxid	0.408	0.316
Calcic oxid	4.725	7.310
Magnesic oxid	1.258	1.376
Ferric oxid	5.663	5.337
Aluminic oxid	3.563	2.738
Manganic oxid	0.175	0.160
Water at 100° C	2.816	2.111
Ignition	3.918	2.143
Sum	99.866	99.375
Oxygen equivalent to chlorin	.005	.008
Total	99.861	99.367
Total nitrogen	0.1426	0.0627
Humus	0.6750	0.2620
Water soluble	0.3875	0.3450

The change in color, showing the line of division between the soil and subsoil, varies from eight to twelve inches in depth. This land seems never to have received deep cultivation which is very desirable in this case. The analyses show what is clearly recognizable by the appearance of the soil itself in section, i. e., that the subsoil is richer in calcic salts, carbonate and sulfate, than the surface soil. There is no reason whatever why this subsoil should not produce quite as well as the surface soil if once loosened up. It is well supplied with plant food, nitrogen perhaps excepted, which might be considered too low for a productive soil, but it is, under our conditions probably fully sufficient. The supply of lime and magnesia is very abundant and their ratio, from four to six of lime to one of magnesia, will have some interest for us.

The analyses of 1911 samples follow in the order of their taking. The number of beets taken in each sample was eighteen. We find it very difficult to thoroughly mix the pulp from so large a sample without expressing some of the juice. In a few of the last sets of samples we took as many as fifty beets in a sample but I doubt the advisability of taking so large a number in one sample.

ANALYSES OF BEETS AND LEAVES,* SEASON 1911.

	CXXVI	CXXVII
Variety	E R	Z R
Date of sampling	8 August	8 August
Nitrate applied per acre to date	None	None
Average weight of beets	439.4 grams	441.0 grams
Average weight of leaves	619.0 grams	745.5 grams
Average weight of beets, trimmed	....	....
	Percent	Percent
Sugar in beets	9.90000	9.80000
Coefficient of purity	75.10000	73.20000
Dry substance in beets	15.48000	15.26000
Dry substance in leaves	9.53000	9.91000
Total nitrogen in beets	0.15576	0.17617
Total nitrogen in leaves	0.33578	0.33792
Proteid nitrogen in beets (Stutzer)	0.06917	0.07022
Proteid nitrogen in leaves	0.25634	0.24665
Ammonic nitrogen in beets	0.00277	0.00277
Amid nitrogen in beets	0.00568	0.00568
Amino nitrogen in beets	0.01789	0.01789
Nitric nitrogen in beets	0.02819	0.03643
Nitric nitrogen in leaves	0.05461	0.05724
Press Juice of Beets According to Ruempler.		
Total nitrogen	0.13852	0.14027
Albumin nitrogen	0.04389	0.05335
Propetone nitrogen	0.00000	0.00025
Peptone nitrogen	0.00000	0.00150

ANALYSES OF BEETS AND LEAVES, SEASON 1911.

ANALYSES.

	CXXVIII	CXXIX	CXXX	CXXXI
Variety	E R	E R Check	Z R	Z R Check
Date of sampling	18 Aug.	18 Aug.	18 Aug.	18 Aug.
Nitrate applied per acre	250 pounds	None	250 pounds	None
Average weight of beets	528.8 grams	482.0 grams	459.6 grams	455.2 grams
Average weight of leaves	786.4 grams	718.2 grams	713.2 grams	670.9 grams
Average weight of beets, trim'd	....	....	....	....
	Percent	Percent	Percent	Percent
Sugar in beets	9.30000	9.70000	9.30000	9.50000
Coefficient of purity	74.20000	74.60000	74.20000	76.00000
Dry substance in beets	15.03000	16.00000	13.69000	15.02000
Dry substance in leaves	9.07000	9.30000	9.08000	9.35000
Total nitrogen in beets	0.15312	0.15378	0.14850	0.14058
Total nitrogen in leaves	0.27522	0.27258	0.27060	0.25674
Proteid nitrogen in beets	0.07656	0.07551	0.07932	0.07997
Proteid nitrogen in leaves	0.21991	0.22097	0.22720	0.20673
Ammonic nitrogen in beets	0.00264	0.00303	0.00198	0.00211
Amid nitrogen in beets	0.00607	0.00581	0.00594	0.00568
Amino nitrogen in beets	0.02580	0.02841	0.03178	0.03625
Nitric nitrogen in beets	0.03272	0.02998	0.03086	0.02357
Nitric nitrogen in leaves	0.06125	0.03256	0.06239	0.04360
Press Juice According to Ruempler.				
Total nitrogen	0.12384	0.15297	Lost	0.12367
Albumin nitrogen	0.05277	0.05843	0.05151	0.05730
Propetone nitrogen	0.00452	?	0.00578	?
Peptone nitrogen	0.00226	0.00450	0.00101	0.00175

*By leaves we mean the blades and stems together and by beet the whole root including the crown, but they were trimmed, i. e., the crowns cut off, before they were analyzed.

ANALYSES OF BEETS AND LEAVES, SEASON 1911.

	CXXXII	CXXXIII	CXXXIV	CXXXV
Variety	E R	E R Check	Z R	Z R Check
Date of sampling	1 Sept.	1 Sept.	1 Sept.	1 Sept.
Nitrate applied per acre	375 pounds	None	375 pounds	None
Average weight of beets	672.6 grams	625.3 grams	578.1 grams	510.3 grams
Average weight of leaves	945.0 grams	735.6 grams	711.8 grams	614.3 grams
Average weight beets trimmed	513.5 grams	543.4 grams	663.1 grams	469.4 grams
	Percent	Percent	Percent	Percent
Sugar in beets	11.80000	11.90000	11.60000	13.20000
Coefficient of purity	79.20000	76.20000	76.30000	82.00000
Dry substance in beets	17.02000	18.69000	17.89000	19.76000
Dry substance in leaves	9.87000	10.03000	9.83000	10.53000
Total nitrogen in beets	0.13596	0.13794	0.15196	0.13068
Total nitrogen in blades	0.50534	0.56628	0.48180	0.45102
Total nitrogen in stems	0.12144	0.10362	0.11748	0.11418
Proteid nitrogen in beets	0.07529	0.07317	0.07254	0.07418
Proteid nitrogen in blades	0.39442	0.45302	0.41870	0.42530
Proteid nitrogen in stems	0.07103	0.07238	0.07340	0.07340
Ammonic nitrogen in beets	0.00277	0.00251	0.00237	0.00251
Amid nitrogen in beets	0.00797	0.00634	0.00831	0.00568
Amino nitrogen in beets	0.02561	0.04150	0.04947	0.04244
Nitric nitrogen in beets	0.02320	0.01925	0.02702	0.01670
Nitric nitrogen in blades	0.01060	0.00730	0.01469	0.01096
Nitric nitrogen in stems	0.06412	0.03734	0.07231	0.04816
Press Juice According to Ruempler.				
Total nitrogen	0.09643	0.11480	0.12053	0.11639
Albumin nitrogen	0.03907	0.03772	0.03778	0.03742
Propetone nitrogen	0.01170	0.01464	0.01268	0.01156
Peptone nitrogen	?	?	?	?

ANALYSES.

	CXXXVI	CXXXVII	CXXXVIII	CXXXIX
Variety	E R	E R Check	Z R	Z R Check
Date of sampling	14 Sept.	14 Sept.	14 Sept.	14 Sept.
Nitrate applied per acre	500 pounds	None	500 pounds	None
Average weight of beets	850.5 grams	693.0 grams	889.9 grams	689.8 grams
Average weight of leaves	907.2 grams	659.9 grams	926.1 grams	689.8 grams
Average weight beets trimmed	711.1 grams	579.5 grams	713.5 grams	634.7 grams
	Percent	Percent	Percent	Percent
Sugar in beets	13.10000	13.70000	12.85000	14.30000
Coefficient of purity	78.50000	83.50000	73.80000	78.80000
Dry substance in beets	19.40000	19.20000	17.80000	20.47000
Dry substance in leaves	10.90000	10.95000	10.58000	11.17000
Total nitrogen in beets	0.14536	0.13134	0.16236	0.13596
Total nitrogen in leaves	0.31680	0.28380	0.34425	0.38808
Proteid nitrogen in beets	0.07656	0.07022	0.07313	0.07260
Proteid nitrogen in leaves	0.22836	0.20328	0.25080	0.21648
Ammonic nitrogen in beets	0.00145	0.00172	0.00172	0.00185
Amid nitrogen in beets	0.00396	0.00660	0.00765	0.00489
Amino nitrogen in beets	0.03413	0.06223	0.04535	0.05159
Nitric nitrogen in beets	0.01932	0.01175	0.02454	0.01556
Nitric nitrogen in leaves	0.03181	0.01708	0.04398	0.01353
Press Juice According to Ruempler.				
Total nitrogen	0.12290	0.09708	0.13006	0.12090
Albumin nitrogen	0.04323	0.03289	0.03742	0.03775
Propetone nitrogen	0.00863	0.00545	0.00866	0.00469
Peptone nitrogen	?	0.00297	0.00049	0.00296

ANALYSES OF BEETS AND LEAVES, SEASON 1911.

	CXL	CXLI	CXLII	CXLIII
Variety	E R	E R Check	Z R	Z R Check
Date of sampling	28 Sept.	28 Sept.	28 Sept.	28 Sept.
Nitrate applied per acre	625 pounds	None	625 pounds	None
Average weight of beets	844.2 grams	821.8 grams	918.2 grams	746.6 grams
Average weight of leaves	836.5 grams	743.4 grams	789.1 grams	688.3 grams
Av. weight of beets, trimmed	713.6 grams	689.5 grams	759.2 grams	652.1 grams
	Percent	Percent	Percent	Percent
Sugar in beets	13.10000	14.90000	13.50000	14.80000
Coefficient of purity	78.90000	81.40000	81.40000	84.40000
Dry substance in beets	19.24000	21.06000	19.86000	21.59000
Dry substance in leaves	11.45000	11.95000	10.01000	11.80000
Total nitrogen in beets	0.15708	0.13926	0.15312	0.14190
Total nitrogen in blades	0.55572	5.04516	0.60324	0.47256
Total nitrogen in stems	0.16500	0.13646	0.15704	0.11748
Proteid nitrogen in beets	0.08184	0.08000	0.07788	0.07762
Proteid nitrogen in blades	0.46332	0.45672	0.50292	0.39600
Proteid nitrogen in stems	0.09768	0.10560	0.09610	0.09214
Ammonic nitrogen in beets	0.00356	0.00356	0.00515	0.00541
Amid nitrogen in beets	0.00818	0.00541	0.00515	0.00555
Amino nitrogen in beets	0.03768	0.05659	0.04688	0.04687
Nitric nitrogen in beets	0.02600	0.00969	0.02065	0.01065
Nitric nitrogen in blades	0.01289	None	0.02205	None
Nitric nitrogen in stems	0.08452	0.04744	0.07781	0.04609
Press Juice According to Ruempler.				
Total nitrogen	0.14056	0.12148	0.13323	0.12190
Albumin nitrogen	0.04177	0.04344	0.04638	0.04162
Propetone nitrogen	0.00420	0.00270	0.00371	0.00395
Peptone nitrogen	0.00519	0.00220	0.00296	0.00392

ANALYSES.

	CXLIV	CXLV	CXLVI	CXLVII
Variety	E R	E R Check	Z R	Z R Check
Date of sampling	12 Oct.	12 Oct.	12 Oct.	12 Oct.
Nitrate applied per acre	750 pounds	None	750 pounds	None
Average weight of beets	1,017.5 grams	894.6 grams	801.7 grams	759.2 grams
Average weight of leaves	888.3 grams	812.7 grams	900.9 grams	648.9 grams
Av. weight of beets, trimmed	834.8 grams	768.6 grams	672.7 grams	617.0 grams
	Percent	Percent	Percent	Percent
Sugar in beets	14.40000	15.30000	14.30000	15.80000
Coefficient of purity	80.40000	80.50000	79.40000	82.70000
Dry substance in beets	20.87000	23.07000	20.04000	23.05000
Dry substance in leaves	11.95000	11.30000	11.41000	12.00000
Total nitrogen in beets	0.16896	0.14124	0.16368	0.14388
Total nitrogen in blades	0.56496	0.57288	0.54177	0.50952
Total nitrogen in stems	0.17160	0.15180	0.16764	0.12938
Proteid nitrogen in beets	0.08368	0.07154	0.08104	0.07497
Proteid nitrogen in blades	0.37910	0.35798	0.43428	0.40656
Proteid nitrogen in stems	0.08447	0.10243	0.09081	0.09134
Ammonic nitrogen in beets	0.00211	0.00266	0.00066	0.00224
Amid nitrogen in beets	0.00660	0.00565	0.00778	0.00554
Amino nitrogen in beets	0.03764	0.04595	0.03811	0.03266
Nitric nitrogen in beets	0.01685	0.00503	0.01685	0.00870
Nitric nitrogen in blades	0.01208	None	0.01360	None
Nitric nitrogen in stems	0.04313	0.01956	0.07967	0.01797
Press Juice According to Ruempler.				
Total nitrogen	0.14622	0.11869	0.15074	0.11030
Albumin nitrogen	0.04796	0.04429	0.04968	0.04576
Propetone nitrogen	0.00319	0.00514	0.00413	0.00245
Peptone nitrogen	0.01905	0.00087	0.00296	0.00685

ANALYSES OF LEAVES.* 12 OCT. 1911.

	CLII	CLIII	CLIV	CLV
Variety	E R	E R Check	Z R	Z R Check
Nitrate applied per acre	750 pounds	None	750 pounds	None
Av. wt. whole leaves per beet	888.3 grams	812.0 grams	900.9 grams	648.9 grams
	Percent	Percent	Percent	Percent
Dry substance	11.95000	11.30000	11.41000	12.00000
Crude ash in dry substance	19.66000	19.72000	18.77600	20.18400
Pure ash in dry substance	13.66000	13.63000	12.88500	13.99900
Pure ash in fresh leaves	1.63260	1.54130	1.47020	1.67980
Sulfuric acid	0.15755	0.16360	0.14288	0.19240
Phosphoric acid	0.07090	0.04994	0.06252	0.05665
Chlorin	0.10443	0.11403	0.07499	0.09592
Sodium	0.06879	0.07414	0.04876	0.06237
Potassic acid	0.56674	0.53794	0.49142	0.62295
Sodic oxid	0.39007	0.30820	0.39934	0.34132
Calcic oxid	0.13765	0.16040	0.12156	0.15552
Magnesic oxid	0.11063	0.10650	0.10749	0.12636
Ferric oxid	0.01323	0.01246	0.00642	0.00829
Aluminic oxid	0.00905	0.00920	0.01131	0.01494
Manganic oxid	0.00442	0.00205	0.00351	0.00375
Total nitrogen in blades	0.56496	0.57288	0.54177	0.50952
Total nitrogen in stem	0.17160	0.15180	0.16764	0.12938
Proteid nitrogen in blades	0.37910	0.35798	0.43428	0.40656
Proteid nitrogen in stems	0.08447	0.10243	0.09081	0.09134
Nitric nitrogen in blades	0.01203	None	0.01360	None
Nitric nitrogen in stems	0.04313	0.01956	0.07967	0.01979

Ash Analyses.

	CLVI		CLVII		CLVIII		CLIX	
	Crude	Pure	Crude	Pure	Crude	Pure	Crude	Pure
Carbon	None	.....	None	.....	None	.....	None	.....
Sand	3.022	.....	3.427	.....	1.926	.....	2.126	.....
Silicic acid	2.342	.....	2.985	.....	2.425	.....	2.557	.....
Sulfuric acid	6.706	9.650	7.342	10.616	6.673	9.719	7.985	11.513
Phosphoric acid	3.018	4.343	2.241	3.240	2.920	4.253	2.339	3.373
Chlorin	4.445	6.396	5.177	7.398	3.502	5.100	3.960	5.710
Sodium	.....	4.159	.....	4.810	.....	3.316	.....	3.713
Carbonic acid	24.552	.....	23.724	.....	25.924	.....	24.786	.....
Potassic oxid	24.127	34.719	24.140	34.904	22.951	33.426	25.720	37.086
Sodic oxid	20.495	23.892	18.310	19.997	21.717	27.162	17.540	20.319
Calcic oxid	5.859	8.431	7.192	10.408	5.677	8.268	6.421	9.258
Magnesic oxid	4.709	6.776	4.779	6.910	5.020	7.311	5.217	7.522
Ferric oxid	0.563	0.810	0.559	0.808	0.300	0.437	0.272	0.392
Aluminic oxid	0.385	0.554	0.537	0.776	0.528	0.769	0.617	0.890
Manganic oxid	0.188	0.270	0.092	0.133	0.164	0.238	0.155	0.224
Loss	(0.591)	.....	(0.702)	.....	(1.063)	.....	(1.178)	.....
Sum	101.002	.....	101.153	.....	100.790	.....	100.873	.....
Oxygen equi. to chlorin	1.002	.....	1.153	.....	0.790	.....	0.873	.....
Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000

*The leaves of the beets on the check plots showed the usual signs of ripening, but those of the beets on the plots treated with nitrate did not. The check plots did not show this change until after the first of October. The leaves were frozen about 20 Oct., so these were the last samples of leaves taken for the season. The samples of beets taken on this date were analyzed so that we could have complete analyese of these samples of which the leaves and beets were both in perfect condition.

ANALYSES OF BEETS, SAMPLES TAKEN 12 OCT. 1911.

	CLX	CLXI	CLXII	CLXIII
Variety	E R	E R Check	Z R	Z R Check
Nitrate applied per acre	750 pounds	None	750 pounds	None
Average weight of beets	1017.5 grams	894.6 grams	801.7 grams	752.2 grams
Av. weight of beets trimmed	834.8 grams	768.6 grams	672.7 grams	617.5 grams
	Percent	Percent	Percent	Percent
Sugar in beets	14.40000	15.30000	14.30000	15.80000
Dry substance in beets	20.87000	23.07000	20.04000	23.05000
Crude ash in dry substance	4.01100	3.38360	3.95300	3.40000
Pure ash in dry substance	2.82460	2.31000	2.67600	2.40400
Pure ash in fresh beet	0.58950	0.53297	0.53631	0.55657
Sulfuric acid	0.02494	0.02291	0.02189	0.02493
Phosphoric acid	0.04710	0.05283	0.05457	0.06721
Chlorin	0.01913	0.01307	0.00896	0.01133
Sodium	0.01427	0.00850	0.00582	0.00737
Potassic oxid	0.27855	0.27127	0.27988	0.28225
Sodic oxid	0.10851	0.05256	0.07237	0.05078
Calcic oxid	0.02887	0.03854	0.03106	0.03148
Magnesic oxid	0.05674	0.06383	0.04745	0.07038
Ferric oxid	0.00458	0.00328	0.00610	0.00820
Aluminic oxid	0.00169	0.00259	0.00211	0.00042
Manganic oxid	0.00237	0.00000	0.00170	0.00293
Total nitrogen	0.16896	0.14124	0.16368	0.14388
Proteid nitrogen (Stutzer)	0.08368	0.07154	0.08104	0.07497
Ammonic nitrogen	0.00211	0.00266	0.00066	0.00224
Amid nitrogen	0.00660	0.00565	0.00778	0.00554
Amino nitrogen	0.03764	0.04505	0.03818	0.03266
Nitric nitrogen	0.01685	0.00503	0.01885	0.00870
Injurious nitrogen in beets	0.07657	0.06139	0.07420	0.06113
Injurious ash per 100 sugar	3.09240	2.40720	2.71970	2.38390
Injurious nitrogen per 100 sug.	0.53174	0.40125	0.51887	0.38690
Press Juice According to Ruempler.				
Total nitrogen	0.14622	0.11869	0.15074	0.11030
Albumin nitrogen	0.04796	0.04429	0.04968	0.04576
Propetone nitrogen	0.00319	0.00514	0.00413	0.00245
Peptone nitrogen	0.01906	0.00087	0.00296	0.00658

Ash Analyses.

	CLXIV		CLXV		CLXVI		CLXVII	
	Crude	Pure	Crude	Pure	Crude	Pure	Crude	Pure
Carbon	None	.....	None	.....	None	.....	None	.....
Sand	1.831	.....	1.429	.....	1.735	.....	1.568	.....
Silicic acid	1.510	.....	1.164	.....	1.308	.....	0.605	.....
Sulfuric acid	2.979	4.230	2.939	4.299	2.758	4.081	3.166	4.479
Phosphoric acid	5.627	7.990	6.775	9.912	7.428	10.903	8.537	12.076
Chlorin	2.623	3.725	1.677	2.453	1.129	1.671	1.440	2.037
Sodium	.....	2.423	.....	1.595	.....	1.086	.....	1.324
Carbonic acid	26.237	.....	26.268	.....	26.174	.....	24.052	.....
Potassic oxid	33.276	47.252	35.601	52.082	35.264	52.186	35.851	50.712
Sodic oxid	15.248	18.391	8.201	9.864	10.107	13.494	8.136	9.124
Calcic oxid	3.449	4.897	4.597	6.725	3.914	5.792	3.994	5.650
Magnesic oxid	6.780	9.626	8.168	11.976	5.979	8.848	8.941	12.648
Ferric oxid	0.547	0.777	0.421	0.615	0.769	1.138	1.042	1.474
Aluminic oxid	0.202	0.287	0.331	0.484	0.266	0.394	0.054	0.076
Manganic oxid	0.883	0.402	.....	.....	0.214	0.317	0.238	0.400
Loss	.....	.....	(2.780)	.....	(3.210)	.....	(2.656)	.....
Sum	100.592	....	100.378	....	100.255	.....	100.325	.....
Oxygen equi. to chlorin	0.592	.....	0.378	.....	0.255	.....	0.325	.....
Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000

ANALYSES OF BEET SAMPLES TAKEN 8 NOV. 1911.

	CLXIX	CLXX	CLXXI	CLXXII
Variety	E R	E R Check	Z R	Z R Check
Nitrate applied per acre	750 pounds	None	750 pounds	None
Average weight of beets	967.1 grams	875.0 grams	1088.5 grams	929.3 grams
Av. weigrt of beets, trimmed	819.3 grams	747.0 grams	951.0 grams	784.4 grams
	Percent	Percent	Percent	Percent
Sugar in beet	14.60000	15.60000	14.50000	15.60000
Dry substance in beet	20.21000	21.16000	21.10000	22.00000
Crude ash in dry substance	4.04000	3.67000	4.07200	3.67000
Pure ash in dry substance	2.72950	2.55850	2.80400	2.60100
Pure ash in fresh beet	0.55164	0.54139	0.59255	0.57223
Sulfuric acid	0.02495	0.02561	0.02616	0.02641
Phosphoric acid	0.04303	0.05508	0.05584	0.06256
Chlorin	0.01242	0.01439	0.01312	0.01721
Sodium	0.00808	0.00936	0.00853	0.01119
Potassic oxid	0.25865	0.26141	0.29473	0.28494
Sodic oxid	0.09844	0.06370	0.08256	0.06044
Calcic oxid	0.03006	0.03342	0.03461	0.03338
Magnesic oxid	0.06827	0.07127	0.07154	0.07201
Ferric oxid	0.00352	0.00433	0.00172	0.00193
Aluminic oxid	0.00170	0.00087	0.00108	0.00009
Manganic oxid	0.00252	0.00192	0.00109	0.00208
Total nitrogen	0.16632	0.14882	0.16698	0.14223
Proteid nitrogen (Stutzer)	0.08646	0.08474	0.08461	0.08355
Ammonic nitrogen	0.00118	0.00165	0.00258	0.00171
Amid nitrogen	0.00771	0.00593	0.00868	0.00660
Amino nitrogen	0.05319	0.05621	0.04775	0.04982
Nitric nitrogen	0.01871	0.00827	0.01421	0.00746
Injurious nitrogen in beet	0.07097	0.05651	0.07111	0.05037
Injurious ash per 100 sugar	2.75710	2.45640	2.93200	2.56530
Injurious nitrogen per 100 sug.	0.48610	0.36215	0.49041	0.32290
Press Juice According to Ruempler.				
Total nitrogen	0.14809	0.13383	0.15119	0.12314
Albumin nitrogen	0.05408	0.05439	0.04858	0.05292
Propetone nitrogen	0.00737	0.00489	0.00858	0.00040
Peptone nitrogen	0.00209	0.00256	0.00663	0.00974

Ash Analyses.

	CLXXIII		CLXXIV		CLXXV		CLXXVI	
	Crude	Pure	Crude	Pure	Crude	Pure	Crude	Pure
Carbon	None	.....	None	.....	None	.....	None	.....
Sand	1.430	.....	1.375	.....	1.294	.....	1.398	.....
Silicic acid	4.083	.....	0.912	.....	0.756	.....	0.712	.....
Sulfuric acid	3.056	4.523	3.298	4.731	3.028	4.391	3.271	4.615
Phosphoric acid	5.270	7.800	7.093	10.175	6.499	9.423	7.748	10.932
Chlorin	11.521	2.251	1.854	2.660	1.527	2.214	2.131	3.007
Sodium	.....	1.464	.....	1.729	.....	1.439	.....	1.955
Carbonic acid	28.833	.....	26.802	.....	27.690	.....	25.955	.....
Potassic oxid	31.677	46.888	33.662	48.285	34.303	49.737	35.293	49.795
Sodic oxid	13.389	17.846	9.827	11.766	10.946	13.932	9.352	10.563
Calcic oxid	3.682	5.450	4.304	6.174	4.228	6.145	4.134	5.833
Magnesic oxid	8.361	12.375	9.177	13.163	8.326	12.073	8.918	12.583
Ferric oxid	0.431	0.638	0.556	0.799	0.200	0.283	0.239	0.337
Aluminic oxid	0.208	0.308	0.112	0.161	0.126	0.179	0.011	0.016
Manganic oxid	0.309	0.457	0.249	0.357	0.127	0.184	0.258	0.364
Loss	(1.093)	.....	(1.063)	.....	(1.294)	.....	(1.060)	.....
Sum	100.343	.....	100.418	.....	100.344	.....	100.480	.....
Oxygen equl. to chlorin	0.343	.....	0.418	.....	0.344	.....	0.480	.....
Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000

ANALYSES OF BEETS. SEASON 1911.

	CXLVIII	CXLIX	CL	CLI
Variety	E R	E R Check	Z R	Z R Check
Date of sampling	26 Oct.	26 Oct.	26 Oct.	26 Oct.
Nitrate applied per acre	750 pounds	None	750 pounds	None
Average weight of beets	877.3 gram	1030.0 grams	915.0 grams	776.8 grams
Av. weight of beets, trimmed	708.8 grams	872.5 grams	760.7 grams	661.8 grams
	Percent	Percent	Percent	Percent
Sugar in beets	14.50000	16.10000	15.10000	16.70000
Coefficient of purity	78.40000	81.30000	80.70000	83.50000
Dry substance	20.92000	22.56000	21.37000	23.52000
Total nitrogen	0.18678	0.14850	0.16830	0.12276
Proteid nitrogen	0.09319	0.08579	0.08765	0.08104
Ammonic nitrogen	0.00198	0.00079	0.00449	0.00198
Amid nitrogen	0.01135	0.00647	0.00515	0.00264
Amino nitrogen	0.03266	0.03929	0.03190	0.03848
Nitric nitrogen	0.02270	0.00600	0.01444	0.00253
Press Juice According to Ruempler.				
Total nitrogen	0.17036	0.13236	0.15074	0.11030
Albumin nitrogen	0.05956	0.05564	0.05491	0.04927
Propetone nitrogen	0.01176	0.00025	0.00490	0.00245
Peptone nitrogen	?	0.00392	0.00416	0.00417

It would possibly be better to discuss the analyses of the 1911 samples just given in the next paragraphs, but I shall postpone this to make place for some other analyses.

THE EFFECTS OF DEFOLIATION.

Our efforts in 1910 to obtain some definite measure for the effects of leaf-spot upon the yield and general qualities of beets did not give us results which could be interpreted as conclusive of anything though we obtained the record of 127 fields. We found that many of these fields gave good yields of both beets and sugar and we could discover no relation between the severity of the attack and either the yield of the beets or the percentage of sugar. We did, however, observe that low yields of beets seemed to be associated with higher percentages of sugar. While this was generally true it was not always so. Beets from one section of the valley (Arkansas) could not be compared with those from other sections from the same valley for higher yields and percentages were the rule in some sections as compared with others.

An instance was given of a field which had been very severely attacked, the date of the attack is not known to me, but the field samples showed 16 or more percent of sugar, though the foliage was practically all destroyed. I take it that the injury caused by leaf-spot is due to its destruction of the leaves.

The data at my command relative to the effects of defoliating beets are not concordant. The results probably vary greatly with the stage of development of the beet, the age of the leaves removed, their number, etc. The leaf-spot destroys the oldest leaves first and the young leaves escape the attack for some time or altogether. This was markedly the case with our nitrate beets in 1910; so much so, that, owing to their abundant foliage, it seemed that they had lost but few or no leaves. This was not the case for, by counting the leaves killed by the leaf-spot on a number of beets we convinced ourselves that any judgment based upon the apparent immunity of the nitrate beets, was not at all justified by the facts.

Our observations upon the effects of the leaf-spot are by no means so definite as those recorded by Nicholson and Lyon in Neb. Bul. 67 p. 20, where they state "Where this disease proceeds this far (to the total destruction of the foliage. H.) it seriously affects the yield and sugar content of the beets. At the time of harvest, beets severely attacked produced between three and four tons less than those only mildly affected, while the sugar was fully one per-cent lower."

Lyon and Wiancko in Neb. Bul. 81, p. 11, refer to the effect of removing a part of the foliage, one-half in the case discussed and state, "As regards the practice of breaking off the outer leaves it woud seem that good may result since the yield secured was over two and one-half tons more per acre than the average of the ordinary treated plots. It has been argued that breaking off the leaves or otherwise bruising the beet may result in permanent injury but it was observed in this case that aside from the larger growth of the roots, the leaves were considerably healthier later in the season, being less affected by the leaf-spot than were the plots on either side." Again in their Summary and Conclusions they state that "Breaking off a part of the leaves of sugar beets at 'laying by' time did not injuriously affect the yield or quality of the crop. Beets treated in this way were less affected by 'leaf-spot' disease than those not so treated."

In Jahresbericht der Zuckerfabrikation, 1907, p. 55, the results recorded as obtained by Andrlik and Urban upon the effects of defoliation show that the removal of 70 percent of the leaves in the early part of July depressed the yield 36 percent, the yield of sugar 35 percent and the yield of dry substance 34 percent. The plants removed much less plant food, 38.8 percent less ntrogen, 34.9 percent less potash and 36.0 percent less phosphoric acid, than uninjured plants. The plant food removed with the leaves (by defoliation) was not taken into consideration. Defoliation at the end of July lowered the yield of beets by 24.0 percent, of leaves 23.0 percent, and of sugar 30.5 percent. The percentage of sugar in the beets was lowered 1.1 percent. The plants took up 30.0 percent less nitrogen, 28.0 percent less potash and 18.0 percent less phosphoric acid than uninjured plants. The removal of 19.0 percent of the leaves on 21 Aug. depressed the yield of roots by 13.0 percent, increased the leaves by 3.0 percent, did not change the percentage of sugar in the beets, but the total yield of sugar was reduced 13.0 percent. The factory qualities of the beets were improved.

A defoliation of from 50 to 94 percent depressed the yield of roots from 10 to 26 percent, the sugar in the roots from 0.5 to 2.7 percent. A moderate defoliation reduced the yield of roots from 1.0 to 14.4 percent. The percentage of sugar in the roots was not materially affected. An injurious effect became noticeable in this case only when the beets developed a heavy foliag.e.

Strohmer, Briem and Fallada, Jahresbericht der Zuckerfabrikation, 1908, p. 33, experimented on the defoliation of beets to determine the influence of the development of the beet at the time of defoliation upon the results. They claim that the effect in depressing the sugar in the beet depends upon the time that the defoliation is made. If it be made immediately prior to the period when the most active production of sugar takes place in the leaves the percentage of sugar in the harvested beets will be depressed. If it be made long enough before this period to permit the beets to develop new leaves, the percentage of sugar in the beets may be as high as in normally grown beets, but the total yield of sugar will be less than that of normally grown beets or even of beets defoliated subsequent to the period of greatest sugar production (the end of August). Their results agree with those of earlier investigators in showing that a complete defoliation of the sugar beet depresses both the yield of beets and sugar and that a partial defoliation may produce results in either direction. Their results show that defoliation on 12 July reduced the crop of roots by 37.0 percent and that of the sugar by 36.0 percent; defoliation on 30 July reduced the crop of beets 40.6 percent, that of sugar 43.3 percent; defoliation on 24 Aug. reduced the crop 23.0 percent, the sugar 25.4 percent.

The results obtained by defoliation is probably the best indication that we have of the possible effects of the leaf-spot. It is true that the expression of "badly affected," "very badly affected," etc., heretofore used in this bulletin do not give a definite measure of the extent of the defoliation, but it is the most feasible way of indicating it in our case. "Badly affected" would indicate that from 40 to 60 percent of the foliage had been destroyed and "very badly affected" would indicate that upwards of 60 percent had been destroyed. This disease was so common and severe in 1910 that I doubt whether an attack involving less than 10 to 15 percent would have received any attention at all. We counted the leaves destroyed on a considerable number of beets and the number ranged from 35 to 43. The damage which was apparent varied with different beets, some having put forth a vigorous growth of leaves during August and early September did not show the loss of this number of leaves, while others which had made a less vigorous growth of leaves subsequent to the attack looked very badly indeed. One of our plots which had suffered to this extent i. e. the loss of from 25 to 43 leaves per beet in the latter part of July and early August (25 July to 15 August) yielded 16.85 tons of beets per acre with 16.85 percent sugar. The average yield of beets in the vicinity of Fort Collins in 1910 was less than eleven tons per acre and the average percentage of sugar was about 15.5 percent. By reference to the record of the 120 leaf-spot fields given in the earlier part of this bulletin, it may be seen that their average yield was 12.4 tons beets per acre and the average sugar content was 13.9 percent. There was no leaf-spot in the Fort Collins district, but it was very prevalent in these 120 fields. The distance between the remotest of the leaf-spot fields from one another is not far from 150 miles, while that between the Fort Collins district and the nearest of the leaf-spot fields is about 200 miles. Still consideration must be given to the question of locality. The big fact, however, remains that the yield of these leaf-spot fields if fully an average one and that we cannot detect any relation between the virulence of the attack and the yield or the percentage of sugar. The time of attack, beginning about 25 July, would lead us to expect very pronounced and disastrous results. I believe that in some individual cases that very disastrous results may follow the attack, but it seems very doubtful whether the effect of this disease is generally so great as we have thought, especially upon the yield of beets and the percentage of sugar, but there are other ways that the destruction of the foliage may affect the beets. Some of these have been given in the preceding quotations from Andrlik and Urban, also from Strohmer, Briem and Fallada. I have undertaken to study some further features of the effects of defoliating the beets in two experiments, just as I have endeavored to study the effects of the nitrates to see whether the effects of defoliation are the same as those of the nitrates.

For this purpose I selected five rows of each of the two varieties experimented with and defoliated them on 6 Sept. The beets were growing rapidly at this time. The tops were removed by means of a knife, we left no leaves which had fully expanded, only the small undeveloped ones at the center of the beet. The beets put out perhaps 50 percent of a full foliage before they were checked by the freezing of the tops, which happened 20 Oct. The weather had been fine up to this date. The beets were harvested 8 Nov., almost exactly two months after defoliation. Samples of these beets were taken 1 Sept., when the results were as follows: average weight of beets, E R 625.3 grams, average weight of tops 735.6 grams, Z R average weight of beets 510.3 grams, of the tops 614.3 grams. The percentage of sugar in E R was 11.9 and in Z R 13.2. At the time of harvest the check plots gave for E R average weight of beets

875.7 grams, Z R 929.3 grams, the defoliated beets averaged E R 791.2 grams and Z R 701.3 grams. The increase in the weight of the roots from 1 Sept. to 8 Nov. was for E R normal development 250.4 grams, defoliated 165.9, Z R normal development 419.0 grams, defoliated 191.0. In the case of E R the average weight of the beets was depressed 84.5 grams or 9.6 percent of the weight of the normally developed beets, in the case of Z R the averag weight was depressed 228 grams or 24.5 percent of the weight of the normally developed beets. The latter figure, approximately 25 percent, is the same as obtained by weighing the beets produced by these rows and their check. This applies to both varieties. The percentage of sugar in the normally developed E R variety, harvested 8 Nov., was 15.6, in the defoliated beets harvested same date 14.3, in normally developed Z R 15.6, defoliated 13.2. The normally developed variety E R to which nitre had been applied contained 14.6 and the Z R variety 14.5 percent sugar. In the case of the variety E R the depression of the percentage of sugar in the beet was about the same as that produced by defoliation, 1.0 against 1.3 percent. The difference can scarcely be explained by an increase in the yield caused by the nitrate for according to the field weights given me there was a decrease in the crop caused by the nitre. This is not in harmony with our observations on the relative size of the beets during the season, according to which there should have been an increase of the crop of from 1,200 to 2,000 pounds per acre. In the case of the variety Z R the nitrate caused a depression in the percentage of sugar of 1.1 and the defoliation 2.4 percent. The yields returned to me for these plots, one-enth acre each, were for E R 23.7 and 24.3 tons per acre, for Z R 20.8 and 22.4 tons per acre. The check plots were the higher in both cases, which I fear is a clerical error due to exchanging the plots in recording them. I am personally fully convinced that this is the case, but I have given the record as it stands. The average of these yields is more than twice that of this section for 1910.

The object of our experiment was not to obtain further data regarding these factors which had previously been determined and with which our results agree in so far as they are parallel, but to see what the effect upon the principal factors in the quality of the beets for factory purposes might be. The question with us is why have the beets in the Arkansas Valley fallen off so in quality? I do not know that the yield per acre has fallen off, I do not believe that it has. The average yield for the 120 fields, representing approximately 2,500 acres, is 12.4 tons, an average which is not exceeded in any section of the state. On the other hand the sugar content averaged only 13.9 percent as they were delivered to the factory, and I may add that this is within 0.3 percent of the average for the whole valley in 1910. There are two facts which must be constantly borne in mind, one is that, for some reason, 1911 was a much more favorable year than 1910, that is the beets of 1911 worked much better than those of previous years, 1910 for instance, and that my experiments of 1911 were made at Fort Collins and not in the Arkansas Valley, in other words, that both the season and locality tended to produce beets of good quality, whereas my endeavor was to bring about the inferior quality so generally met with of late years in the Arkansas Valley. This applied to the experiments made with nitre as well as to those with defoliation. The results with nitre have been given in preceding paragraphs and the analyses of the check samples taken 8 Nov. have been given as analyses CLXX and CLXXII. Samples of these varieties were taken immediately before defoliation and on 8 Nov. The analytical results obtained on these samples 1 Sept. and 8 Nov. were as given in table.

It has already been stated that the yield of roots was depressed about 25 percent by the almost complete defoliation of the beets and that of the sugar not less than 35.7 percent in the case of the variety E R and apparently still more in the case of Z R.

The effect upon the quality of the beets was to lower the percentage of sugar, in the case of the variety E R, this decrease was 1.3 percent, in that of the variety Z R it was 2.4 percent. It also depressed the percentage of dry matter in the beets, in the case of E R 1.66 and in that of Z R 2.8 percent. It increased the pure ash in the beets very slightly, 0.003 in E R and 0.008 percent in Z R. It did not perceptibly affect the composition of the pure ash, the phosphoric acid in particular remaining very nearly the same, 10.175 against 9.876 in E R and 10.932 against 10.855 percent in the case of Z R, which is apparently an important factor. The total nitrogen in the beets was decidedly depressed, from 0.14882 to 0.12408 in E R and from 0.14223 to 0.11286 percent in Z R. The injurious ash per 100 sugar was slightly increased, from 2.456 tot 2.668 in E R and from 2.565 to 3.133 in Z R. The injurious nitrogen per 100 sugar was decreased from 0.362 to 0.326 in E R and from 0.323 to 0.136 percent in Z R. The total nitrogen in the press juice was also lowered from 0.134 to 0.102 in E R and from 0.123 to 0.092 percent in Z R. The beets of these varieties which matured normally contained 0.00827 and 0.00746 percent nitric nitrogen, the defoliated beets contained 0.01367 and 0.01584 percent, approximately twice as much. The nitric nitrogen was evidently transformed in some manner in the normally developed beets but not in the defoliated ones to anything like the same extent as appears from the fact that on 1 Sept. the beets contained, E R 0.1925, Z R 0.01670, on 8 Nov. the defoliated beets contained, E R 0.01367, Z R 0.01584 percent, while the normally developed beets contained, E R, 0.00827 and

ANALYSES OF BEETS DEFOLIATED 6 SEPT., HARVESTED 8 NOV. 1911.

	CLXXVII	CLXXVIII	CLXXIX	CLXXX
Variety	E R*	E R	Z R	Z R
Date of sampling	1 Sept.	8 Nov.	1 Sept.	8 Nov.
Average weight of beets	625.3 grams	791.2 grams	510.3 grams	701.3 grams
Av. weight of beets, trimmed	543.4 grams	701.0 grams	469.4 grams	590.0 grams
	Percent	Percent	Percent	Percent
Sugar in beets	11.90000	14.30000	13.20000	13.20000
Dry substance in beets	18.69000	19.60000	19.76000	19.27000
Crude ash in dry substance	4.64900	3.98000	3.94200	4.28000
Pure ash in dry substance	3.24960	2.77100	2.79500	3.01500
Pure ash in fresh beet	0.60735	0.54440	0.55235	0.58100
Sulfuric acid	0.02358	0.02414	0.02341	0.02462
Phosphoric acid	0.05425	0.05380	0.06435	0.06307
Chlorin	0.02314	0.01933	0.01413	0.02563
Sodium	0.01484	0.01254	0.00917	0.01666
Potassic oxid	0.31460	0.26493	0.29742	0.28042
Sodic oxid	0.09825	0.06062	0.06676	0.06624
Calcic oxid	0.02456	0.03603	0.02140	0.02808
Magnesic oxid	0.04813	0.06775	0.05010	0.07262
Ferric oxid	0.00329	0.00178	0.00301	0.00158
Aluminic oxid	0.00145	0.00126	0.00162	0.00092
Manganic oxid	0.00104	0.00193	0.00098	0.00117
Total nitrogen	0.13794	0.12408	0.13068	0.11286
Proteid nitrogen (Stutzer)	0.07317	0.06731	0.07418	0.09029
Ammonic nitrogen	0.00251	0.00105	0.00251	0.00118
Amid nitrogen	0.00634	0.00387	0.00568	0.00343
Amino nitrogen	0.04150	0.06267	0.04244	0.05071
Nitric nitrogen	0.01925	0.01367	0.01670	0.01584
Injurious nitrogen in beet	0.05592	0.05185	0.04831	0.01796
Injurious ash per 100 of sugar	3.98650	2.66820	3.11290	3.13320
Injurious nitrogen per 100 sug.	0.45922	0.32658	0.36591	0.13606
Press Juice According to Ruempler.				
Total nitrogen	0.11480	0.10178	0.11639	0.09155
Albumin nitrogen	0.03772	0.03639	0.03742	0.03389
Propetone nitrogen	0.01464	0.00356	0.01156	0.00273
Peptone nitrogen	?	0.00444	?	0.00548

Ash Analyses.

	CLXXXI.		CLXXXII.		CLXXXIV.		CLXXXIII.	
	Crude	Pure	Crude	Pure	Crude	Pure	Crude	Pure
Carbon	None	.....	None	.....	None	.....	None	.....
Sand	1.279	....	1.095	.....	0.808	.....	0.946	.....
Silicic acid	1.001	.....	0.857	.....	0.973	.....	0.784	.....
Sulfuric acid	2.714	3.883	3.158	4.533	3.005	4.238	2.986	4.238
Phosphoric acid	6.244	8.933	6.879	9.876	8.262	11.651	7.647	10.855
Chlorin	2.663	3.810	2.472	3.551	1.814	2.559	3.107	4.410
Sodium	.....	2.477	.....	2.309	.....	1.660	.....	2.867
Carbonic acid	26.275	.....	26.989	.....	24.107	.....	26.360	.....
Potassic oxid	36.207	51.794	33.875	48.636	38.181	53.845	34.001	48.264
Sodic oxid	13.640	16.176	9.880	11.129	10.157	12.087	10.751	11.401
Calcic oxid	2.827	4.044	4.608	6.617	2.747	3.874	3.405	4.833
Magnesic oxid	5.539	7.924	8.663	12.440	6.432	9.071	8.805	12.499
Ferric oxid	0.379	0.542	0.227	0.325	0.386	0.545	0.191	0.271
Aluminic oxid	0.167	0.245	0.161	0.230	0.207	0.293	0.112	0.159
Manganic oxid	0.120	0.172	0.247	0.354	0.126	0.177	0.143	0.203
Loss	(1.546)	.....	(1.447)	.....	(3.104)	.....	(1.463)	.....
Sum	100.601	.....	100.558	.....	100.409	.....	100.701	.....
Oxygen equi. to chlorin	0.601	.....	0.558	.....	0.409	.....	0.701	.....
Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000

*The samples taken 1 Sept. represent the composition of the beets at the time of defoliation. Analyses CLXX and CLXXI represent the same with normal development and harvested 8 Nov.

Z R, 0.00746 percent. It has already been pointed out that even these latter figures are high for beets grown without the application of nitrates in excess or highly nitrogenous manures. The soil in which these beets were grown contained, according to our latest analyses, Apr. 1912, 0.142 percent nitrogen and 0.063 percent in the subsoil; the nitric nitrogen in the soil was at this tme 0.0008 percent, but was very much higher in September, 1911, as is elsewhere stated.

These effects of defoliation are not those which constitute the subject of our study, especially is this the case with the nitrogen. The subject of defoliation was taken up, as previously stated, because we assume it to present the best imitation of the effects of the leaf-spot disease, and while our experiments were extremely severe the leaf-spot has often approached the same severity. These experiments answer the purpose for which they were made very well and are in full accord with later investigations of this subject, but the subject is worthy of a much fuller study for there are some very perplexing things that have been observed. A field previously referred to, which had been defoliated by the leaf-spot disease quite as severely as I defoliated these beets, produced a small yield but the beets were rich in sugar, 16 to 17.5 percent, and this could not be attributed to drying out of the beets. This is not an isolated instance though it is an extreme one.

In this attempt to determine the effects of defoliation upon the composition of the beet, we find that in addition to reducing the yield both of beets and sugar and the percentage of sugar in the beets, it reduced the percentage of dry matter, it did not positively increase the pure ash in the dry substance in one case, but in the other it did. It showed a decided depression of the total nitrogen in the beet, from 0.148 and 0.142 to 0.124 and 0.113 percent, the phosphoric acid in the fresh beet was scarcely changed. We find in the normally matured beets 0.05508 and 0.06256 and in the defoliated beets 0.05380 and 0.06307. This identity is quite as evident when the composition of the pure ash is considered in which we have for these varieties given in the same order, 10.175 and 10.932 percent in the pure ash of normally developed beets and 9.876 and 10.855 percent in that of the defoliated beets. The figures for the potash are also very similar, 0.26141 and 0.28494 in normally developed beets and 0.26493 and 0.28042 in the defoliated ones. The injurious ash per 100 of sugar was slightly increased, 0.21 and 0.57 part per 100 sugar; the injurious nitrogen was not changed or lessened. The total nitrogen in the press juice was lessened and the ratio of the proteid nitrogen to the total materially lowered. The ratio of the lime to the magnesia remained practically unchanged.

The most marked effect upon the composition of the beet was upon the content of nitric nitrogen. On 1 Sept. we found in these beets nitric nitrogen equal to 0.01925 and 0.01670 percent, in the normally matured beets on 8 Nov. we found 0.00827 and 0.00746 and in the defoliated beets harvested the same day, 8 Nov., we found 0.01367 and 0.01584 percent. It is evident that the leaves on the normally matured beets have played an important part in eliminating or transforming the nitric nitrogen between 1 Sept. and 20 Oct., when the leaves were killed by a heavy freeze. The last samples of leaves were taken 12 Oct., when we find that the blades of beet leaves to which no nitrate had been applied contained no nitric nitrogen, but the stems contained 0.01956 and 0.01797 percent for the respective varieties. On 1 Sept., five days before we defoliated the beets, both the blades and the stems contained nitric nitrogen, but on 28 Sept., the next date when the blades and stems were analyzed separately, the blades contained none which, from the amount found for the whole leaf on 14 Sept., was probably the case at this time. At all events the nitric nitrogen disappeared wholly from the blades between 1 and 28 Sept., but the stems were still quite rich, 0.01956 and 0.01797 on 12 Oct., when the nitric nitrogen in the beet had fallen to 0.00503 and 0.00870, quite as low as we found it on 8 Nov., the latest sample of the season. The decrease of nitric nitrogen in the defoliated beets from 6 Sept. till 8 Nov. was not enough to be proportional to the increased weight of the beet, so that it seems probable that the beets continued to take up some nitric nitrogen after defoliation but that no transformation of it took place. This detail statement is made for the purpose of presenting as forcefully as possible the question whether the leaf-spot disease may not by destroying the foliage to the extent that it sometimes does, be the cause of excessive amounts of nitric nitrogen which we find in our beets? I think that the facts adduced in this connection go very far to establish it as a fact, that given the nitrates in the beets at the time the fungus destroyed the foliage that it would remain in the beets, to a greater or less extent, depending upon the sufficiency of the foliage which may have escaped the fungus injury to carry on the normal functions of the beet, and in this way the leaf-spot might account for the presence of nitric nitrogen in the beets and the molasses made from them, but this only accounts for the failure of the maturing beet to eliminate, if I may use the term, the nitric nitrogen, but does not account for its presence at the time of the injury, any more than the cutting off of the leaves accounts for the nitric nitrogen present in the beets on 6 Sept. It, however, does account for the fact that we found the nitric nitrogen in the beets on 8 Nov., but nothing more. The other changes in the composition of the beet are not those which we find in the beets of the Arkansas Valley. We will go into the details of these a little later.

Our experiments of 1911 were made on land more than sufficiently well supplied with nitrogen, especially in the form of nitric nitrogen. This statement assumes that the facts pertaining to the presence of nitric nitrogen established for fallow spots in the beet-field in 1910 and in fallow ground adjacent to the beet plots in 1911 apply in the same measure to the ground actually occupied by the beets, which is an assumption and not a proven fact, but on this assumption the beets in 1911 had at their disposal up to 13 Sept., the date on which we sampled the fallow land, which, though cultivated, had not been irrigated, not less nitric nitrogen than the equivalent of 480 pounds of sodic nitrate in the top six inches of soil. The nitric nitrogen averaged 3.24 percent of the total nitrogen, which was about 0.134 percent. The determinations were made on 10 composite samples which included 124 subsamples. Experiments have shown that the application of this quantity of nitre, about 500 pounds, applied by or before 1 May, was, under the conditions of our experiments in the Arkansas Valley, more than sufficient to produce the maximum beneficial effects and was, in fact, somewhat objectionable. It has been stated that another section of this field produced in 1910 a big growth of leaves and a small crop of poor beets, 13.3 percent sugar. Had I been able to obtain land of my own choice I would not have used this, but this was kindly placed at my disposal by the Department of Agronomy, and it was the very best that they had.

My immediate object was to determine the effects of an excessive supply of nitrates upon the beets subsequent to the period of their greatest activity in appropriating nitrogen, which is during the months of June and July. The results give us at the same time a clear presentation of the effects of nitre upon the growth and composition of the beet. That nitrates prolong the period of growth and stimulate vegetation has long been established as a fact, our object was not to reconfirm this, but to study their effects upon the composition of the beets. The effects of an application of nitre at the rate of 250 pounds per acre on 4 Aug. made themselves manifest in the color and growth of the leaves in from ten to fourteen days to such an extent that it attracted the attention of casual observers. This continued to become more marked through the remainder of the season till the leaves were killed by frost. In fact it was more evident on 15 Oct. than on 15 Sept. because the beets to which no application of nitrates had been made, showed clearly the process of maturation, whereas the others did not, and this is one of the bad effects of the nitre, i. e., that it very materially delays the maturation of the beets, a statement which I have previously made in other forms. The effects upon the crop and its composition under these conditions, all of which were such as to tend to conceal or lessen the effects of the nitrates were: an increase in the size of the beet and the weight of the tops, a decrease in the percentage of sugar and dry substance in the beet by approximately one percent in each case. There was an increase of pure ash in the dry substance of from 7 to 9 percent or more. There was a decided suppression of the phosphoric acid in the beets. The potash was very high in the beets from both the treated and check plots, but it was nearly the same. These statements apply to both sets of samples, 12 Oct. and 8 Nov. The sodic oxid and chlorin were both increased, at least this was the rule. The total nitrogen showed an increase beginning in the variety Z R on 18 Aug. and in E R 14 Sept., and continued throughout the season. This increase in the samples of 8 Nov. was for E R 11.8 and for Z R 17.5 percent.

This increase in the nitrogen is perhaps more evident in the press juice than in the beets for in this it is, for the variety E R 9.0 and for Z R 18.0 percent. The ratio of albumin nitrogen was also reduced from 40 to an average of 34 percent. The injurious ash per 100 sugar, sampled 8 Nov., was increased from 12.0 to 16.0 percent, while the injurious nitrogen per 100 sugar was increased in E R 34.0 and in Z R 52.0 percent. The nitric nitrogen in the beets on 8 Nov., showed an increase of 126.3 percent in E R and 90.5 percent in Z R. These particular effects can be due to no other causes than the excessive nitrate applied, for an analysis of the results obtained both with the leaves and the beets from the check plots, as well as the quantities of nitric nitrogen found in the fallow land 13 Sept., corroborate our observations on the development of the beets, to the effect that the beets in the check plots had an abundant supply of this form of nitrogen. The beets did not at any time suffer from drought or from an attack of any enemy, and they were grown in an unusually long and favorable season. Further, the questions of seepage, of alkali and of any deficiency of plant food are completely eliminated by the location and properties of the land. The leaves were examined throughout the season and the results of these examinations alone serve to show how radical the effects of the nitrates must have been, for the nitric nitrogen in the blades of our check beets was unquestionable but it had completely disappeared by 29 Sept., while it was very abundant in the blades of the nitre beets on 12 Oct. The abundance and the persistence of this form of nitrogen in the leaf stems is very striking.

The effects of defoliation are, it is true, very marked, but they are not those produced by the nitrates. Those sufficiently interested will find a complete statement of the analytical results in analyses CLXIX to CLXXVI and CLXXVII to CLXXXVI, the former give the complete analyses of the beets normally developed, both with and without application of nitre, the latter give the complete analyses of the varieties at the time of defoliation and at the time of harvest. The defoliation evidently caused a stoppage in the development of the beet; it did not depress the phosphoric acid in the beet, it did not increase the total nitrogen in the beet, but it did arrest, apparently almost completely, the elimination or transformation of the nitric nitrogen. The extent of the defoliation was extreme, almost complete and undoubtedly arrested some functions of the plant completely, while others were disturbed to a less extent. We see for instance that the beets attained to a fair size, 791 and 701 grams, untrimmed, and this is the average weight of 50 beets in each case.

It was very advisable, in fact quite necessary, that the experiments of 1911 should be made before any interpretation of the results of 1910 should be undertaken, for however pronounced the effects of the nitrates may have been there would be misgivings, even in our own minds, as to the part *Cercospora beticola*, the leaf-spot, might have played and what the nitrates had really effected. The experiments of 1911 enable us to state, as we have done, pretty fully, what the nitrates did even when applied at a period when the rate of appropriation of nitrogen by the beet had, according to Prof. Remy, already abated very materially and was becoming still slower. Unfortunately our check field practically failed us in 1910, nevertheless, not to such an extent as to be wholly useless, though its value is very much less than we had hoped it would be.

The application of 250 pounds of nitrate per acre, 1 April, just before planting the seed, resulted in an increase in the yield of roots and sugar, and the general quality of the beets was very good, crop 16.85 tons, sugar in beets 16.85 percent. The phosphoric acid in the beets was low and the alkalis relatively high. The total nitrogen was relatively low, the ratio of proteid nitrogen to the total was better than 50 percent; in the juice, according to Ruempler, it was 31 percent, the nitric nitrogen was low for the Arkansas Valley beets, 0.00144 percent; the injurious ash and nitrogen per 100 sugar also low, the former 2.1267, the latter 0.36424. The beets from this field were among the best analyzed in 1910 and were really very good beets. We have elsewhere stated that these results are not in accord with others obtained with smaller applications of nitrate, but the soil was different.

With the application of 500 pounds per acre the field results were good, crop 15.52 tons per acre, sugar in beets 15.8 percent, but the effects upon the composition of the beet were easily recognized in the analytical results by an increase of the total ash, a very moderate amount of phosphoric acid, high alkalis, particularly soda, a marked increase in the total nitrogen, a lower ratio for the proteid to the total nitrogen, evident in the juice as well as the beet, a very large increase in the nitric nitrogen, ten times, a very decided increase in the injurious ash and nitrogen per 100 of sugar, 3.205 for the former and 0.6822 for the latter. The diffusion juice from these beets showed a considerable reduction in its percentage of nitrogen and yielded a thick juice of 88.29 purity.

With the application of 750 pounds of nitre per acre, the results were bad, crop 14.94 tons, sugar in beets 13.4, dry substance 20 against 22 with 250 pounds, pure ash in fresh beets greatly increased, 60 percent, phosphoric acid reduced from 0.0375 to 0.03588, the alkalis increased, potash to 0.30088 and the soda to 0.18359, the total nitrogen increased from 0.14485 in the beets grown with 250 pounds of nitre to 0.29610 in the beets, and 0.27065 in the juice, and the ratio of the proteid nitrogen to the total was very greatly depressed, to 16.9 percent in the juice, the nitric nitrogen increased from 0.00144 in the beets grown with 250 pounds of nitre, to 0.04143. The real coefficient of purity of the thick juice produced from these beets was 86.66.

The results obtained by the application of 1,000 pounds in four portions did not show a further reduction in the yield but the percentage of sugar and dry substance in the beets were reduced to 11.0 for the sugar and 17.6 for the dry matter; the pure ash in the beet was quite high, 0.7444, the phosphoric acid fell still further to 0.02373, the total alkali was nearly 0.46 and the soda rose to 0.23728, the total nitrogen was high both in the beets and juice, the proteid nitrogen was low and the nitric nitrogen in the beet rose to 0.06285 and the real coefficient of purity of the thick juice was 86.37.

For some reason, as stated more in detail elsewhere, the plot which received 1,250 pounds in five applications and our check plot which lay alongside of it, gave us unexpected and discordant results. The general results, however, with 1,250 pounds per acre, were the same as those with 1,000 pounds, low percentages of sugar and dry substance, low percentage of phosphoric acid, high alkalis, especially soda, high total nitrogen, low ratio for proteid nitrogen, high nitric nitrogen, high amounts of injurious ash and nitrogen per 100 sugar, 4.04 for the former and 1.1151 for the latter. The real coefficient of purity of the juice from these beets was 86.43. Though the results obtained on our check plot, probably due to a flooding in early August which also involved a part of the field which had received the application of 1,250 pounds of nitrates, were altogether unsatisfactory, still the real purity of the thick juice from these beets was 88.26, which is at least one point lower than it should be and still we see that the effect of 1,000 pounds of nitrate of soda per acre was to depress the coefficient of purity of the thick juice by 1.89 points below this and hereby probably increased the molasses which these beets would produce by from 3 to 4 percent on the weight of the beets cut, or in other words, would increase the molasses produced in a factory working such beets alone to probably 8.5 percent or possibly more on the weight of the beets cut.

Analyses VII, VIII and CLXXXV represent the best beets that I have been able to obtain, with these might be grouped Analysis XI. No. VII was grown in Michigan, VIII near Fort Collins, XI in the extreme eastern part of the Arkansas Valley in Colorado, while CLXXXV was grown in Montana. These are all good beets but the samples from Colorado and Michigan are excelled by the Montana beet and for this reason I will consider the Montana beet alone in this place and only from the standpoint of quality without any attempt to account for it. The trimmed beets from Michigan averaged 1.8, those from Fort Collins 1.5 and the Montana beets 1.06 pounds. The weight of the Arkansas Valley beets was not noted but they were only a little smaller than the Fort Collins beets and can be safely estimated at about 1.25 pounds. The Montana beets show the following qualities: high sugar content, 18.24 percent, low ash, pure ash in beet, 0.4909 percent, high phosphoric acid 0.08117 percent in beet, high potash, low soda, low total nitrogen, high ratio for proteid nitrogen both in the beet and juice, nitric nitrogen entirely wanting, injurious ash per 100 sugar very low, 1.6724, injurious nitrogen very low, 0.16722 per 100 sugar. The amount of phosphoric acid in the pure ash is fully normal, a feature which is very markedly wanting in our Colorado beets. The ash of sample VIII, given in Analysis X, approached it more nearly than any other sample that I can recall and it has 12.515 percent phosphoric acid in pure ash and 0.0762 percent in beets. I do not know what the composition of the Arkansas Valley beets was during the years previous to 1904 but our records show that the sugar content was not far from 17.5 percent—this figure is more than sustained by the average sugar content of the beets received at the factory at Rocky Ford during its first three or four campaigns. The beets given in Analysis XI are not the richest beets harvested from this field, several wagon loads sampled above 16 percent and this same territory in 1911 averaged between 17 and 18 percent sugar. The growth of the beets in 1911 was of an entirely different type from that of previous years. These facts are stated to remove the impression that there is no justification for taking a beet of such high quality as the Montana beet as a standard. The College land is probably as good as any on which beets were grown in 1910 or 1911 from which we gathered samples. The College samples 13 Oct. 1910 contained 13.3 percent sugar, were five percent lower in dry substance, and 23 percent richer in pure ash in beet than the Montana beets. The phosphoric acid was fairly high, 0.07342, the sodic oxid was high, 0.12858, the total nitrogen was 0.18636 and the nitric nitrogen

0.02138. Injurious ash per 100 sugar was 3.4164, and injurious nitrogen 0.6384. The beets grown in a part of the same field in 1911 were much better in every respect except that the phosphoric acid was much lower. This difference was not due to the date of harvesting, for the one was gathered on 11 Oct., the other on 12 Oct. When we pass to ordinarily good land in the Arkansas Valley and consider the quality of the beets grown on such land without any fertilizers we find low percentages of sugar and dry substances, high ash, low phosphoric acid, often high chlorin, high potash (alkalis), variable total nitrogen, high nitric nitrogen and large amounts of injurious ash and nitrogen per 100 sugar. Analyses XX and XXVII represent beets grown on good land but of surprisingly poor quality. This land was a sandy loam; the water supply in 1910 was good throughout the season and the cultivation was also good. The beets suffered some from leaf-spot, no fertilizers used. The percentage of sugar in the sample taken 3 Nov. was 12.7 percent; of dry substance 20.0, pure ash in beet 0.7176, phosphoric acid 0.03825, chlorin 0.03342, sodic oxid 0.17585 after deducting enough to combine with the chlorin present, total nitrogen 0.25215, nitric nitrogen 0.04537, injurious ash per 100 sugar 3.703 and injurious nitrogen per 100 sugar 1.07246. There is neither seepage nor alkali, as we usually use this term, in this land. The beets did not suffer from drought nor were they injured to any extent by the leaf-spot and yet the contrast between these and good beets is marked in every respect. I do not know the variety of these beets. Compared with either one of the samples, especially with the Montana beets, they yield very interesting results. The figures for the Montana beet are given first; sugar 18.24-12.7; dry matter 25.37-20.00; pure ash in beet 0.4909-0.7176; phosphoric acid 0.08117-0.03825; soda 0.01312-0.17595; total nitrogen 0.10494-0.25215; nitric nitrogen 0.0000-0.04537; injurious ash per 100 sugar 1.67240-3.7030; injurious nitrogen per 100 sugar 0.16722-1.07246; ratio proteid nitrogen to total nitrogen in press juice 53.0 percent—20 percent. We can almost exchange these figures for the Colorado sample throughout for those obtained in the case of beets grown with the application of 750 pounds of nitrate per acre—in other words, the results are not only identical in character but almost identical in extent.

We have just placed in juxtaposition the results obtained with the very best beets that I have analyzed and a very poor sample of beets grown on good land and under favorable conditions—the one factor, the presence of leaf-spot, excepted. We look upon the results obtained by defoliating the beets as having already eliminated this. We can, however, eliminate it still more effectively and at the same time show that we have other recourse than the comparison of the excellent beets from Montana with the bad beets grown in Colorado to show the effects of nitrates in the soil upon the quality of the sugar beet. In this case we shall use the good effects of a beneficial quantity of nitrate to show the bad effects of an excessive quantity. In this case all questions of differences of climate, soil, water-supply, cultivation, time of sowing, harvesting, variety, attack of leaf-spot or any other favorable or unfavorable condition are eliminated for the beets were grown on two acres of land in the same field separated by an intervening acre. Both plots received a dressing of sodic nitrate, the first one given 250 and the second 750 pounds per acre; sugar 16.5-13.4; dry substance 22.4-20.6; pure ash in beet 0.51948-0.82238; phosphoric acid 0.03750-0.03588; sodic chlorid 0.03782-0.10638; sodic oxid 0.20800-0.18359; total nitrogen 0.14485-0.29610; nitric nitrogen 0.00144-0.04143; injurious ash per 100 sugar 3.1267-4.7812; injurious nitrogen per 100 sugar 0.36424-1.29250; ratio proteid nitrogen to total nitrogen in press juice 31.0-17.0.

The results which we have just reviewed are such as we meet with on good lands with which, under ordinary conditions, no fault would be found. The next results are such as we meet with on bad ground, not poor ground but bad ground, land in which we meet with conditions involving the questions of seepage and alkali. This land is very rich in nitre. In Colorado Experiment Station Bulletin 155, p. 24, I stated, "We find the nitrates present in soils where there is a great deal of moisture, but in places where there is too much water, the nitre does not appear. In little valleys and saucer shaped depressions in which the lower portions are too wet, there is no visible alkali, then follows a zone where white alkali abounds and above this the nitre is formed. I do not mean to say that there may not be nitre mixed with the white alkali, but that the nitre in such cases appears in higher ground than that on which the white alkali usually appears. Furthermore, it is not intended that anyone shall infer that it is only in valleys and depressions that the nitre occurs." Again in the same bulletin, 155, p. 12, I refer to a condition met with in the soil which I described as muddy, and state, "The soil is very wet at a depth of two and a half feet and forms a real mud from this point downward, but at a depth of six feet the water came in so slowly that in order to fill a two-gallon jug we had to let the hole stand open over night. * * * I had never seen anything similar to this condition before I began to study this subject. * * * * It is surprising that the soil can be so wet and muddy for 3½ feet and that we should be unable to find a proper water-table within six feet of the surface." We met with somewhat similar conditions in portions of this land. Borings were made to determine the height of the water-plane 14 Nov. 1910; it was met with in the lowest cultivated portion of the field at five feet below the surface and one foot above the bottom of a drainage ditch 600 feet to the north and west of this point, at no other point in the line of borings did they find water within six feet of the surface. In 1897, 1898 and 1899 I grew excellent beets both in regard to crop and sugar content on land in which the water did not fall to a greater depth than four feet below the surface at any time and the soil was heavily impregnated with the white alkali common throughout the state. I have no analyses of these beets comparable to the analyses here presented, but samples taken 8 Nov. 1898 showed 17.29 and 18.24 percent sugar, the beets were of excellent shape and of medium size. The subsequent year another variety grown in the worst section of the plot gave 15.82, other samples gave 15.86 and as high as 16.34; the apparent coefficient of purity for these beets was about 84. No nitrogen determinations were made but the ash of this variety was analyzed and gave the following results for the pure ash:

ANALYSIS PURE ASH OF BEETS GROWN ON ALKALI LAND, 1899.

	Percent	Percent in Fresh Beet
Sulfuric acid	4.93	0.043
Phosphoric acid	11.48	0.100
Chlorin	11.93	0.104
Sodium	7.75	0.063
Potassic acid	48.55	0.426
Sodic oxid	1.18	0.010
Calcic oxid	3.66	0.032
Magnesic oxid	9.13	0.077
Ferric oxid	0.89	0.008
Aluminic oxid	0.24	0.002
Manganic oxid	0.26	0.002
	100.00	0.872

The injurious ash per 100 sugar in these beets was 4.18, which is higher than is desirable, but much less than one who is familiar with the conditions of the land at that time would expect. For full discussion of the soil conditions and crop see Bulletins 58 and 65 of this station. The only points presented by this analysis which are in any way abnormal for our western beets is its quantity, 0.872 percent of the fresh beet and the relatively large amount of chlorin, 0.104 percent. The excess of sodic oxid over that necessary to combine with chlorin to form sodic chlorid is very small and the phosphoric acid is very high, two features which are wanting in beets grown with the application of or in the presence of nitrates, especially the phosphoric acid which is always depressed by the nitrates. These data are presented as the most definite and reliable that I have showing the effects of excessive water and alkali, other more general information has been stated in the earlier portion of the Bulletin. The questions of water and alkali are involved in the land which we have designated as bad land and on which the samples under discussion were grown. This land had a fall of about 2.4 feet per hundred to the north, so that the south end of our field was about 18 feet higher than the north end and the excessively bad conditions prevailed in only a small portion of that planted to beets. For the purpose of our study we divided the plots into three sections, the highest, the medium and the lowest, in which the worst land that the owner had tried to cultivate was not included. A sample from this portion, however, is included with those from our check plot. These beets are represented by Analyses C, CI, CII and CIII, their ashes by Analyses CXIV, CXV, CXVI and CXVII. The variety of beets was the Original Kleinwanzlebener. The character of the beets from the various sections differed only in degree, and in this not to the extent that one would expect. We see by an inspection of the analyses that the percentage of sugar is low, 13.2 to 8.6 percent, the dry substance is low, from 21 to 16.5, the pure ash in the beets is very high, from 0.89514 to 1.32875, the phosphoric acid is very low, from 0.03875 to 0.02007. The chlorin is high, from 0.15188 to 0.30396, the potassic oxid is only moderately high, see percentage in pure ash, the sodic oxid above that required by the chlorin is moderately high. The total nitrogen is high, one sample excepted, 0.23345 to 0.3451, the nitric nitrogen is high in all samples, from 0.01936 to 0.08337, the injurious ash per 100 sugar is from 5.629 to 13.433, the injurious nitrogen from 1.02880 to 2.04840, and the ratios of albumin nitrogen to total nitrogen in press juice 22.6 to 19.0. We have in these analyses results which are altogether characteristic of the effects of nitrates and while the excessive salts in the soil may have influenced the composition of these beets they have not done so to a sufficient extent to conceal in the least these effects characteristic of the nitrates, for instance, low percentages of sugar, dry substance, phosphoric acid, high total nitrogen, high nitric nitrogen, low ratio of albumin or proteid nitrogen to total nitrogen and high ratios for the injurious ash and nitrogen per 100 pounds of sugar. The pure ash calculated on the beet and the chlorin are both high, but these effects are common to the nitrate, excessive moisture and the alkalis, so their joint effect is cumulative and the effect of one does not tend to lessen or remove the effect of the other.

Beets grown on the worst section of this land were run in an experimental plant and the diffusate treated as usual and evaporated to a thick juice, which had a real coefficient of purity of 69.56, not much better than molasses. The carbonated ash of this thick juice equalled 14.810 percent. The amount of nitrates present in the surface six inches of this soil as calculated from samples of soil taken, one of them from about the beets, actually beneath the leaves, was between 15 and 17 tons per acre.

The experiments made with sodic nitrate in 1910 and 1911 to show its effects upon the quality of beets and upon the character of the thick juice produced in the factory, together with the properties of samples of beets grown upon apparently good land, and also such as were grown upon evidently bad land show by the character and uniformity of the results that it is more than reasonable to attribute the falling off in the quality of the beets in the Arkansas Valley to the formation of excessive amounts of nitrates in the soil during the season and not to climatic conditions or to the effects of the leaf-spot. These are most certainly factors which have a decided influence upon the crop, specifically upon the bad qualities of the beets. They cause the very general production of beets with low percentages of sugar and phosphoric acid, with a high percentage of total nitrogen, especially of nitric nitrogen, and a low ratio of albumin nitrogen to the total nitrogen in the juice, with a high percentage of ash. This results in the production of abnormally high percentages of molasses, 7.5 to even 10 percent from beets which have not been frozen and subsequently deteriorated.

The general applicability of this statement is shown by the nitric nitrogen in the fifteen samples of Colorado molasses as compared with the six from other sources, especially with the four from Bohemia. The maximum ratio that we find in the latter for the nitric to total nitrogen is 0.37, while the minimum found for this ratio in any Colorado molasses examined is 10.66 and the maximum is 28.88. We need not go farther in the discussion of these results, the big fact that many of our Colorado molasses are very rich in nitrates is evident. In this connection, however, I may mention a fact observed by Dr. Potvliet in studying the thick juices prepared in our experimental work, i. e., that the nitrates in the dry substance of the thick juice was lower than it should have been to correspond with the nitrates found in the dried cossettes. This loss was very considerable, amounting to 50 percent in the case of the last beets discussed. In view of this actual loss of nitrates observed and the possibility of its taking place in the factory on a large scale as well as in the battery samples, the very large amount of nitric nitrogen found in our molasses becomes even more suggestive than it already is of the large amount in the beets worked.

The deterioration in the quality of the crop in the Arkansas Valley during the past eight years has not, of course, been accepted with indifference and no effort made to check it, on the contrary, the situation has been recognized as serious by the managers of the plants who have been responsible for the success of the companies operating in the valley. The cause of the trouble was not recognized, but was attributed to various things, climatic conditions, leaf-spot, insect injuries, seepage, alkali, etc., all of which are factors in determining the quality of the season's crop. Another thing suggested was, naturally enough, a lack of some plant food in the soil and consequently attempts were made to find out by direct experiment whether anything could be added to the soil which would produce satisfactory crops both in quantity and quality. I have recorded the results obtained in regard to the yield of both beets and sugar in the earlier pages of this bulletin, which were rather disappointing so far as commercial results were concerned. We, unfortunately, do not feel justified in modifying them in a desirable direction. We can, however, present a review of what the study of the effects of the fertilizers used, had upon the chemical composition of the beets, at least in their bolder features. The weights and combinations of fertilizers used have been given on previous pages. We had in all in 1910, 31 experiments with fertilizers, that is distinct from the nitrate experiments. The beets grown on nine of these plots and two check plots were studied with the object of determining what changes, if any, we had effected in the composition of the beets. The land on which these experiments were made has already been described and its chemical composition given in connection with the detailed statement of the analyses. The results are in harmony with those obtained when considered from the purely commercial basis. The best beets in every respect with one unimportant, partial exception were those grown on a check plot. The plots to which only potash or phosphoric acid had been applied yielded beets of quite as good quality, but the yield and sugar content were a trifle lower in both cases. Stockyard manure seemed to increase the phosphoric acid in the beets though it had been applied in 1909 and we had only a residual effect in 1910. In these experiments the effects of sodic nitrate stand in strong contrast with those obtained in the experiment in which 250 pounds were applied to the field, designated as No. 1. In this case it produced most excellent results, but in every instance in which it was used in the series of experiments under discussion it produced deleterious results though used in quantities less than 250 pounds to the acre. One effect was to increase the chlorin appropriated by the beets—for instance, the beets from check plot contained 0.12746 percent, already very high, those with potassic sulfate alone, 0.14657, with superphosphate alone, 0.12489, those with potassic sulfate and sodic nitrate, 0.24613, those with superphosphate and sodic nitrate 0.17743. The amount by which the nitrate increased the chlorin was very irregular, as are all of the results, but none of them were beneficial. The beets from the check plot were from the standpoint of composition the best beets of the eleven samples examined with possibly one partial exception.

I was and am still of the opinion that the inferiority of nitrate beets is due largely to their immaturity at the time of harvesting. This of course does not explain the depression of the phosphoric acid in the beet which certainly takes place. I do not know the function of phosphoric acid in the first year's growth of the beet except that the application of superphosphate is credited with inducing an early ripening of the beet. We saw no proof of it in these experiments but it was on this theory that I applied superphosphate at the rate of 1,000 pounds per acre to a portion of our field of very bad land. We will compare the beets from the first and third sections of this plot with those from the adjoining sections of the check plot. In the lowest part of the third section the water plane was five feet below the surface. The surface of the first sections was eighteen feet higher than the point where this boring was made. The figures for the beets from the check plot will be given first. First section: Weight of beets, 788.1-751.3. Sugar, 13.2-10.9. Dry substance, 21.0-17.6. Pure ash in beets, 0.942-0.941. Phosphoric acid, 0.03875-0.04816. Chlorin, 0.15188-0.12032. Total nitrogen, 0.2493-0.25860. Nitric nitrogen, 0.01936-0.04982. Injurious ash per 100 sugar, 5.6292-7.1557. Injurious nitrogen per 100 sugar, 1.02880-1.41290. Third Section: Weigh of beets, 569.9-708.7. Sugar, 12.1-10.2. Dry substance, 18.9-18.0. Pure ash in beets, 1.122-1.0644. Phosphoric acid, 0.03109-0.02732. Chlorin, 0.23134-0.20047. Total nitrogen, 0.23345-0.24350. Nitric nitrogen, 0.05370-0.07260. Injurious ash per 100 sugar, 7.92850-9.04210. Injurious nitrogen per 100 sugar, 1.04790-1.78290. The middle section showed no benefit from the application of this amount of superphosphate. The same results varying slightly in their measure was obtained with potassic chlorid and sodic chlorid. These chlorids, 400 pounds per acre, did not affect the amount of chlorin taken up. In five out of six cases the chlorin is lower in the samples grown with these substances than in the samples from the check.

The results obtained with mineral manures are not promising. The general results obtained with stockyard or farmyard manure are much more so than those obtained with the mineral manures. We obtained good beets with green manures but as I have already explained I am unwilling to accept the results obtained without repetition. The beets, however, grown with the mustard and wheat, were excellent in every respect except in regard to the weight of the crop—omitting this factor we have excellent beets, scarcely any better. The beets grown on the wheat ground are given first, then those grown on the mustard land. Sugar 18.5-17.3. Dry substance 24.4-24.4. Phosphoric acid 0.06711-0.07439. Chlorin

0.04062-0.06542. Total nitrogen 0.17940-0.15270; nitric nitrogen, 0.00348-0.00141. Injurious ash per 100 sugar, 2.4190-2.87730; injurious nitrogen, 0.44243-0.34711, and the ratio of the albumin nitrogen to total nitrogen in the press juice is 36 and 40 per cent respectively.

The object had in view in this bulletin has been to discover if possible the cause for the falling off of the beets grown in some sections in sugar content and in general factory qualities. That such a falling off has actually taken place is a fact beyond dispute. We have put this falling off at about three percent in sugar, and the general deterioration in factory qualities may be expressed in terms of the molasses produced at a minimum of two percent, calculated on the beets cut. There has been a variation from year to year. The year 1911, for instance, showed a considerable improvement in this respect. I may remark that the samples of molasses examined in 1911 contained much less nitric nitrogen than the samples from preceding campaigns, except from one factory. We have purposely desisted from taking up in detail the effects produced by the fertilizers used in our attempt to find, if possible, in an experimental way, some feasible means for bringing back the good qualities shown by the beets from 1893 to 1904. The real problem whose solution we have attempted is baffling, as the variety of causes assigned as producing this condition suggests, yet it seems proper that we should discuss briefly some of the salient features of these results from the standpoint of composition wholly irrespective of their technical aspects.

We were fully convinced from the beginning that we could not properly use German or Austrian or any available data as applicable to our beets. The German and Bohemian data vary considerably. I have found no recent complete analyses of German beets. The most satisfactory data that has come to my notice is contained in the Siebenter-Bericht ueber die Versuchswirtschaft Lauchstaedt, 1910, from which it appears that sugar beets grown with 528 pounds nitrate of soda, 600 pounds superphosphate, 264 pounds 40 percent potash salt per acre contained, as the average of seven years, 0.19486 percent nitrogen, 0.06923 percent phosphoric acid and 0.17948 percent of potash in the fresh beet. With the application of nitrate alone 0.20188 percent nitrogen, 0.04431 percent phosphoric acid and 0.16511 percent potash. With no fertilizer 0.20132 percent nitrogen, 0.05479 percent phosphoric acid and 0.16959 percent potash. The average percentages of sugar given for these three series are, respectively, 17.93, 17.32 and 18.29, and those for the dry substance in the beets are 25.64, 24.65 and 26.09 percent. R. F. Strohmer and O. Fallada give in Oesterreichisch-Ungarische Zeitschrift fuer Zuckerindustrie und Laudwirtschaft, XI Jahrgang, 3 Heft S. 425, the composition of beets grown with the application of phosphoric acid, nitrogen (as nitrate and ammonia salts) and soda. The results vary so little for the different sets of beets that we may consider them as within the limits of the natural variability of the plant itself. The soil experimented with was not so rich in lime, magnesia, potash, phosphoric acid or nitrogen as we find our soils to be. The general composition of the eleven samples analyzed is: average weight of beets, 253 to 384 grams. Sugar 17.2 to 19.2, average 18.2. Dry substance 24.68 to 26.54, average 25.61. Ash, apparently carbonated ash, in dry substance 2.19 to 2.55, average 2.39. Ash in beet (carbonated?) 0.61208. Total nitrogen in dry substance, 0.80 to 1.29, average 0.95364, in beet 0.2445. Phosphoric acid in dry substance, 0.28 to 0.38, average 0.3082, in beet 0.07893. Potash in dry substance 0.58 to 0.84, average 0.7155, in beet 0.1833. Owing to the fact that soda in the form of sodic chlorid was applied as a fertilizer, and that sodic salts constitute a considerable percentage of our alkalis, the results obtained in regard to the effects of soda have an especial interest for us. The soda in the dry substance of these beets was from 0.18 to 0.48 percent, the average 0.2496, in the beets 0.06541. We quote the analyses of the pure ash in full, omitting the details of the experiments.

ANALYSES PURE ASH AUSTRO-HUNGARIAN BEETS.

	1	11	2	5	8	4	7	10	3	6	9
Silicic acid......	2.60	2.31	1.87	2.00	2.47	2.61	3.62	4.79	3.26	1.00	1.90
Sulfuric acid....	3.12	4.04	3.27	2.00	2.97	2.61	4.14	3.59	3.26	5.98	2.85
Phosphoric acid.	15.60	18.47	13.53	12.53	14.86	17.80	19.66	17.96	15.76	13.96	14.22
Chlorin	1.56	1.73	3.27	3.00	2.48	1.57	1.55	1.80	2.72	2.99	2.37
Potassic oxid ...	43.68	33.47	34.05	38.08	38.63	36.65	30.52	31.13	41.85	34.90	38.88
Sodic oxid.......	10.40	14.43	22.39	15.53	18.32	9.98	14.49	17.36	9.24	13.46	18.97
Calcic oxid......	10.92	12.12	11.66	11.53	9.91	16.75	14.48	8.98	9.24	12.47	10.43
Magnesic oxid...	10.92	12.12	8.86	10.52	8.92	9.42	10.82	13.77	10.33	10.96	9.96
Ferric and Alumnic oxids.	1.56	1.73	1.87	5.51	1.98	3.14	1.03	1.20	4.89	4.98	0.95
	100.36	100.42	100.77	100.70	100.54	100.53	100.36	100.58	100.55	100.70	100.53
Oxygen equi. to chlorin	0.35	0.39	0.74	0.76	0.56	0.52	0.35	0.60	0.55	0.76	0.53
	100.01	100.03	100.03	99.94	99.98	100.01	100.01	99.98	100.00	99.94	100.00

Numbers 1 and 11 received no fertilizers of any sort. The authors failed to discover any relation between the amount of sodic oxid and the sugar in the beets. The ratio of the proteid nitrogen to the total in the dry substance ranged between 60 and 65 percent.

There are radical differences in the composition of these European beets as we find them represented in their literature and those which we have studied. It is not feasible to go into the details of all of our analyses, but the general results may be expressed as follows: The whole nutrition of the beet seems to be very greatly modified. The total nitrogen in our beets is decidedly lower than in the European beets except under abnormal conditions. The average total nitrogen in Lauchstaedt beets grown without fertilizers is 0.20132 percent. This average is based on seven years' observations. The average of those just quoted from Strohmer and Fallada is 0.2445 percent, that for the six samples of cossettes quoted from Andrlik is 0.233 and for twenty-three other samples also given by Anrdlik the average is 0.2285 percent. The average for the total nitrogen in our beets grown on good land without fertilizers will not exceed 0.15 to 0.18 percent. The proteid nitrogen is low, being as a rule less than 50 percent of the total in the harvested beets, and in the case of beets grown on bad ground, even with the application of superphosphate at the rate of 1,000 pounds per acre, it fell to a little less than 20 percent of the total. The European beets contain almost no nitric nitrogen, so little that the determination is seldom attempted. Further, the Bohemian molasses given in this bulletin show very little of this form of nitrogen, while it is present in our beets in liberal quantities, reaching in the case of beets grown on very bad ground 0.08 percent and is so good as never entirely wanting. The sample of Montana beets contained none and one sample from Fort Collins contained only 0.0009 percent. Usually our best, mature beets contain 0.003 or more percent. The injurious nitrogen in our beets is very high. Andrlik states that "beets poor in nitrogen contain only one-fourth to one-third of their total nitrogen, on the other hand beets rich in nitrogen contain as much as one-half of it as injurious nitrogen," Zeitschrift des Vereins der Deutschen Zuckerindustrie 1903, p. 922, and gives examples in support of his statement showing beets with from 0.224 to 0.306 percent nitrogen which contain injurious nitrogen reaching from 37.9 to 43.8 percent of the total. Four of the best samples grown by us in 1911 containing 0.14124, 0.14388, 0.14882 and 0.14223 percent total nitrogen, contained 42.55, 43.47, 37.98 and 35.43 percent of it in the form of injurious nitrogen. These beets were grown without any fertilizers and were harvested, the first pair on 12 Oct. and the second pair on 8 Nov. This shows the betterment of the beets by ripening. I may add that beets grown with application of nitrates subsequent to 1 Aug. showed an improvement also but to a less extent, the total nitrogen in these beets was essentially 0.165 percent. The injurious nitrogen in these, the same varieties as above given and harvested on the same dates, amounted to 45.33, 45.07, 42.67 and 42.58 percent of the total. We see that these percentages are very much higher than those given by Andrlik, whose beets with 0.165 percent nitrogen contained 32.1 percent of it as injurious nitrogen. This is 10.5 percent less than we find in beets of equal nitrogen content in their very best condition.

Our beets carry much less phosphoric acid as a rule than the

European beets. The Lauchstaedt beets grown with a complete mineral manure, showed for the seven year average 0.06923 percent in the beet, and beets grown without any fertilizer showed as an average for the same period 0.05479 percent. The samples given by Strohmer and Fallada with and without fertilizers give an average of 0.07155 percent in the beets. A few of our samples are as rich or richer even than these averages indicate, but the greater number of them are materially lower. The percentages of dry substance and its ash content together with the percentage of phosphoric acid in the pure ash are the factors which give us these figures. In our beets these factors are different from those of the European beets. The percentage of dry substance in our beets is materially lower, as a rule, the ash is somewhat higher, the phosphoric acid in the pure ash is very much lower. In the analyses of pure ashes given by Strohmer and Fallada, the lowest percentage given for phosphoric acid and calculated on the pure ash is 12.53 and the highest is 19.66. Of 50 ashes of Colorado beets analyzed in connection with this bulletin, only two have shown in the pure ash as much as 12 percent of phosphoric acid, these contained 12.515 and 12.076. The average of the 50 determinations using the nearest whole figure in the second decimal place is 6.78 percent. It is just to state that 13 of these samples were grown on very bad ground, but when these beets have been deducted, the average is only 8.07 percent, while the average of the Strohmer-Fallada samples is 15.6 percent. The pure ash of the Montana beet analyzed contained 16.536 percent.

The potassic oxid in our beets is higher than in the European beets. In these latter its average is not far from 0.17 percent, while in ours it is seldom as low as 0.22 and reaches as high as 0.54, ranging mostly between 0.26 and 0.44.

In regard to the sodic oxid nothing can be said, it seems to be as erratic in the European beets as in ours, and without relation to the sugar in the beet.

Our beets contain very little lime, usually a trifle over one-half as much as the European beets, but they contain rather more magnesia. The ratio of these two substances in the European beets is approximately 1:1, the calcic oxid being slightly in excess, but with our beets this ratio is approximately 1:2.

The chlorin is extremely variable in the ashes which can sometimes, but not always, be attributed to the presence of a large amount of it in the soil.

Among the subordinate constituents we often find less iron and alumina than is given for the European beets; on the other hand, manganese is seldom if ever given in their analyses. I do not remember to have seen it given at all. Ruempler, Die Nichtzuckerstoffe der Rueben, p. 31, says "Caesium and Manganese have been detected by Von Lippmann in unrecoverable (nicht gewinnbaren) traces, the former by means of the spectroscope in beets, beet leaves and beet products." We find manganese always present in the ashes of our beets and beet leaves, varying from a few hundredths to 0.3 percent in sugar beets and to 0.5 in the long red mangold.

We will recapitulate these differences, our beets (the ones that we have been studying) are larger in size, lower in sugar, lower in dry substance, higher in ash constituents, lower in nitrogen, lower in proteid nitrogen, higher in injurious ash and higher in injurious nitrogen than the European beets cited. The beets are poor in phosphoric acid and rich in potash. The soda and chlorin content is very erratic. The calcic oxid is low, about one-half as much as in European beets, while the magnesic oxid is a little higher than in these. It does not appear that the magnesic oxid is abnormally high but that the lime is abnormally low. The soils in which the beets discussed were grown are without exception rich in calcic oxid from 4.0 to 6.0 percent, also in magnesia about 1.5 percent, with carbonic acid usually about 5.0 percent. These differences must indicate great differences in the nutrition and transformation of substances in the beet.

We have a little light on some of these differences but not on all of them. We can account in some cases for the low sugar, low dry substance, higher ash, low proteid, higher injurious nitrogen and lower phosphoric acid content. We cannot explain the higher potash and lower lime nor have we at the present time any knowledge of their significance.

A study of the effects of nitrates upon the composition of the beet shows that they increase the size of the beet and the top; reduce the percentage of sugar and dry matter; increase the ash; suppress the phosphoric acid; increase the total nitrogen; decrease the ratio of proteid nitrogen to total nitrogen and increase the nitric nitrogen even in beets grown in soil already rich in this form of nitrogen even if applied at a time when the beets are supposed to use only a small amount of nitrogen. Nitrate applied 4 Aug. to 28 Sept. 1911 in all equal to 750 pounds per acre increased the size of beets by 9.9 and 14.6 percent; reduced sugar 1.0 and 1.1 percent; dry substance 0.9 from 22.0 to 21.1; increased total nitrogen from 0.14223 to 0.16698; reduced ratio of proteid nitrogen from 60 to 50 percent, increased injurious nitrogen from 0.3229 to 0.49041 per 100 sugar; increased nitric nitrogen from 0.0083 and 0.0074 to 0.0187 and 0.0142 and suppressed the phosphoric acid in the pure ash from 10.1 to 7.8 and from 10.9 to 9.4 percent. These results were obtained with beets on excellent land free from seepage and alkali and the plants were free from the leaf-spot. This was during the season that produced the best beets that we have had for years. A like amount of nitrate in 1910 applied in three portions, beginning 28 March and making the applications four weeks apart, decreased the sugar from 16.85 to 13.4, dry substance from 22.4 to 20.6, increased the pure ash in the beet from 0.52 to 0.82; increased total nitrogen in the beet from 0.1449 to 0.2961; reduced the ratio of proteid nitrogen to total from 40 to 30 percent; increased the nitric nitrogen from 0.00144 to 0.04143 and reduced the phosphoric acid in the pure ash from 7.218 to 4.363 percent.

The averages for seven years given by the Lauchstaedt Experiment Station show that beets grown with complete mineral fertilizers contained 0.06923, those grown without the application of any fertilizer contained 0.05479, while those grown with addition of nitrate alone contained 0.04431 percent of phosphoric acid.

The effects upon the leaves which were studied in 1911 may be more freely discussed at another time, but it may be stated that the nitric nitrogen disappeared from the blades of the beets to which no nitrate had been applied about 14 Sept., while it continued in the blades of the nitrated beets up to the time that they were frozen. The nitrates seem to migrate into the petioles as these are richer in nitric nitrogen at all times than either the beets or the blades. Nitric nitrogen continued in the petioles of the leaves of beets which had not been dressed with nitrates up to the latest date that the samples were taken, 12 Oct. The amount was approximately one-fourth as much as was present in the petioles from beets which had received nitrate. The nitric nitrogen in the petioles from beets which had not been dressed with nitrate was from four to five times greater than the amount found in the beets and was larger than the amount found in the roots of those plants which had been treated with nitrate.

That the foliage of the beet plant is the efficient agent in the transformation and elimination of the nitric nitrogen taken up by the beet appears evident from the results obtained by defoliating the beet. The beets were defoliated 6 Sept. The nitric nitrogen in the roots on 1 Sept. was 0.01925 and 0.01796 percent. The beets were harvested on 8 Nov. and though the average weight of the beets had increased by 160 and 130 grams for the respective varieties the nitric nitrogen in the beets as harvested equalled 0.01367 and 0.01584 percent. The increase in the size of the beets was approximately 22 percent, the decrease in the percentage of nitric nitrogen was only 11 percent, the gain in nitric nitrogen in the roots was approximately 30 percent. Beets which had not been defoliated, the checks corresponding to these samples contained 0.00827 and 0.00746 percent nitric nitrogen. The complete destruction of the leaves stopped the transformation of the nitrates and probably other substances until the production of a new foliage, which of course began immediately, but could not be restored for those beets in the eight weeks of the season, which events proved were remaining. It would be interesting to know what the results of various degrees of partial defoliation would be, this would more perfectly imitate the action of the leaf-spot. We reserve this for the future.

The results of our fertilizer experiments were so divergent that we can use them to prove almost anything, except that they did some material good. Measured by the percentage of sugar, the injurious ash and injurious nitrogen per 100 sugar in comparison with those of the check plot, they did no good, but rather some harm.

We have seen the effects produced by excessive quantities of nitrates under conditions which leave no room for doubt in regard to them. We presented the composition of beets grown on good ground in the Arkansas Valley and also such as were produced on bad ground. We find that a sample of beets harvested 3 Nov. 1910, grown on a sandy loam, well located and free from all apparent objections, thoroughly cultivated and abundantly supplied with water, contained sugar 12.7, dry substance 20.0, pure ash in beet 0.7176, phosphoric acid in beet 0.03342, total nitrogen 0.25215, nitric nitrogen 0.04537 percent, injurious ash 3.703 and injurious nitrogen 1.07246 parts per 100 of sugar. The bad land referred to contained no free water within five feet of the surface but it was very rich in nitrates. The sample here given was grown in a bad, but not the worst section of this bad land, sugar 10.2, dry substance 18.0, pure ash in beet 1.06, phosphoric acid in beet 0.02732, total nitrogen 0.30675, nitric nitrogen 0.0726 percent, injurious ash 9.0421 and injurious nitrogen 1.7829 parts per 100 sugar. The phosphoric acid in the pure ash of this sample was only 4.659 percent and the beets were dressed with superphosphate at the rate of 1,000 pounds per acre.

In addition to these details of composition we have previously seen that beets grown with excessive nitrates produced thick juices of very low coefficient of purity, even when grown on the very best land at our disposal, and under conditions which were in every respect favorable. The depression of the coefficient of purity corresponded to an increased production of molasses over that of reasonably good beets of three percent or more. In addition to these facts we have our Colorado molasses carrying nitric nitrogen equivalent to a maximum of 28.88 percent of its total. The deterioration in the beets is characterized by the falling off of approximately three percent in the average sugar content, by yielding juices difficult to work and the production of too much molasses. This molasses is rich in nitric nitrogen as we have seen. We find the properties of the beets, whether studied in separate samples from the field or on the larger scale of factory practice agreeing in every respect with our nitrate beets. The only possible question which can obtain is in regard to the presence and source of the nitrates. We have answered this question in Bulletins 155, 160 and 178 and further in this one, using Mr. Zitkowski's figures which show the presence, and as I believe the formation of very much larger quantities of nitrates than I have ventured to apply.

SUMMARY.

The object of this bulletin is to determine whether the quality of the sugar beets grown in some sections of Colorado is such as is produced by an undue or untimely supply of nitrates and to determine whether the depreciation in the quality of beets, which fact is not questioned, may be due to a widespread and excessive supply of nitrates in the soil.

Up to 1904 the quality of the beets grown in the Arkansas Valley was excellent but since that time there has been a general depression in the quality of the beets. The percentage of sugar has fallen from an average of 17.5 percent prior to 1904 or 1905 to an average of about 14.5 percent from 1905 to 1911 inclusive. This falling off in the percentage of sugar has been persistent throughout this period and not for one year or two years only. The amount of molasses which has had to be worked by the Steffens process has been abnormally high, 7.5 percent, and sometimes even more, calculated on the beets cut.

There has been no season but that there were some sections which produced good beets so far as the percentage of sugar and crop were concerned, nevertheless the average quality of the beets has been much below what it formerly was. The causes generally thought to be operative in bringing this about may be included under the following designations: Alkali, seepage, possible lack of some plant food, or an improper ratio of the elements of plant food to one another, leaf-spot *Cercospora beticola*, and climatic conditions.

The first two are usually associated in the public mind, though some of our land is rich in alkalis but is not excessively wet.

Our observations upon the effects of alkali and water on the sugar content of the beet do not support this view. Sugar beets grown four years in succession on strongly alkalized land were as rich in sugar as beets grown on wholly unobjectionable land. The conclusions drawn from the four years' observations were that the alkali *per se* was not detrimental to the quality of the beets; that it did not affect the amount of dry matter in the beets; that it slightly increased the quantity of the ash, but that it did not affect the composition of the ash so positively that we could assign any definite effect to this cause. The water plane in portions of the land experimented with did not at any time, in the four years, fall to a greater depth than four feet and was less than three feet below the surface for a good portion of the growing season, without serious effects upon the yield or quality of the beets. These observations have been repeated many times since this series of experiments was made. Again, the conditions popularly described as seepage and alkali are not prevalent enough to justify their serious consideration as the cause of the deterioration of the general crop.

The view that the quality of the beets has fallen off because the plant food in the soil has either been exhausted or the relative quantities have been so modified that this change may be the cause, is held by some. Experiments were made in an endeavor to answer these questions, i. e., to see if we could obtain an increased yield and at the same time effect an improvement in the sugar content of the beet. These were in the beginning the objects had in view. The only probable deficiency in our soils, judging from analytical data, is in the supply of nitrogen, but experiments with different fertilizers in various combinations were made to demonstrate their value in the solution of our problems. The results obtained were disappointing, and in no case have we obtained results which justified the view that the depreciation in the sugar content of the beets was due to the lack of plant foods, or to their ratio within the limits of the quantities used in the experiments. The soil on which the experiments of 1909 and 1910 were made was sampled to a depth of three feet. The samples were taken from the check plots and showed a great abundance of both phosphoric acid and potash. The samples represent sections of one foot each. The phosphoric acid soluble in strong hydrochloric acid in the surface foot of the respective plots was 7,520 and 8,040 pounds; the potash soluble in the same medium was 35,480 and 32,520 pounds and the total nitrogen was found to be 4,320 and 3,684 pounds. The application of nitrogen either in the form of stockyard manure or in that of sodic nitrate alone or in conjunction with phosphoric acid and potash did not produce the favorable results expected. This statement applies to the yield of sugar rather than to the other qualities of the crop which form a separate question. The sugar in this whole series of beets was low, the yield very moderate, scarcely an average one, the ash in the beets was high, the pure ash in the fresh beet exceeded in some cases one percent. The results indicate that the poor quality of these beets was not due to any lack of plant food, not even of nitrogen. The moderate yield and low sugar content could not be attributed to indifferent cultivation, lack of care or intelligent management, or to injury by insect or fungi. There was some leaf-spot but it was not serious.

An effort was made to establish the effects of leaf-spot on the yield and percentage of sugar in the beet by obtaining the yield and percentage of sugar in 127 cases, on fields aggregating about 2,500 acres from 16 sections or districts of the Arkansas Valley. Some of these fields were badly affected while others were not. The yield and percentage of sugar varied greatly, but there was very decidedly greater differences in both the yield and percentage of sugar in the different districts than between the individual fields in the same district which had been attacked by the leaf-spot with varying degrees of severity. The average percentage of sugar shown by the field samples from some of the fields which had been severely affected by leaf-spot showed from 16 to 17 percent of sugar. These percentages of sugar could not in these cases be attributed to drying out of the beets in the ground. The record of 127 fields does not show with any decisiveness what the effect of the leaf-spot is. The beets grown on the College Experiment Farm showed the same characteristics in their composition as those from the Arkansas Valley and they had not suffered from the leaf-spot, so it is not at all satisfactorily shown what the effects of the leaf-spot really are. The results obtained do not show any constant or definite relation between the severity of the attack and the yield and percentage of sugar. The development of the beet at the time of the attack is probably an important factor and this cannot be given.

The thesis presented in this bulletin is that the causes mentioned as the ones to which the deterioration of the beet is due have not been shown to produce the effects assigned to them; on the contrary, it is conclusively shown that neither alkali nor seepage, except possibly in land wholly unfit for cropping, do not of themselves produce beets either low in tonnage or percentage of sugar. Further, analytical results obtained with samples of the soil as well as the results obtained by experiments with fertilizers fail to show any lack of plant food, unless the analytical results be interpreted as indicating a lack of nitrogen, which interpretation is contradicted by the results of experiments with nitrogenous fertilizers. Further, that while the leaf-spot is very serious, we have been unable to detect any such relation between the severity of the attack of this disease and either low tonnage or low quality of the beet as to justify us in attributing the general deterioration which has taken place during the past eight or ten years to this cause. Further, that while climatic conditions, late frosts in the spring, early ones in the fall, long continued hot weather, high winds, failure of water or severe and general hail storms are all factors in determining the tonnage and quality of a crop, the facts obtaining during the past ten years do not justify a serious consideration of "climatic conditions" as the cause of the deterioration, for it has continued very generally throughout a large district for a number of years in which the "climatic conditions" have been both good and bad. Further, that when insect injuries are the cause of a deteriorated crop the fact is patent and the same is true with fungi and bacteria. Neither one nor all of these causes have been shown to have brought about the deterioration of which we write. Our thesis is that the cause hereof is a soil condition which permits too generous a supply of nitric nitrogen throughout the season which in the first place prolongs the period of vegetation and delays maturation to such an extent that the beets are harvested in an immature condition and of poor quality. The tops are unduly large, the beets white and watery, of poor keeping qualities and yield juices which require heavy liming, boil badly and produce a great deal of molasses.

It has been shown by experiments that nitrates applied to beets at the rate of 528 pounds per acre affects the quality of the beet prejudiciously. A few investigators claim that the application of nitrates in three portions and in smaller quantities improve the quality. Our question is, what is the effect of larger quantities, and not whether some may be of benefit? Another consideration is in regard to the time when the nitrates become available to the crop. That nitrates applied at the time of seeding or during the early development of the plant may be beneficial, is abundantly established, while the same amount applied later might be injurious. It is shown in Bulletin 155 that many of our cultivated soils, such as had been planted to beets contained in samples taken, 1-15 Oct. nitric nitrogen corresponding to larger amounts of sodic nitrate than 528 pounds in the surface six inches of soil. The maximum found in October corresponded to 1,902 pounds of sodic nitrate in the surface six inches. In another set of samples taken in January we found the maximum of 1,680 pounds in the top six inches. We further found in October that the fallow spots in a beet field contained very large amounts, from 10 to 30 times as much as the land in the rows or between the rows, the maximum found was 1,407 pounds in the top two inches. These are quantities which would have been very prejudicial had they been available to the beets during the months of June, July and August. It is not asserted that the beets growing in other portions of these same rows had at their disposal during the growing season so large an amount of nitrates, but that it was possible for them to have had. The beets in this field had very large tops, the roots were small, the sugar content was low and the beets did not ripen during the season. The tops were killed by being frozen on 7 Nov., on which date they were entirely green and showed no signs of ripening.

Occasional mention is made of the deleterious effects of nitrates upon beets, but the statement seems to have been based upon general opinions or factory practice. Up to the time this study was begun, at most, only a few analyses had been made to determine what effects the nitrates actually have upon the composition of the sugar beet. At the present time I know of only two such, made by Andrlik. Our first step was to establish a series of experiments to demonstrate this point and to ascertain whether beets grown with known excessive quantities of nitrates possess the qualities and composition of our general crop. We applied in 1910 from 250 to 1,250 pounds of Chile-saltpetre in portions of 250 pounds each. This required six plots, five of which received nitrates while the sixth did not. Another series of experiments was made with superphosphate, potassic chlorid and salt, sodic chlorid, on a piece of bad ground which had been planted to beets to see what effect these fertilizers would have upon the crop, the ripening and composition of the beets.

As standards of comparison for quality and composition, we have chosen samples from three localities, Montana, Michigan and Colorado. The Montana sample did not come to hand till this work was nearly completed but it possesses the highest quality of any sample examined.

The beets analyzed represent several classes: First, beets grown on ordinary, good soil without fertilizers; second, beets grown on good soil with various fertilizers; third, beets grown on good soil with various quantities of nitrates alone; fourth, beets grown on soil in which large quantities of nitrates had already developed; fifth, beets grown on nitrate land with the application of phosphoric acid, potash and soda; sixth, beets grown with green manure; seventh, beets grown on College Experiment Farm at Fort Collins, 1910; eighth, beets grown with application of nitrates on College Experiment Farm, Fort Collins, in 1911; ninth, beets grown on College Experiment Farm in 1911 without application of nitrates; tenth, beets grown on the College Experiment Farm from which the tops were removed 6 Sept. 1911.

The criteria adopted to judge of the quality of our beets, though not formally enumerated, are the following: the nitric nitrogen, the phosphoric acid, the injurious ash, the injurious nitrogen, the ratio of the proteid nitrogen to the total, especially in the juice, and the percentage of sugar. Andrlik used the percentage of sugar, the injurious ash and the injurious nitrogen per 100 of sugar. I have added the nitirc nitrogen, the phosphoric acid and the ratio of the proteid nitrogen to the total nitrogen because they appear to be important factors in this study.

In regard to standards, we observe in the six samples of cossettes quoted from Andrlik that the total nitrogen is quite high, and that the ratio of the proteid to the total nitrogen is practically 59 percent. This ratio, even in his poorest sample, does not fall below

39 percent. The phosphoric acid in the fresh beets is, in his best, 0.084, and in his poorest, 0.042 percent. The injurious ash per 100 of sugar is from 1.95 to 2.75 parts; the injurious nitrogen from 0.407 to 0.975, while the sugar is from 14.5 to 17.3 percent. The nitric nitrogen in these cossettes was not determined. In the Montana beet which we had used as a standard we have for the ratio of the proteid to the total nitrogen in the press juice, 53 percent, for the phosphoric acid in the beet 0.081, for the total nitrogen 0.105, for the injurious ash per 100 of sugar 1.67, for the injurious nitrogen per 100 of sugar 0.167 part, and for the sugar 18.24 percent. There was no nitric nitrogen in these beets.

In our Fort Collins beets we have: ratio of proteid nitrogen to the total in the press juice 39.0 percent, phosphoric acid 0.076, injurious ash per 100 sugar 2.2, injurious nitrogen per 100 sugar 0.629, nitric nitrogen 0.0009, and sugar 18.3 percent. In the Michigan beet we have the ratio of proteid to total nitrogen in press juice about 30 percent, phosphoric acid 0.062 percent, injurious ash per 100 sugar 1.945, injurious nitrogen per 100 sugar 0.513, nitric nitrogen 0.0032, and sugar 15.3 percent. Of these standards the Michigan sample contains the largest amount of nitric nitrogen, has the lowest percentage of phosphoric acid, the lowest ratio for the proteid to the total nitrogen in the press juice and the lowest percentage of sugar.

The first class of beets, those grown on good soil without fertilizers, contain some samples of excellent quality—the Colorado sample chosen as a standard was such an one. We find beets grown on new land, prairie sod, grown in the Arkansas Valley meeting the standard of the Michigan beets at least, ratio of proteid to total nitrogen 52.0 percent (proteid nitrogen determined by Stutzer method, which gives higher results than the press juice treated according to Ruempler), the phosphoric acid 0.05786, injurious ash per 100 sugar 3.529, injurious nitrogen per 100 sugar 0.374, nitric nitrogen 0.00358 and sugar 14.2 percent. We find the quality of beets grown on good ground usually much poorer than the samples just given. For instance, beets grown on a good soil in 1910 gave, ratio of proteid to total nitrogen (Stutzer) 42.0 percent, phosphoric acid 0.041, injurious ash per 100 sugar 4.9, injurious nitrogen per 100 sugar 0.5687, nitric nitrogen 0.011, sugar 14.4 percent, and another sample grown on a sandy loam with an ample supply of water and good cultivation gave the following data: ratio of proteid to total nitrogen in press juice 20.0 percent, phosphoric acid in the beet 0.0334, injurious ash per 100 sugar 3.70, injurious nitrogen per 100 sugar 1.07246, nitric nitrogen in beet 0.04537, and sugar 12.70 percent. These last two samples represent a large percentage of the beets grown in some sections. The following tabular presentation of these factors for Andrlik's No. VI, the Montana sample, and for two samples of beets grown on good land, will show the contrast:

COMPARISON OF GERMAN, MONTANA AND COLORADO BEETS.

	Andrlik Nov.VI	Montana	Good Soil Colorado	Good Soil Colorado
Sugar	17.200	18.240	14.400	12.7000
Phosphoric acid	0.084	0.081	0.041	0.0334
Nitric nitrogen	.....	None	0.011	0.0454
Ratio proteid to total nitrogen.	59.000	53.000	42.000*	20.0000
Injurious nitrogen per 100 sug.	0.407	0.167	0.569	1.0725
Injurious ash per 100 sugar....	1.950	1.670	4.900	3.7000

The beets grown on unobjectionable land may be either good or very poor in quality, often as poor as the sample given in the last column but, of course, this is not always the case. The sample given in the third column is probably a fair average of the beets of this class.

Colorado soils produce under favorable conditions most excellent beets, though it seems probable that even under the best conditions our beets contain a rather large amount of ash, specifically of injurious ash. Notwithstanding this fact many of our beets during the past seven or eight years have been very low in quality. The cause for this fact is indicated by the high percentage of nitrogen present in the form of nitrates.

The second class of beets, i. e., such as were grown with fertilizers to determine their effects, was also a disappointment. The effects of fertilizers, stockyard manure, phosphoric acid, potash and nitrogen, upon the yield and sugar content of the beets proved to be disappointing in that no single fertilizer or combination of fertilizers improved either the yield or percentage of sugar so positively as to force our consent to it as a fact. The results in regard to their effects upon the quality of the beets are uniformly unfavorable, sometimes a favorable feature may be recognized, but this is more than counterbalanced by others which are unfavorable. There were eleven samples of these beets fully analyzed except that the press juice was not investigated. There were two check samples and nine samples grown with various fertilizers. The best results were obtained with the samples from one of the check plots and from the two plots which had separately received 300 pounds of potassic sulfate and 400 pounds of superphosphate per acre. The total nitrogen in the beets from these plots was low, 0.10875, 0.1232 and 0.12895 percent, the nitric nitrogen was low in the sample from the plot that received the potassic sulfate, but not especially low in the others, 0.01034 and 0.00967 percent. The pure ash in the beets from these plots was uniformly high; about 1.00 percent, the phosphoric acid in the pure ash was uniformly low, but owing to the

*Proteids determined by Stutzer's method.

high percentage of pure ash in the beet this constituent appeared about normal when calculated on the fresh beet. The beets grown with fertilizers were lower in sugar than those grown without them in eight out of nine cases. The injurious ash was higher in eight out of nine cases and the injurious nitrogen was higher in seven out of the nine. The increase in these two factors was in some cases very great, from 4.27 to 7.68 for the injurious ash per 100 sugar and from 0.37 to 0.95 for the injurious nitrogen. The nitric nitrogen fell to 0.0025 in the sample grown with the application of potash alone, but otherwise they all contained about 0.01 percent of this form of nitrogen, apparently unaffected by the amount of sodic nitrate added. The low percentage of sugar, the high percentage of pure ash with its low percentage of phosphoric acid, the high injurious ash and injurious nitrogen, with ruling high percentage of nitric nitrogen are again suggestive of too liberal or an untimely supply of nitrates. These results do not indicate a lack of any of these elements of plant food and do not justify us in looking to these as means for the amelioration of these conditions.

The third class of beets was studied to obtain a decisive answer to the question, "What are the effects of nitrates upon the composition of the sugar beet?" It is generally agreed that nitrates added in too large quantities or too late in the season lengthen the period of growth and it has been shown within the last few years that it increases the injurious nitrogen. Many of our beets are green when harvested and of course the juices often work badly. I have known of the occurrence of unusual quantities of nitrates in some of our soils for six or more years. I had already associated these facts in a causal relation several years before the investigations of recent years had become available to me. I knew of no investigation which had satisfactorily answered the query stated above, so its answer was imperative in the prosecution of this work. In 1903 Andrlik published two analyses showing that 525 pounds of sodic nitrate per acre applied in three portions depressed the percentage of sugar and increased both the injurious ash and injurious nitrogen. The amount applied, 525 pounds of Chile-saltpetre per acre, is a very moderate quantity compared with the equivalent of the nitric nitrogen that we find in many of our soils.

In order to study this subject a piece of choice land was selected and various quantities of nitrates applied from 250 to 1,250 pounds per acre, the larger quantities were applied in portions of 250 pounds each. The first application of 250 pounds was made two days before the seed was planted, the succeeding ones at intervals of four weeks up to 27 July, the date of the last application. The following tabular statements in which we include the Montana beet for comparison exhibits the results:

RESULTS OF EXPERIMENTS WITH NITRATES.

	Montana	Colo.	Colo.	Colo.	Colo.	Colo.
Sodic nitrate, pounds per acre....	200	250	500	750	1,000	1,250
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Sugar	18.240	16.500	15.800	13.400	11.000	12.800
Pure ash	0.491	0.519	0.726	0.822	0.744	0.680
Phosphoric acid	0.081	0.038	0.061	0.036	0.034	0.024
Nitric nitrogen	None	0.001	0.010	0.042	0.063	0.042
Total nitrogen	0.105	0.145	0.205	0.296	0.255	0.254
Ratio proteid to total nitrogen....	53.000	31.000	23.000	17.000	16.500	20.500
Injurious ash per 100 sugar.......	1.670	2.127	3.205	4.781	5.472	4.050
Injurious nitrogen per 100 sugar..	0.167	0.364	0.682	1.293	1.403	1.115

The maximum results were obtained with 1,000 pounds Chile-saltpetre per acre, but the depression of the phosphoric acid is the greatest with the 1,250 pounds. Another sample from this plot showed only 0.02205 percent phosphoric acid in the beets. The following effects of the nitrate applied are very evident, i. e., that while the 200 pounds in the case of the Montana beets and the 250 pounds in our case were decidedly beneficial the larger applications depressed the percentage of sugar. The maximum depression being 55 percent or 33.33 percent of the sugar, it increased the pure ash by 43.0 percent, it increased the nitric nitrogen from ten to sixty-three fold, it depressed the phosphoric acid from 0.038 to 0.024, about 37.0 percent, it increased the total nitrogen by 100 percent, it depressed the ratio of the proteid to the total nitrogen from 31 to 16.5, almost 50 percent, it increased the injurious ash to two and one-half times as much as the beets grown with 250 pounds of nitrate per acre contained. If the comparison be made wih the Montana beets as the standard even the beets grown with 250 pounds nitrate per acre appear inferior in the following points: the phosphoric acid is low, nitric nitrogen is present, and the ratio of the proteid nitrogen to the total is low. An examination of the detailed statement of the analyses further shows that the chlorin and the sodic oxid were both increased by the larger quantities of the nitrate. These are the points in detail which characterize our poor beets grown on good soil, i. e., the sugar is low, the pure ash is high, the phosphoric acid is low, the chlorin and soda are often high, nitric nitrogen is always present, often in considerable quantities, and while the total nitrogen may not be excessively high, the ratio of the proteid to the total nitrogen is low, the injurious ash and nitrogen per 100 of sugar are high. These characteristics, too, are the ones that persist through our series of beets grown with the application of fertilizers. It has been shown by others that the effects of sodic nitrate may be lessened but not wholly set aside by the joint application of potash and phosphoric acid. The amino nitrogen was determined throughout the series and as would be expected shows an increase as the nitrogen applied to the growing plant is increased.

These beets, grown with nitrates on the most desirable land that we could select, were tested in an experimental sugar plant and the process carried to the production of thick juices. The real coefficients of purity of these were, for the beets grown with 250 pounds nitrate per acre, 87.91, for those grown with 500 pounds per acre, 88.3, for those grown with 750 pounds 88.6, for those grown with 1,000 pounds 86.37, and for those grown with 1,250 pounds per acre 86.43. We have here a depression of the real coefficient of purity in the thick juice of 1.93 points, which signifies a tremendous increase in the amount of sugar that will go into the first green syrup or what amounts to the same thing a great decrease in the amount of granulated sugar obtained in the first crystallization. These results indicate that this cause, nitrates in the soil, is fully adequate to account for the production of an undue amount of molasses which is another of the undesirable qualities of these beets, because it overtaxes the crystalizer capacity of the factories and necessitates the recovery of a large percentage of the sugar by the Steffens process.

The fourth class of beets studied were such as were grown on very bad soil. We had several objects in view, principally, however, to determine the quality of the beets produced and the effects of phosphoric acid, potash and salt, sodic chlorid, upon beets grown under these conditions. The land chosen was excellent for these purposes, for owing to the fact that it had a decided slope it enabled us to make our observations on more and less objectionable land, which involved no questions of composition, etc., at the same time The depth to the water-plane was determined by borings made at the end of September and was found to be five feet in the lowest portion of the cultivated area. This depth was only one foot above the bottom of the drainage ditch. This soil was sampled to a depth of four inches in two sections each two inches deep. The potash, soluble in hydrochloric acid, the phosphoric acid, total nitrogen and nitirc nitogen were determined in these samples. The averages of the six determinations of potash, phosphoric acid and total nitrogen were for the potash 1.15 (0.874 to 1.275), for phosphoric acid 0.1461 (from 0.0765 to 0.1913), and for total nitrogen 0.1081 (from 0.0850 to 0.1480). The supply of potash and phosphoric acid is abundant but that of total nitrogen is rather moderate. The ratio of the nitric nitrogen found to the total nitrogen was 19.00 percent in the top two inches of the worst, and 3.5 percent in the second two inches of the best portion of the field. In parts per million of the soil the nitric nitrogen ranged from 30 parts in the second two inches of the third and second sections to 280 parts in the top two inches of the first or worst section of the land. These samples were composite, each containing eight subordinate samples. The growth of the beet tops on this field was very luxuriant, they stood at a hight of 36 inches on 8 Aug., and were erect because they were so abundant that they could not spread out. The color was a bluish green. The yield according to the factory returns was 14.14 tons per acre. We took three sets of samples, 39 individual samples in all. The analytical results are quite consonant in the indications relative to the quality of these beets throughout the season. We will again use the Montana beet as standard because we consider it the best beet that we have analyzed and is the only one that we have found entirely free from nitric nitrogen, though a Fort Collins standard beet contained only 0.0009, a very small amount. The following tabular statement presents the principal features in the composition of these beets:

	Montana	Check Best (1st) Section	Check Bad (2d) Section	Check Worst Land	Phosphoric Acid Best (1st) Section	Phosphoric Acid Bad (3d) Section	Potassium Chlorid Bad (3d) Section	Sodium Chlorid Bad (3d) Section
Sugar	18.240	13.200	12.100	8.600	10.900	10.200	12.200	10.400
Pure ash in beet	0.491	0.942	1.122	1.327	0.941	1.064	1.149	1.425
Phosphoric acid	0.081	0.039	0.031	0.034	0.048	0.027	0.016	0.028
Nitric nitrogen	None	0.019	0.053	0.083	0.050	0.073	0.051	0.087
Total nitrogen	0.105	0.245	0.233	0.345	0.259	0.307	0.345	0.340
Ratio proteid to total nitrogen	53.000	22.460	18.730	14.280	19.080	19.900	19.900	17.210
Inj. ash per 100 sug.	1.670	5.629	7.930	13.433	7.156	9.042	8.245	12.049
Inj. nit. per 100 sug.	0.167	1.029	1.048	2.048	1.413	1.783	1.629	1.788

These results are identical in kind with those produced by the sodic nitrate but much greater in degree, but not at all in proportion to the amount by which the nitric acid in this soil exceeded that applied in our experiments with the nitrate. We find that we reached our maximum effect with 1,000 pounds of nitrate applied in four portions. One thousand pounds nitrate applied per acre would add but 83 p. p. m. of nitric nitrogen provided it were uniformly mixed with the surface six inches of soil which we here consider as weighing 2,000,000 pounds. We have as a matter of fact on 22 June, 70 p. p. m. in the top four inches of the soil in the best part of this field, and 405 p. p. m. on this date in the worst portion of the field taken to the same depth. The best portion of these plots reaches a hight of 18 feet above the worst portion. The beets from the first section of the check, the best section, have a composition very similar to that of those grown with 750 pounds of nitrate applied in three portions which corresponds to 62.5 p. p. m. nitric nitrogen, calculated on the top six inches of soil. We place these results side by side that the similarity may be easily seen. The figures are all calculated on the fresh beet or on 100 of sugar.

	Montana Beets	Beets Grown with 750 Pounds Nitrate	Beets Grown on Best Portion of Bad Land
Sugar	18.240	13.400	13.200
Pure ash	0.491	0.822	0.942
Phosphoric acid	0.081	0.036	0.039
Nitric nitrogen	None	0.041	0.019
Total nitrogen	0.105	0.296	0.245
Ratio proteid to total nitrogen	53.000	16.920	22.460
Injurious ash per 100 sugar	1.670	4.781	5.629
Injurious nitrogen per 100 sug.	0.167	1.292	1.029

This statement shows how similar these two samples are and how widely they differ from the very excellent sample from Montana. It has already been conclusively shown that the poor quality of the second sample given in this table was caused by the 750 pounds of sodic nitrate applied to the beets in three portions, the last application being made by the first of June. The results obtained with those beets to which phosphoric acid in the form of superphosphate was applied are worthy of careful consideration, for the effects produced are the reverse of what was anticipated and the beets are very low in quality. These results are not quite consonant with those observed in the case in which we used superphosphate alone in our series of fertilizer experiments but are more nearly in harmony with the results obtained from its use in conjunction with the nitrates.

The beets grown with the application of various quantities of Chile-saltpetre in 1910 and one sample grown on very bad land, i. e., land very rich in nitrates, were treated in an experimental factory for the production of thick juices. This was done to determine whether the practical, technical results were the same as those obtained on the large scale by various factories in the Valley. We have stated the results obtained showing a depression of the real coefficient of purity by 1.93 points. The real coefficient of purity of the thick juice produced from the beets grown on very bad land was 69.56, only a few points higher than the real coefficient of purity of molasses. The nitric nitrogen in these thick juices ranged from a minimum of 0.05 to a maximum of 0.49 percent. These juices were not boiled, in other words we did not actually determine the amount of molasses produced or its composition. We did, however, examine in all 21 samples of molasses from various sources, 4 from Bohemia, 1 from California, 1 from Michigan and 15 from Colorado. The Colorado molasses are lower in total nitrogen than the Bohemian and Michigan samples but very much higher in nitric nitrogen. The largest amount of nitric nitrogen found in the Bohemian molasses was 0.0082 percent, while the largest amount found in Colorado molasses was 0.400 percent. The nitric nitrogen in Colorado molasses was lower in 1911 than in 1910 and it was a matter of general comment that the juices worked much better in

1911 than for years past. The Steffens waste-water is rich in nitrates, a concentrated sample of this showed the presence of 0.61 percent nitric nitrogen or practically 3.6 percent sodic nitrate.

The amount of nitric nitrogen in the soil of two beet fields was determined on seven different dates during the season of 1911, each field was divided into seven sections for the purpose of sampling and the samples were taken to a depth of one foot. In one field the minimum quantity was reached in August, in the other the maximum was reached on the same date. The minimum found in any sample from the first field was 2.5 parts nitric nitrogen per million of soil, 25 August, and the maximum 130 p. p. m., 27 June, the minimum found in any sample from the second field was 3.1 p. p. m., 9 August, and the maximum 333.0 p. p. m., 25 August. The sugar in the beets from the first field on 18 September was 16.2 percent, while it was only 12.6 percent in those from the second field.

The results obtained with green-manuring appear to be encouraging, but there are a number of facts which we have observed which indicate that the few results obtained with green-manure may not have been due to it but to other conditions. We have, therefore, laid but little stress upon the results though the beets grown by this method were of very good quality, sugar 17.3, pure ash 0.6987, phosphoric acid 0.0743, nitric nitrogen 0.0014, total nitrogen 0.1527, ratio proteid to total nitrogen 38.48, injurious nitrogen per 100 sugar 0.3471, and injurious ash per 100 sugar, 2.8743. This represents a very good beet compared with the average Colorado beets heretofore presented. This subject is worthy of further study, the work done is not sufficient to justify any conclusions.

It has been shown by Prof. Remy that beets appropriate about three-fourths of all the nitrogen that they use in the months of June and July. In our experiments with sodic nitrate in 1910, the maximum effect was produced by the application of 1,000 pounds, in four portions, the last one having been applied 22 June or about the middle of the period of most active appropriation of nitrogen. Our observations on the amount of nitric nitrogen in our soils indicate the presence of large quantities much later in the season. In order to study the effects of nitrates applied subsequent to this period of most rapid appropriation, we made an experiment in duplicate in 1911, beginning 4 August. In 1910 our last application was made 27 July and it apparently produced but little effect in addition to that produced by the application up to and including 22 June. The points had in view in the 1911 experiments were whether an abundant supply of nitrates during August and September would produce any effect upon the composition of the beet. We applied during August and September sodic nitrate corresponding to 750 pounds per acre. We made four applications, the first one at the rate of 250 and the subsequent ones at the rate of 125 pounds per acre. The land used for these experiments was already abundantly supplied with nitric nitrogen and the growth of the beets was luxuriant. The effects of the nitrates applied became noticeable within a few days and became more marked as the season advanced. The beets on the check plots showed signs of ripening by 10 October, while those on the nitre-plots remained entirely green. The beet tops on the nitre-plots were bigger and had a deep green color up to the time when they were killed by frost, 20 October. The average weight of the beets was slightly increased as well as the ripening delayed.

The composition of the beets and leaves was determined at the time of the first application of nitrate was made and every 14 days thereafter till the beets were harvested 8 November. The last sample of leaves was taken 12 October because they were frozen on 20 October. The effect of the nitrate upon the composition of the leaves was noticeable 18 August or 12 days after its application and also upon the composition of the beets, the total nitrogen both in the beets and in the press juice being higher than in those from the check plots, the first sample of which complete analyses of both leaves and beets were made was taken 12 October. The leaves of the beets to which nitrate had been applied were still green, while those on the check plots had just begun to show ripening. The leaves were separated into blades and stems for the purpose of the nitrogen determinations but the ash was prepared from the whole leaf. The differences in the composition of the leaves on this date are smaller than one would expect, especially as the check plots were very evidently maturing while the others were not. The total nitrogen in the blades was not very different in the two samples and was very nearly the same as it had been in the earlier samples. The total nitrogen in the stems, petioles, on the other hand, was higher than it had been in earlier samples, and was higher in those of the beets that had received nitre than in those from the check plots. The greatest differences were shown in the nitric nitrogen present. The first samples of leaves which were divided into blades and stems were taken 1 September. The blades in these samples showed the presence of nitric nitrogen, those from the beets which had been dressed with nitre approximately 50 percent more than those from the check plots. The blades from the variety E R contained, on this date, 1 Sept., 0.01060 and 0.00730 percent nitric nitrogen respectively. The next samples of leaves that were divided into blades and stems were taken 28 Sept. The blades of the same variety E R contained on this date 0.01289 and 0.0000 percent of nitric nitrogen, in other words, the nitric nitrogen had entirely disappeared from the blades of the leaves from the check plots, while the amount in the blades of the others had increased. Each leaf, blade and stem was carefully wiped with a damp cloth before final sampling, so that the danger of external, mechanical contamination was guarded against. The next and last samples of leaves for the season was taken 12 Oct., when we obtained the following results: E R 0.01208, E R check 0.0000 percent. The stems or petoiles for the same variety E R and dates were as follows: 1 Sept. 0.06412 and 0.03734, 28 Sept. 0.08452 and 0.04744 and on 12 Oct. 0.04313 and 0.01956 percent. While the nitric nitrogen had been completely eliminated from the blades by 28 Sept. it remained very abundant in the stems till 12 Oct., and was almost twice as abundant in those of beets which had been treated with nitre as in those of beets from the check plots. The nitric nitrogen present in the beets on these dates was, 1 Sept. 0.02320 and 0.01925., 28 Sept. 0.02600 and 0.00969, and on 12 Oct. 0.01685 and 0.00503 percent, which for the beets that had been treated with nitre and for the three dates is about one-third of the amount found in the stems.

The final samples of beets in these experiments were taken 8 Nov., the leaves of course had been ruined for our purposes by the freeze of 20 Oct. The results of the experiment may be stated as follows: Chile-saltpetre applied at the rate of 750 pounds per acre in four applications between 4 Aug. and 28 Sept., both dates included, increased the average weight of the beets, and also that of the tops; it decreased the percentage of sugar by one percent, it decreased the dry substance in the beet by about one percent, it increased the pure ash in the beet slightly, it decreased the phosphoric acid in the pure ash by about two percent and apparently had the opposite effect upon the phosphoric acid in the ash of the leaves; it increased the nitric nitrogen in the beet about twice, it increased the injurious nitrogen per 100 sugar and the injurious ash to a slight extent, and also depressed the ratio of the albumin to the total nitrogen. These are again the specific points in which our Colorado beets show their inferiority in comparison with the best beets. These experiments not only establish more firmly the effects of the nitrates upon the composition and quality of the beets but show that a development of them quite late in the season may be decidedly injurious. The effect upon the phosphoric acid contained in the pure ash or in the beet is also fully corroborated. The season of 1911 produced the best beets that we have had for several years and they worked exceptionally well in the factories; the piece of land on which these beets were grown was as good as any that we have and the nitre was applied late in the season, so that the effects of the amount of nitre added are probably as small as we would ever be likely to obtain. This view does not rest solely upon the general report of persons in charge of factories whose judgment alone ought to be acceptable, but is also indicated by the properties of the beets grown on these plots without the addition of nitre as compared with those produced by the same land in 1910, when the crop was 7 tons per acre against a minimum of 20.8 tons in 1911. The maximum sugar content was 13.3 in 1910 against 16.7 percent for 1911.

Our observations on the effects of leaf-spot in 1910 could not be interpreted as showing any definite effect of this disease upon the crop or quality of the beets. Many of the fields that were severely attacked showed large yields and high percentages of sugar, while other fields in the same districts which were much less severely attacked showed a great variety of results. Assuming that the effect of the leaf-spot upon the yield and quality of the beets is due wholly to the destruction of the foliage we tried to imitate this action by defoliating the beets rather late in the season to determine the kind of changes that it would produce in the quality of the beets. There is a fair quantity of data on the general effects of defoliation scattered through the literature of the sugar beet, but nothing upon its effects upon the composition and quality of the beet. We defoliated some beets on 6 Sept., a date at which the beets were already well developed. All the leaves were removed because we have seen fields of beets so badly attacked by the leaf-spot that scarcely any leaves at all were left, and though it was late in the season, our beets were green and growing very rapidly. We had no leaves in this case to examine so our investigations were confined to the roots. The defoliated beets continued to increase in size, attaining weights of 701 and 590 grams for the trimmed beets. The beets that developed normally were larger by 46 and 190 grams. The percentage of sugar in the defoliated beets was quite low, 14.2 and 13.2 percent. Sugar in the variety with 13.2 percent remain stationary from the time of defoliation till harvest, the other variety increased from 11.9 to 14.2 after defoliation. The total nitrogen in the beets was materially lowered, normally developed beets contained 0.14882 and 0.14223, the defoliated ones 0.12408 and 0.11286 percent. Neither the amount of pure ash nor that of the phosphoric acid was affected; the injurious ash per 100 sugar was increased in one case but not in the other; the injurious nitrogen per 100 sugar was reduced in both cases, while the total nitrogen in the juice was also reduced, the albumin nitrogen was reduced to a still greater extent, so that the ratio of albumin to total nitrogen was depressed three percent in one and six percent in the other. The nitric nitrogen in the normally developed beets fell to 0.0082 and 0.00746 percent but in the defoliated beets it remained nearly the same as at the time of defoliation, being at the end of the season, 0.01367 and 0.01584 percent, whereas at the time of defoliation the respective percentages were: 0.01925 and 0.01670. The beets grown on the plots that had received applications of nitrates had on 1 Sept. 0.02320 and

0.02702, and on 8 Nov. 0.01871 and 0.01421 in these cases the beets had, it is true, increased in size by 50 percent or more but the decrease is greater than would be required by the increase in size provided no changes had taken place in the nitric nitrogen in the beets. In the normally developed beets without nitre, the nitric nitrogen fell in this time from 0.01925 to 0.0082 and from 0.01670 to 0.00746. It would seem that by removing the leaves we had practically stopped the transformation of the nitric nitrogen in the beet. The actual loss of nitric nitrogen over the apparent loss due to increase in size is only 11 percent of the nitric nitrogen present at the time of defoliation. It seems evident that the transformation of the nitrates took place in the leaves. The nitric nitrogen in the stems on 1 Sept., the earliest date on which we examined the blades and stems separately was almost exactly five times as much as in the blades, by 28 Sept. it had entirely disappeared from the blades but persisted in the stems till 12 Oct., the latest date on which we examined the leaves when we found in the stems of beets grown without addition of nitre 0.01956 and 0.01797 for the two varieties E R and Z R.

Defoliation produced big changes in the beets but the character of these changes does not appear to be the same as those produced by an excess of nitrates, nor do these beets have the characteristic qualities of the beets grown on bad ground nor of the low quality beets grown on good ground, see Analysis XX, in which we have high percentages of pure ash, nitric nitrogen, total nitrogen, both in the beets and in the press juice, the injurious ash and nitrogen per 100 sugar are high, especially the injurious nitrogen, on the other hand, the phosphoric acid is decidedly low, whereas in the defoliated beets it is quite high, i. e., for Colorado beets. The only point that they really seem to have in common is a low percentage of dry substance. These results greatly strengthen the conclusions at which we arrived in 1910 relative to the problematical influence of the leaf-spot upon the quality of the beets in the Arkansas Valley. There is no question but that the destruction of the leaves even as late as 1 Sept. is prejudicial to the beets in several ways, but the composition of the beets is quite different from that of the poor beets produced in the Valley even on good ground, which, on the other hand, do have the composition and qualities of beets grown with an excessive supply of nitrates. The leaf-spot disease is serious enough and affects the crop prejudicially, if it is equivalent only to defoliation, but it cannot be held accountable for the general deterioration of the beets complained of throughout the Arkansas Valley.

A comparison of our beets with German beets shows them to be of larger size and to contain less sugar, less dry substance, more ash constituents, less total nitrogen, less proteid nitrogen, always some nitric nitrogen, often considerable quantities of it, more injurious ash per 100 of sugar, more injurious nitrogen per 100 of sugar, less phosphoric acid—which apparently correlates with the presence of nitric nitrogen, more potassic oxid and very much less calcic oxid, about one-half as much, though our soils are very rich in calcic oxid carrying from 4.0 to 6.0 percent of it. Manganese is always present in small quantities, from 0.02 to 0.50 percent of the ash.

The deterioration that we have endeavored to study may be summed up as consisting of a decided falling off in the percentage of sugar and the production of unusual quantities of molasses. These properties are often if not always accompanied by poor keeping qualities. The molasses produced are characterized by very large amounts of nitric nitrogen. Our experiments demonstrate that these properties in the beets are produced by nitrates applied to the soil and that the beets so produced are identical in composition with many, if not with the greater portion of the beets delivered to the factories. Further, our investigations have proven that these soils contain varying, often very large amounts of nitric acid or nitrates, much larger than we have shown is necessary to produce exceedingly poor beets. Further, our experiments show that while the beet is probably most susceptible to the prejudicial effects of larger amounts of nitrates in June and July an abundant supply in August and September will affect the beets prejudicially.

Our conclusion is that the increased production of nitric nitrogen in our irrigated soils over large sections is the chief cause for the deterioration of our beets.

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