The Effect of Several Nitrogen Sources On Beet Sugar Yields in Kern County, California[1]

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Experiments conducted by the University of California in Kern County (7)[3], (6) have indicated that potato yields are increased greatly by the use of nitrogen fertilizers but the increase varies with the type of nitrogen supplied to the plant. In general these trials have concluded that ammonium sulfate or dried blood or a combination of these two nitrogen sources is superior to calcium nitrate, sodium nitrate or uramon when applied in equivalent amounts of nitrogen. In one of these trials the yields from plots fertilized with dried blood and ammonium sulfate exceeded those from plots fertilized with sodium nitrate, calcium nitrate, or uramon by 75 to 175 cwts. of potatoes per acre. Split applications of the nitrate materials had no effect on yields as compared to single applications. This with other data[4] indicates that the yield differences are not due to the leaching of nitrates by the frequent irrigations applied to this crop.

Ulrich (8) conducted pot experiments with sugar beets over a period of six years on the effect of chemical forms of nitrogen on beet sugar production. Metz silty clay loam from the King City area of California was used in these trials. The results indicated no important differences in yield or sucrose concentrations among plants fertilized with anhydrous ammonia, calcium cyanamide, ammonium nitrate, urea, ammonium sulfate, sodium nitrate, or calcium nitrate.

Because of the increase in yields of potatoes from ammoniated fertilizers, a preference by the grower has been shown for this type of nitrogen. This rather marked plant response to ammonia fertilizers has not been reported in other potato growing areas. The question arises: is this condition peculiar to this area or only to this particular crop? The following experiment was designed to study the growth response of the sugar beet to various nitrogen fertilizers in this early potato growing area of California.

METHODS AND PROCEDURES

The field selected for this experiment is located about five miles north of Wasco in Kern County. The soil is Hesperia loam, which is rated as one of the better soils of the area.

It was arbitrarily decided, after considering the field's past history and the general practice in the area, to apply the nitrogenous materials at the

[1] This experiment was conducted by the Spreckels Sugar Co. and the Agricultural Extension Service of Kern County. Assistance was received from Dr. Albert Ulrich of the Division of Plant Nutrition, University of California, Berkeley, Calif., in analyzing the leaf samples. Appreciation is extended to Mr. W. L. Bergen for furnishing the land for this experiment and for his excellent cooperation in its conduct.

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[3] Figures in parentheses refer to literature cited.

[4] Unpublished data of L. D. Doneen, Division of Irrigation, Univ. of Calif., Davis, Calif.

rate of 100 pounds of nitrogen per acre. Five different nitrogen carriers were selected: ammonium sulfate, ammonium nitrate, uramon, calcium nitrate and sodium nitrate. Phosphate or potassium were not applied as experience in this area had not indicated responses to these nutrients. Subsequent leaf analyses indicated that these elements were not deficient.

The field was planted on February 28, 1948, on single row beds spaced 30 inches apart and was irrigated for germination immediately thereafter. On April 13, when the plants had reached the eight- to ten-leaf stage, they were thinned to approximately one hundred sixty plants per 100 feet of row. A uniform section of the field was selected and the fertilizers applied on April 15 and 16.

The experimental design consisted of a 6x6 Latin square; and five nitrogen carriers plus a machine check (plots not fertilized but subjected to the side dressing action of the applicator) constituted the six treatments. Each plot was eight rows wide and 60 feet long. The fertilizers were applied one row at a time with a Fairbank (2) applicator and banded on each side of the row approximately 5 inches from the plants and 5 inches deep.

Starting May 4, leaf samples were collected at monthly intervals. The petioles of these samples were analyzed for nitrate-nitrogen, phosphate-phosphorus and potassium by the division of plant nutrition of the University of California according to methods developed at that laboratory (10). The leaves selected for analysis were "recently matured leaves" as defined by Ulrich (9). At each sampling date from fifteen to twenty such leaves were taken from the center two or four rows of the center 50 feet of each plot.

The experimental area was irrigated every ten to fourteen days. Judging from the appearance of the plants, soil moisture was adequate except just prior to the second and third irrigations when the plants wilted during the hot part of the day. Thereafter no serious wilting was observed.

On August 11 and 12 the center 50 feet of the four center rows of each plot were harvested by hand. Considerable dry rot canker was present and counts were made to reflect the extent of damage. All readily visible rotted beets were counted as "rotted." Two ten-beet samples were taken from each plot for sucrose and tare determinations.

RESULTS

1. The Effect of the Treatments on Beet Yield and Sucrose Concentrations

A marked response to nitrogen occurred (Table 1). All fertilizer materials increased significantly the tons of beets and gross sugar per acre. Among the nitrogen carriers the yield differences were not significant. None of the treatments differed significantly in sucrose concentration.

2. The Effect of Nitrogen on the Incidence of Dry Rot Canker

Dry rot canker is caused by the organism *Rhizoctonia solani* Kuhn. This organism is also one of the pathogens which causes damping-off of sugar beet seedlings. The fungus is commonly present in many California beet fields and has been reported occasionally to have caused appreciable losses on mature beets in the form of dry rot canker. In at least one other California experiment (12) it has been found that a nitrogen deficiency favors the incidence of this disease. The same relationship was found by Leach and Davey (5) with southern sclerotium root rot *(Sclerotium rolfsii* Sacc.) In several California field trials they were able to reduce infection through nitrogen applications by 28 to 65 percent over non-fertilized plots.

In this experiment it was observed repeatedly throughout the growing period that more plants were dying from dry rot canker in the check plots than in those which were fertilized. The harvest results (Table 1) support these observations.

All five nitrogen treatments showed significantly lower infections than the non-fertilized areas. This is reflected both in the reduction of the number of beets harvested from the non-fertilized plots and in the lower percentage of infected roots from the plots receiving nitrogen.

Among the nitrogen sources the calcium nitrate and ammonium sulfate treatments had significantly lower amounts of infection than the sodium nitrate treatments. The difference is significant at the one percent level for calcium nitrate and at the five percent level for ammonium sulfate. The infection in uramon and ammonium nitrate plots was intermediate and did not differ significantly from the other nitrogen sources.

The high coefficient of variation for the incidence of this disease indicates the possibility that considerable experimental error may be involved. Additional experiments must be conducted to investigate more intensively this problem before general conclusions can be drawn.

3. Plant Analysis as Related to the Response to Nitrogen

Inspection of Table 2 reveals that all the nitrogen treatments increased significantly the concentrations of nitrate in petioles over that of the check plots from the first sampling date, May 4, until July 19, at which time the same low concentration was reached in petioles from all treatments.

Ulrich (11) has tentatively defined the critical concentration of nitrate nitrogen in such plant material at approximately 1,000 ppm. On this basis a response to nitrogen was indicated by the early date at which the unfertilized plants reached this critical level. Petiole material from plants of all the nitrogen treatments reached this concentration within one or two weeks of each other, indicating that measurable yield differences among these treatments would be unlikely on the basis of differential nitrogen absorption.

4. Differential Concentration of Petiole Nitrates Among the Nitrogen Treatments.

An interesting phase of this experiment are the differences in the concentrations of nitrate in petiole material associated with the nitrogen carriers. On May 4, three weeks after the application of the fertilizers, the plants which were fertilized with calcium nitrate contained significantly higher concentrations of nitrate in their petioles than those which received sodium nitrate or ammonium sulfate. At this date the concentration in plants of the ammonium nitrate treatment was also higher than that of plants fertilized with ammonium sulfate. On May 25 and June 21 the leaf samples show that plants fertilized with calcium nitrate and uramon had higher concentrations of nitrate than those fertilized with any of the other nitrogen carriers. Petioles from the sodium nitrate treatment contained less nitrate than those from any of the nitrogen treatments while those from ammonium nirate and ammonium sulfate treatments occupied a middle position.

On April 28 and again on May 19 soil samples[5] were taken from two plots of each of the following treatments: calcium nitrate, ammonium sulfate and check. As nearly as possible the samples were taken from the fertilizer bands. Analysis of these samples showed the checks to be low in

Table 1.—Comparison of treatments as to yield, sucrose percent, harvested stand and rotted beets.

Treatment[1]	Tons per Acre Gross Sugar	Beets	% Sucrose	Beets Harvested per 100 ft. of Row	Rotted Beets (Percent of Total Harvested)
No nitrogen	3.241	23.38	13.85	148.7	23.2
Sodium nitrate	4.124	28.64	14.38	155.5	16.5
Ammonium sulfate	4.111	29.26	14.05	156.7	9.3
Uramon	4.080	29.71	13.74	154.7	11.8
Calcium nitrate	4.080	28.89	14.16	155.3	8.6
Ammonium nitrate	4.011	28.62	14.04	157.0	12.9
Significant difference[2]	0.245	1.39	N. S.	5.4	5.6[4]
F Value[3]	16.33	24.56	1.01	2.77	8.07
Coefficient of variation	5.3%	4.1%	3.9%	2.9%	34.2%

[1] All fertilizer materials were applied at the rate of 100 pounds of N per acre.
[2] Significant difference is at the 5% level, N. S. means not significant.
[3] Required F value for significance at the 5% and 1% levels are 2.71 and 4.10 respectively.
[4] Required difference for significance at the 1% level is 7.8%.

nitrate at both sampling dates and indicate no important differences in nitrogen (as ammonium plus nitrate) between the two fertilizer treatments. Rapid nitrification is indicated by the disappearance of most of the ammonium in the ammonium sulfate plots by the second sampling date.

Work carried out by others on soils of this area affords data from which it may be postulated that much of this differential absorption of nitrogen might have been associated with the effect of the treatment on water infiltration.

Huberty and Pillsbury (4) in field trials on Hesperia sandy loam near Wasco, Kern county, found that sodium nitrate and also ammonium sulfate (but at a slower and less consistent rate) reduced infiltration as much as 95 percent. Fireman, Magistad and Wilcox (3) in laboratory experiments confirmed these results on this soil and found the same thing on many other western soils. In their experiments sodium nitrate when applied to surface soil in concentrations comparable to 200 to 500 pounds of side dressed material reduced the permeability of Hesperia silt loam 50 percent. They also found that ammonium nitrate and ammonium sulfate reduced permeability but to a lesser extent than sodium nitrate.

In the experiment reported here the sodium nitrate was applied at the rate of 617 pounds per acre side dressed on both sides of the row. The planting was on beds, therefore, water penetrating to the center of the beds had to pass through the fertilizer bands. The nitrate or urea distributed

[5] Dr. L. D. Doneen of the Univ. of Calif., Davis, Calif., kindly assisted in taking these samples and in having them analyzed.

throughout the root zone would be in proportion to the amount of water moving through the fertilizer zones. Any treatment reducing the movement of water in this region would also reduce the distribution of nitrate or urea and likely result in less nitrogen available for absorption. It is assumed that calcium nitrate would tend to aid rather than decrease water infiltration and that appreciable amounts of soluble urea were disbursed throughout the root zones before oxidization to ammoniacal forms.

Table 2.—Comparison of the nitrate-nitrogen concentration in recently matured petioles. Expressed in ppm-dry basis.

Treatments	May 4	May 25	Sampling dates June 21	July 19	Aug. 12[1]
No nitrogen	5,980	360	340	360	375
Calcium nitrate	13,650	10,400	2,630	590	705
Uramon	12,250	10,530	2,220	535	480
Ammonium nitrate	12,720	6,750	1,580	410	530
Ammonium sulfate	10,370	5,730	1,740	410	450
Sodium nitrate	11,270	4,830	1,250	375	290
Significant difference[2]	2,020	1,390	840	N.S.	N.S.
F Value[3]	15.86	65.63	7.82	0.92	1.21

[1] Harvest date—samples taken from buffer rows.
[2] Significant difference is at the 5% level. N. S. means not significant.
[3] Required F values for significance at the 5% and 1% levels are 2-71 and 4.10 respectively.

An attempt was made to detect possible differences in water infiltration. Metal cylinders (1) were pressed into the soil over the fertilizer bands and filled with the same water used to irrigate the field. The infiltration rate was measured by the drop in the level of water over a definite period of time. No differences among the treatments were observed in this manner. Since a surface phenomenon is probably not involved, this method may not be applicable.

DISCUSSION

These results are contrary to those for potatoes in that they indicate large variations in the yield of beet sugar are not likely to be associated with the type of nitrogen carrier used.

Conclusions concerning general or continued use of these fertilizers cannot be drawn from this single experiment. Information is needed as to the effect of these materials when used on other soil types, on the same soil over a period of years, and when they are applied at higher rates.

SUMMARY

1. Five nitrogenous fertilizer materials (ammonium sulfate, ammonium nitrate, calcium nitrate, sodium nitrate and uramon) were applied to sugar beets at the rate of 100 pounds of nitrogen per acre. The plots were arranged in a Latin square. All of the fertilizer materials increased beet yields and sugar production significantly over the check but none affected significantly the sucrose concentration. Among the nitrogen carriers there were no significant differences in beet yields, sugar production, or sucrose concentration.

2. The amount of dry rot canker was appreciably greater in the unfertilized plots.

3. Plant analyses are in agreement with the observed yield responses to nitrogen and also indicate that the plants were supplied adequately with phosphate and potassium.

4. Differences in the concentration of nitrate-nitrogen in petiole material among the plants receiving the various sources of nitrogen were observed. Calcium nitrate and uramon supplied the plants with the highest concentrations of nitrogen. Sodium nitrate supplied less nitrogen than any of the carriers. A reason for this differential absorption of nitrogen is postulated.

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