Influence of Nitrogen Placement and Source on Surface Nitrate Accumulation and Sugarbeet Production[1]

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Maximum sucrose production is dependent on the proper level of available nitrogen throughout the growing season. Nitrogen should be readily available during early and mid-season to provide good root yield. In contrast, nitrogen deficiency during the 4 to 12 weeks preceding harvest is essential for maximum sucrose content (3, 5)[3]. Maintaining the proper nitrogen level is difficult because of the many forms, biological activity, and mobility of nitrogen in the soil.

Nitrate nitrogen has been shown to accumulate in considerable quantities near the soil surface when beets are planted on beds and furrow irrigated (4). If nitrate accumulates near the soil surface early in the growing season, it may not be available to the beet crop when needed. Also, if leached into the active root zone by late season rains, this nitrogen will reduce beet quality (3). A flush of top growth is sometimes observed in the Texas Panhandle following late summer and early fall precipitation. This flush of growth is usually attributed to leaching of nitrate from the bed surface.

The placement of nitrogen fertilizer in a bed-furrow system would influence the magnitude of surface nitrate accumulation. Broadcasting nitrogen on the soil surface, even with some incorporation, would favor accumulation on the bed surface after irrigation. Placement directly below the water furrow should result in more downward movement and less movement towards the bed surface (1).

Since the ammonium ion is immobile in soil, this source of nitrogen fertilizer would reduce surface nitrate accumulation until nitrification occurs. In some instances this might allow more time for the crop to utilize nitrogen before it became positionally unavailable. One report demonstrated that ammonium sources were more slowly available to a beet crop than nitrate fertilizers (2). However, the difference was only 7 to 10 days.

These experiments were undertaken to determine the influence of fertilizer nitrogen placement and source on surface nitrate accumulations and subsequent sugar beet production.

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[3]Numbers in parentheses refer to literature cited.

Materials and Methods

Field experiments with six treatments consisting of a factorial combination of three nitrogen sources and two methods of placement were conducted in 1973 and 1974. Nitrogen sources, chosen to give a range of ammonium to nitrate ratios, were calcium nitrate, ammonium nitrate, and ammonium sulfate. The calcium and sulfate ions would not be expected to affect beet production on the experimental soil, Pullman clay loam, a productive, slowly permeable soil with pH 7.5 and 1.2% organic matter in the plow layer. The two methods of placement used in these studies are referred to as surface and subsurface. Surface placement consisted of spreading the nitrogen fertilizer on the surface of the water furrow between beet rows and incorporating lightly with a rolling cultivator. In subsurface placement, the nitrogen was banded 4-6 inches below the soil surface in the bottom-center of the water furrow, Figure 1. Soil samples (0-1 inch depth) were taken equally from the entire 10-inch width of the bed surface during the growing season to check for nitrate accumulation.

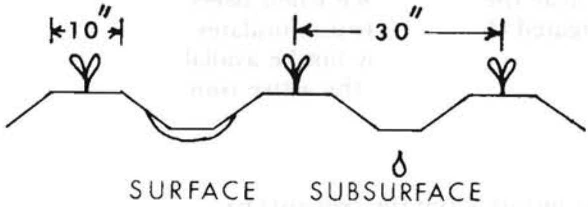

Figure 1.—Diagram showing initial location of fertilizer nitrogen with surface and subsurface placement.

Plots were four rows wide and 30 ft long with the six treatments arranged in randomized complete blocks. The beets were machine harvested in November. Sugar sample analysis was performed by Holly Sugar Corporation using standard sucrose analytical methods. A specific ion electrode was used for soil nitrate determination.

1973

Eight replications of variety HH23 were planted April 30 at eight seeds/ft and later hand thinned to a 6-inch spacing. Sixty lb/acre actual nitrogen from each source was applied May 25 when the beets had two true leaves. Soil residual nitrate nitrogen was 142 and 229 lb/acre in the upper 4 and 6 ft, respectively.

1974

Five replications of variety Mono HyD2 were replanted April 8 (emergence watered April 11) after freeze-out of a March 2 planting. Planting to stand at four seeds/ft resulted in an average harvest stand of 160 plants/100 ft. It was decided that a higher rate of applied nitrogen would be desirable in 1974 to more severely test the possible effects of surface nitrate accumulations. Thus, 180 lb/acre actual nitrogen was applied to all plots on February 20. Soil residual nitrate nitrogen was 97 and 197 lb/acre to a depth of 4 and 6 ft, respectively. Recommended residual (4-ft test) plus fertilizer nitrogen is 200 to 220 lb/acre for beet fields with a high production potential in this area.

Results and Discussion

The beets made good growth and were essentially disease free except for moderate powdery mildew in 1974. Nearby studies indicated that the optimum nitrogen fertilizer rate for maximum sugar production was about 120 lb/acre both years compared to the 60 and 180 lb/acre applied in 1973 and 1974, respectively. The study area developed severe nitrogen deficiency by mid-August in 1973. Deficiency symptoms were not evident in 1974.

Precipitation from the time of nitrogen fertilizer application until harvest was 48 and 130% of normal in 1973 and 1974, respectively, Table 1. August and October of 1974 had unusually heavy rainfall. Despite considerable differences in precipitation, the pattern of nitrate accumulation and removal from the bed surface was similar for the two years of study, Figures 1 and 2. Nitrates accumulated on the surface of the bed when irrigation followed fertilizer application. However, the surface accumulations were short-lived and there was never more than 0.5 lb/acre nitrate nitrogen on the bed surface after August 1.

Peak nitrate accumulation detected on the bed surface amounted to about 11% of the applied nitrogen both years. That is less than was expected considering that part of the accumulation would represent residual soil nitrate.

Table 1.—Precipitation in inches at experiment site, USDA Southwestern Great Plains Research Center, Bushland, Texas.

Month	Year 1973	Year 1974	Normal 1939-1971
January	0.83	0.27	0.43
February	0.47	0.38	0.46
March	4.43	1.70	0.56
April	2.62	0.00	1.12
May	2.27	3.09	2.67
June	0.47	1.16	3.11
July	2.17	1.44	2.72
August	1.29	8.32	2.53
September	0.91	1.92	1.69
October	1.09	4.00	1.68
November	0.05	0.15	0.72
December	0.05	0.41	0.59
Total	16.65	22.84	18.29

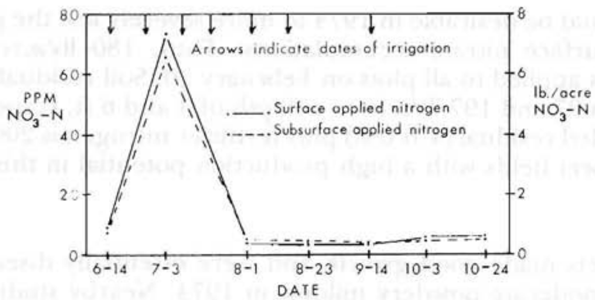

Figure 2.—Soil nitrate nitrogen in the surface one inch of a 10 inch wide bed during the 1973 growing season at Bushland, Texas.

These results are in strong contrast to those of Stout (4) for furrow irrigated culture of sugar beets in Utah. He often found 1,000 ppm or more nitrate nitrogen on the bed surface prior to harvest where beets were furrow irrigated. The results presented here are similar to Stout's observations on sprinkler irrigated fields. Greater rainfall in the Texas Panhandle could account for the different observations.

Nitrate levels deeper in the soil profile (1-6 ft) in September 1973, with severe nitrogen deficiency symptoms, were uniformly about 2 ppm compared to about 5 ppm in the surface inch of soil. Thus, there was only a very slight concentrating effect at the soil surface after mid-season. In Utah (4), surface concentrations were often several hundred times that found in subsoils (24-36 inches) under furrow irrigated conditions during the later part of the growing season.

Subsurface application of nitrogen was slightly superior to surface application in avoiding nitrate accumulation on the bed surface (significant at 5% level in 1974 only), Figures 2 and 3. The effect of placement was quickly obliterated by rainfall and was certainly of no consequence by early September when nitrogen deficiency is desired in this area. In a climate with little or no summer rainfall, proper placement of nitrogen might be of some benefit.

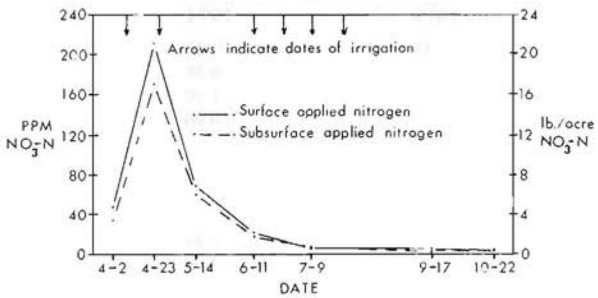

Figure 3.—Soil nitrate nitrogen in the surface one inch of a 10 inch wide bed during the 1974 growing season at Bushland, Texas.

The source of nitrogen fertilizer had no significant influence on nitrate accumulation in the bed surface under the conditions of this study. Thus, the data presented in Figures 2 and 3 is a mean of the three sources of fertilizer nitrogen.

Fertilizer source and placement had no effect on sugar beet production, Table 2. This would be expected since any differences between placements or sources were at most short-lived under our conditions.

Table 2.—The influence of source and placement of nitrogen fertilizer on sugar beet production.

		Sucrose %			Root yield, tons/acre		
Source	Placement	1973	1974	Mean	1973	1974	Mean
$Ca(NO_3)_2$	Surface	17.1	14.2	15.6	26.9	30.4	28.7
	Subsurface	17.4	14.7	16.1	26.9	30.4	28.7
NH_4NO_3	Surface	17.6	14.6	16.1	25.6	31.3	28.5
	Subsurface	17.3	14.0	15.7	25.8	32.1	28.9
$(NH_4)_2SO_4$	Surface	17.3	14.6	16.0	25.8	32.1	29.0
	Subsurface	17.4	14.3	15.9	26.2	32.6	28.9

Summary

Sugar beets were grown on beds and furrow irrigated. Nitrate nitrogen accumulated on the bed surface in amounts up to 21 lb/acre (210 ppm) when irrigation followed fertilizer application. These surface accumulations were quickly depleted, apparently by rainfall leaching the nitrate into the active root zone.

Placement of nitrogen fertilizer had only limited effect on surface accumulations of nitrate. Any influence of placement was no longer evident by mid-season. The source of fertilizer nitrogen had no significant influence on surface nitrate accumulations.

Placement and source of fertilizer nitrogen had no influence on sugar beet yield or percent sucrose.

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