Nitrogen Effects On Sugar Crops

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Nitrogen is an interesting nutritive element. In fertilizer it occurs generally in two forms: ammonium (including urea) and nitrate. Ammonia is adsorbed on the soil exchange complex and does not leach readily; it is not utilized to any great extent by most crops except, perhaps, in the early stages of growth. Ammonia is converted to the nitrate form through the action of soil microorganisms. Nitrites are not adsorbed by the soil but move freely within the soil water. They can be leached rather rapidly in the absence of an active root system.

Soil microorganisms, in decomposing organic residues, compete with growing plants for available soil nitrogen. This nitrogen is then tied up within their bodies. Most of this nitrogen goes through the mineralization process. If the organic residues undergoing decomposition are highly carbonaceous, nitrogen deficiency symptoms may appear in the leaves of the growing plant. If mineralizable nitrogen is released during the latter stages in the development of the plant, it may be difficult to ripen the crop.

Thus, the problem of providing the plant with the correct amount of nitrogen must take into consideration not only the amount of nitrogen in the applied fertilizer but also the amount that is being released in the soil through the mineralization process.

The major impact of applied nitrogen on plant growth is to increase the rate of top growth more rapidly than the root growth. There is an increase in the top:root ratio. In the case of small grains, excessive nitrogen generally causes lodging of the crop. With potatoes, there is a decrease in tuber formation and the production of large amounts of tops. Extra nitrogen on tobacco reduces the sugar content and increases the nicotine. Sugar crops respond to high amounts of nitrogen by giving increased tonnages of the plant but a decrease in the percentage of sugar present. It is the function of this brief discussion to show the similarity between sugar beets and sugarcane in their behavior to nitrogen fertilization.

The Effect of Nitrogen on Sugar Beets

The Institute for Sugar Beet Investigations at Gottingen, Germany has made extensive studies of the effect of the amount
and timing of nitrogen on the yield and quality of sugar beets\textsuperscript{a}. Their studies established two rather significant points. In the first place, there was an increasing concentration of unassimilated nitrogenous compounds in the beet juice as the amount of nitrogen applied to the beets as fertilizer was increased. This nitrogen, given the name "harmful nitrogen", consists primarily of amino acids and related compounds. In the second place, increased nitrogen fertilization raised the amount of ash in the juice. Both of these factors had a deleterious effect upon the pol and the extraction of the sugar.

![Graph showing the effects of increasing amounts of fertilizer on sugar beets](image)

Figure 1.—The effects of increasing amounts of fertilizer upon sugar beets (Ludecke).

The data in Figure 1 illustrate the impact of increasing amounts of fertilizer, containing the same ratio of N-P-K, upon beet-root and beet-sugar production and the composition of the juice. The basic fertilizer treatment was 80 lbs N, 70 lbs P\textsubscript{2}O\textsubscript{5} and 100 lbs K\textsubscript{2}O per acre. Nitrogen was increased by 40-lb increments, with the other nutrients being raised proportionately to keep the same ratio. For the first increment of nitrogen, the tonnage of beets and tops increased about the same. However, more nitrogen beyond this point resulted in a tremendous increase in top growth in comparison with the added tonnages of the roots. In other words, the top:root ratio was increased significantly. The pol of the juice decreased rather significantly

\textsuperscript{a} H. Ludecke, Zuckerfabrik Northeim, 1953.
with all three increments of nitrogen. This decrease, when coupled with a rather modest increase in beet yields, resulted in no increase in total sugar for the second and third increments of nitrogen. The curves also point out rather clearly the rather high amounts of ash and the increasing amounts of harmful nitrogen with the extra nitrogen additions.

Figure 2.—The effects of increasing amounts of nitrogen upon sugar beets (Ludecke).

Figure 2 shows the relative effects of increasing the amount of nitrogen from 80 lbs to 200 lbs of nitrogen per acre. The yields of tops, beets, and sugar for the 80-lb N application is equal to 100% in these comparisons. These data corroborate those in Figure 1. There is a very large increase in the top:root ratio. The effect of the decrease in pol on sugar yields is more dramatic, however, than in Figure 1. In this case, there was an over-all decrease in the amount of sugar produced when nitrogen applications exceeded 120 lbs per acre. The usual effects on increasing amounts of ash and harmful nitrogen are clearly shown.

Increasing amounts of nitrogen increase the top:root ratio, amounts of ash and harmful nitrogen and decrease the percentage of pol. Late applications of nitrogen also have similar effects; this is clearly shown in Figure 3. Here, 140 lbs of nitrogen were applied before seeding. This was compared with the same amount of nitrogen applied as split applications before seeding, after thinning, and two weeks after thinning. The delayed
nitrogen increased the top:root ratio as well as the amount of ash and harmful nitrogen. Pol was decreased, with a slight decrease in sugar produced from the latest application.

This impact of nitrogen on sugar beet quality was considered as one of the major problems of the industry in 1957. It will be interesting to find out in a visit to the Institute in 1964 how they have resolved it.

The Effect of Nitrogen on Sugarcane

Field observations and experiments have indicated that excessive nitrogen increases the amount of cane but may not necessarily increase the amount of sugar produced due to a decrease in pol. When the cane plant puts on new growth as a result of nitrogen additions, it could be either through an increase in the amount of green tops or through the production of new suckers. In both cases, this green material is high in both un-assimilated nitrogen and reducing sugars. The deleterious effects of nitrogen on sugar yields depend considerably upon the cane variety and the climatic conditions. Some varieties are relatively insensitive to nitrogen additions as far as the effect upon juice quality is concerned. Others are relatively sensitive. With certain varieties, an increase in nitrogen may even result in a decrease in the amount of cane produced. Cloudy, cool weather during the boom and ripening stages in the crop's growth tends to give poorer juice quality than does sunny, warm weather.
The effects of nitrogen on sugarcane; therefore, are quite similar to those discussed for sugar beets. Both the amount and timing of the nitrogen are important in assessing the impact of nitrogen on cane. The data in Figure 4 illustrate the effects on the increase in sucker growth of increasing the amount of nitrogen from 200 lbs to 600 lbs per acre and delaying application of nitrogen from 3 months to 8 months of age. With increased and delayed amounts of nitrogen, the amount of primaries in the total stalk population decreases and the number of suckers increases.

The impact of nitrogen upon pol % cane is shown in Figure 5. Effects are shown for four different harvesting dates, from 15 to 24 months. At each harvest date, there is a decrease in pol % cane as the nitrogen is increased from 200 lbs to 600 lbs per acre. Similar decreases are observed when the date of application is delayed from 3 months to 12 months.

*George Stanford, Hawaiian Planters' Record, 56:289, 1963.*
These data become quite important from a practical point of view when one analyzes the sugar production trends of the industry in relation to fertilization. From 1950 through 1955 the Hawaiian industry as a whole showed an increase of about 18 tons of cane and nearly 2 tons of sugar per acre. New, higher-yielding varieties were coming into the picture. There was an increasingly favorable weather pattern. Fertilizer consumption \((N + P_2O_5 + K_2O)\) increased from about 24,000 tons to 37,000 tons. However, there was a decrease in both cane and sugar produced for both the 1956 and 1957 crops. This took place in spite of the fact the fertilizer tonnages had increased to about 50,000 for the 1957 crop. Compared with 1951, in 1957 the irrigated plantations, for example, were producing about 50% as much sugar per unit of fertilizer applied. This apparently was the combination of over-fertilization with nitrogen and poorer climatic conditions.

Apparently, nitrogen is the major factor affecting the quality of sugar crops over which man should have some control. Experience both in the beet and cane fields, as well as in the experimental plots, has shown that man has not been doing too good a job exercising this control.