Effect of Nitrogen on Yield and Subsequent Germinability of Sugar Beet Seed[1]

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The general effect of nitrogen on crop yields is well known. In the Pacific Northwest of the United States, the yield of sugar beet seed has been increased very significantly by applying a nitrogen fertilizer (1). The percentage of germination also has been increased by applying nitrogen and phosphorus fertilizer (1). This paper reports the effect of different levels of nitrogen in nutrient solution on yield and germinability of sugar beet seed.

Methods and Materials

In 1956, the annual variety SL 9460 was grown. Seedlings from fast-germinating seeds were planted in three-inch pots. After approximately three weeks' growth, two seedlings were transplanted into each of 18 four-gallon crocks containing vermiculite. A balanced nutrient solution, designated the "low" nitrogen solution, was applied daily to the crocks until the differential levels of nitrogen were initiated 13 days later (April 26). Half of the crocks (nine) remained on the "low" nitrogen solution; the other half received the "medium" nitrogen solution. Beginning May 7, the plants were given continuous light for two weeks. The crocks were placed outdoors on May 22 and remained there until after the seed was harvested. Flowering began the week of June 3-10.

In 1957, 3 clones of biennial sugar beets, E209-3w, E221-1w, E223-61e, were used as experimental plants. Following 10 weeks of photothermal induction, a plant was transplanted into each crock and placed outdoors on May 16. All plants received the "low" nitrogen solution until June 3. On June 3, a 3 x 3 x 3 experiment was begun. Each of the 3 nitrogen levels (low, medium, and high) contained 3 plants from each of the 3 clones. The first flowers on these plants opened between June 15 and 20.

The nutrient solution contained the following salts, expressed as grams per liter: KH_2PO_4 — 0.12, KCl — 0.60, KNO_3 — 0.30, $MgSO_4.7H_2O$ — 0.48, $NH_4H_2PO_4$ — 0.24, NH_4Cl — 0.24. In the 1956 experiment, $Ca(NO_3)_2.4H_2O$ was added to the above solution at 0.62 grams per liter and in 1957 at 0.48 grams per liter. Additional nitrogen was supplied as ammonium nitrate. The molar concentrations of nitrogen in the nutrient solutions are shown below.

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	Solution Designation					
	Low Nitrogen		Medium Nitrogen		High Nitrogen	
Year	Molarity of N	Molar Ratio N-P-K	Molarity of N	Molar Ratio N-P-K	Molarity of N	Molar Ratio N--P-K
1956	0.0148	5.1-1-4.1	0.0484	16.7-1-4.1	--------	--------------
1957	0.0136	4.7-1-4.1	0.0472	16.3-1-4.1	0.0808	27.9-1-4.1

When the different nitrogen levels were initiated, 800 milliliters of nutrient solution were supplied daily to each crock. As the plants became larger, sufficient water was added in the morning to cause flushing. The nutrient solution was added in the afternoon. The crocks were flushed thoroughly with water every 7 to 10 days.

The seed was harvested when nearly all of the seedballs were straw colored. Weights of seed were recorded. Although insecticides were applied to control insects, in 1957, the weights of seed were approximate because a few plants were damaged by stalk borers.

The speed of germination of the seedlots was determined by a nutrient solution technique (2) using a solution of 10.1 atmospheres osmotic pressure. Eighty whole seedballs from each seedlot were used.

Results

1956 Data

The differential nitrogen levels, although initiated at the 8-to 12-leaf stage, did not have any effect on rate of bolting or earliness of flowering. Within a month, the foliage of the plants receiving the "medium" nitrogen solution was darker green than the foliage of those on the "low" solution. By July 10, a "tip burn" of the terminal portions of the flower stalks had developed. The severity of burn correlated directly with the amount of nitrogen in the solution.

The plants were maintained on the same nutrient solution for 10 days after the seed was harvested, then all plants were given the "low" nitrogen solution. In spite of the change to the "low" nitrogen solution, those plants which formerly received the "medium" solution continued to deteriorate. Within a month after harvest, 16 of the 18 plants died. In comparison, all the plants which formerly received the "low" nitrogen solution survived. The annual variety SL 9460 seems to be sensitive to the amount of nitrogen supplied.

Plants receiving the "low" nitrogen solution produced 106 grams of seed per plant, while those on the "medium" solution produced only 95.5 grams. This difference was significant at the 2.5 percent level.

Seed harvested from plants receiving the "medium" nitrogen solution germinated as rapidly as seed harvested from plants receiving the "low" nitrogen solution. The percentage of germination also was unaffected by the amount of nitrogen supplied to the parent plants.

1957 Data

The foliage of plants receiving the "low" nitrogen solution was a lighter green than the foliage of those plants receiving the "medium" and "high" nitrogen solutions. As the seed approached maturity, the lower leaves of those plants on the "low" solution were more chlorotic than those on the higher amounts of nitrogen. These clones did not reveal the "tip burn" observed in the annual variety SL 9460 in 1956. Plants on the "low" solution remained turgid when those on the "medium" solution began to wilt. Those on the "high" solution wilted most readily.

The osmotic concentration, as measured by specific conductance of the effluent from the crocks, correlated with the increment of nitrogen in solution. However, the increased osmotic concentration did not seem to account fully for the greater tendency to wilt. One of the three clones receiving the "high" nitrogen solution wilted more readily on sunny days than the other two. The tendency to wilt was essentially independent of the size and leaf area of the plants, suggesting that the wilting was the result of differential water absorption among the clones exposed to the "high" nitrogen solution.

Seed yields were reduced slightly due to insect injury to 8 of the 27 plants. Only two of the plants, however, had an appreciable reduction in yield. The injured plants were dispersed among the three levels of nitrogen so that the total amount of seed produced under a given nitrogen level should reflect the trends. The total weight in grams of seed produced for each level of nitrogen was as follows: high—1670, medium—1760, and low—1800. The significance of these differences cannot be evaluated.

The clones differed significantly (1 percent level) in speed of germination. The level of nitrogen did not affect significantly the speed or percentage of germination at three days. However, the high level of nitrogen supplied to the parent plants increased significantly (5 percent level) the percentage of germination in five days. The data have been summarized in Table 1. The seed produced by two clones receiving the "high" nitrogen solution germinated best.

Table 1.—Effect of Nitrogen Supply to Parent Plants on Percentage Germination of Seed. Counts Made 3 and 5 Days After Placing in Contact with Nutrient Solution.

	Percentage of Germination by Nitrogen Levels[1]					
	Low		Medium		High	
Clone	3	5	3	5	3	5
E209-3w	8.3	62.1	20.0	79.2	31.7	69.6
E221-1w	24.2	37.1	22.9	42.5	20.4	52.5
E223-61e	35.0	58.3	40.4	57.5	48.8	75.0
Average	22.5	52.5	27.8	59.7	33.6	65.7

[1] Average of three replications.

Discussion

Results from these nutrient solution experiments suggest a guide for nitrogen fertilization in the production of sugar beet seed. In interpreting the nutrient data, the relatively complete availability of all nutrient elements in the solution must be recognized. Also, in terms of nutrient balance, the "low" nitrogen solution would be considered to be very nearly adequate. Yield data support this latter statement.

The level of nitrogen supplied to the parent plants did not have a very pronounced effect on the speed or percentage of germination of the seed. Therefore, the amount of nitrogen supplied should be based more specifically on its effect on the parent plant. Some evidence was obtained to indicate that an excess of nitrogen may be sufficiently detrimental to the parent plants to reduce the yield of seed. Nitrogen should be supplied in balance with the other nutrients and in amounts sufficient to produce a maximum yield of seed.

The results of this investigation do not appear to be incompatible with those obtained in field experiments conducted in the Pacific Northwest, since the yield at the lowest level of nitrogen employed in this study exceeded the yield from greater amounts of nitrogen, suggesting that nitrogen was not deficient at the lowest level. Both studies suggest that additional nitrogen supplied to the parent plants may, at least under certain conditions, improve the percentage germination.

Summary

There was no marked difference in speed or percentage germination of seed from sugar beet plants supplied with ade-

quate versus excess quantities of nitrogen (Ammonium Nitrate) in nutrient solutions.

Clones and varieties of sugar beets reacted differently to an excess of nitrogen in nutrient solution. Some of the plants were injured, even succumbing after the seed was harvested.

Nitrogen fertilizer should be supplied in balance with the other nutrient elements and in amounts sufficient to obtain maximum yields of seed.

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Literature Cited

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