# The Effect of Manure on Sprangling of Sugarbeet Roots[1]

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Occasionally, sugarbeets with sprangled or abnormally branched roots can be observed at harvest. This condition apparently results from increased development of secondary roots after injury to the tap root. The effect of sprangling on root yield and sucrose content of sugarbeets is not known.

In 1967-68, large numbers of sprangled roots were observed in several fields in central Arizona. Fields with the highest incidence of sprangled roots had received heavy applications of manure before planting, which indicated a possible correlation between sprangling and manure. Animal manures have been shown to cause root injury in lettuce and carrots (3,5)[3]. In preliminary tests in pots, beets grown in soil-manure mixtures produced a higher percentage of sprangled roots than those grown in soil only.

The present study was designed to further investigate the influence of soil applications of manure on sugarbeet growth and development. Field and greenhouse tests were involved. In addition, experiments were conducted to obtain information concerning the factor(s) in manure which may cause sprangling.

## Materials and Methods

### Field Experiment

A field experiment was conducted during 1968-69 at the University of Arizona, Mesa Branch Experiment Station, to determine the effect of different rates of manure on sprangling. Experimental plots were located on Laveen clay loam that had a pH of 7.8 and organic matter content of 1.25% in the surface layer.

Pulverized steer manure at application rates of 0, 10, 20, 40, 60, and 100 tons per acre was incorporated into the soil to a depth of 12 inches 2 weeks before planting. The sugarbeet

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[3] Numbers in parentheses refer to literature cited.

variety S-301H was planted on September 26, 1968, on 40-inch, double-row beds and irrigated up. The beets received a preplant application of 200 pounds per acre of 11-48-0 fertilizer. At thinning time, all plots were sidedressed with 110 pounds of nitrogen per acre. Manure treatments were arranged in a randomized complete block design with six replications. On June 10, 1969, plants from 24 feet of row per plot were harvested to determine the incidence of sprangling, root yield and sucrose content. Roots were considered sprangled if the fleshy tap root was branched or if secondary roots were abnormally enlarged.

**Greenhouse Experiments**

*Experiment 1.* The same concentrations of manure and soil that were used in the field were duplicated in an experiment in the greenhouse. Manure was mixed into steam-pasteurized greenhouse soil and placed in 8-inch pots. Excess seed was planted and the resulting seedlings were thinned to 6 per pot.

Treatments were arranged in Latin square designs in all greenhouse experiments except Experiment 4. The beets were irrigated with tap water supplemented with weekly applications of a complete fertilizer. Plants in all greenhouse experiments were harvested 6 weeks after planting by carefully washing soil from the roots. In greenhouse experiments, roots were considered sprangled if branched in the first 3 inches below the soil surface.

*Experiment 2.* An experiment was conducted by using manure and soil which was sterilized to determine the role, if any, of microorganisms in sprangling. Manure and soil (3 parts field soil to 1 of peatmoss) were autoclaved for 1 hour at 15 psi. Sterilized and nonsterilized manure at a rate equivalent to 100 tons per acre was mixed into similarly treated soil. In this and following experiments, excess seed was planted in 6-inch pots and seedlings were thinned to 5 per pot. At harvest, the roots were rated according to severity of sprangling.

*Experiment 3.* Beets grown in soil containing leached manure were compared with those grown in soil containing nonleached manure to determine whether the factor responsible for sprangling could be removed by leaching. Four-pound batches of autoclaved and nonautoclaved manure were leached with 12 liters of distilled water. Leached and nonleached manure was mixed into soil at a rate of 100 tons per acre.

*Experiment 4.* As a further test to determine if the sprangling factor could be leached from manure, seedlings watered with manure leachates were compared with those receiving only tap water. Four-pound batches of manure were leached with distilled water and the first 4 liters of leachate from each were collected. Pots containing greenhouse soil were irrigated daily with a half-strength solution of the leachates, beginning 3 days after seed

was planted and continuing until 3 days after seedlings emerged. Experimental design was a randomized complete block replicated 6 times.

## Results and Discussion

### Field Experiment

The incidence of sprangling was high in those treatments receiving 40 tons or more manure per acre (Table 1). Examples

Table 1.—Effect of application rate of manure on sprangling, root yield and sugar content of sugarbeets. Field experiment and greenhouse experiment No. 1.

| Manure application rate | Field experiment | | | Greenhouse experiment No. 1 |
|---|---|---|---|---|
| | Roots sprangled | Yield per acre | Sucrose content | Roots sprangled |
| Tons per acre | % | Tons | % | % |
| 0 | 3[ab1] | 28.2[a] | 11.0[a] | 2[a] |
| 10 | 1[a] | 28.7[a] | 10.2[a] | 22[b] |
| 20 | 8[b] | 28.8[a] | 10.1[a] | 36[b] |
| 40 | 36[c] | 30.4[a] | 10.2[a] | 60[c] |
| 60 | 60[d] | 29.4[a] | 9.9[a] | 82[d] |
| 100 | 74[e] | 28.2[a] | 9.6[a] | 91[d] |

[1] Means followed by the same letter are not significantly different at the 5% level.

of sprangled roots obtained in the field are shown in Figure 1. When application rates were less than 40 tons per acre, the sprangling response was not significantly different from the check plots. Although the rates of manure that induced the most sprangling were higher than those commonly used commercially, growers sometimes use excessive amounts when bringing newly leveled land into production.

There were no significant differences among manure treatments in either yield of roots or sucrose content. Differences in root yield might have been expected, considering the large quantity of nitrogen supplied by the heavier manure rates; however, even beets in plots receiving no manure apparently had adequate or even excessive nitrogen throughout the growing season. The presence of excessive nitrogen was indicated by low sucrose percentages and high petiole nitrate-nitrogen levels (in excess of 4000 ppm) obtained for all treatments at harvest. No visual symptom of manure injury was observed in the aerial portion of the plants.

### Greenhouse Experiments

*Experiment 1.* The incidence of sprangling at each application rate of manure was higher in pots than in the field (Table 1). This may have resulted partly from the inability to mix manure with soil as uniformly under field conditions as in the greenhouse. Other factors such as climatic conditions and cul-

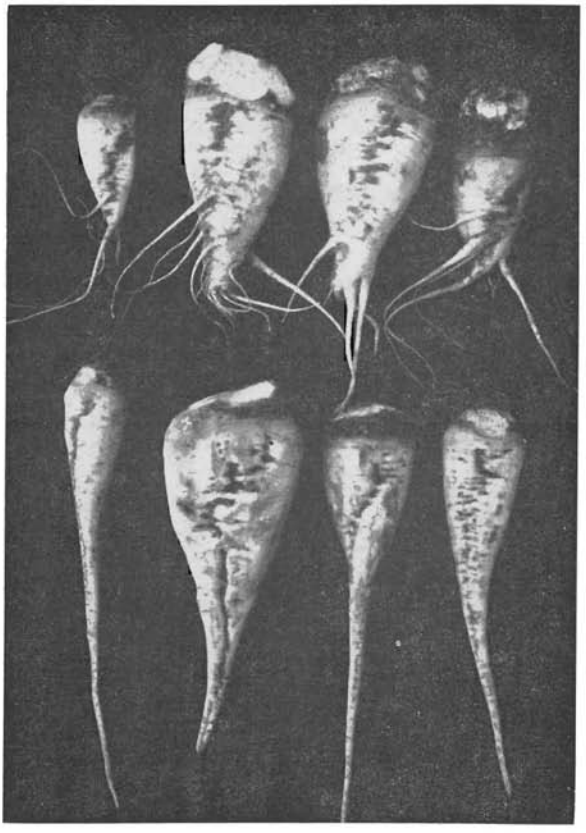

Figure 1.—Comparison of sprangled and normal sugarbeet roots. Top—Sprangled roots from plots receiving an application of 40 tons per acre of manure. Bottom—Normal roots.

tural methods differed between the field and greenhouse experiments and these differences may have affected the experimental results. Plants grown in pots at very high concentrations of manure generally were stunted and occasionally showed an interveinal chlorosis in the new leaves.

*Experiment 2.* Sterilized manure, when mixed with sterilized or nonsterilized soil, induced as much sprangling as nonsterilized manure (Table 2). These results suggested that microorganisms in soil or manure were not directly involved in the etiology of sprangling. While the manure and soil of certain treatments were sterile at the beginning of the experiment, no attempt was made to maintain asceptic conditions for the duration. Thus, although pathogenic microorganisms probably did not contaminate the

Table 2.—Effect of sterilization of manure on sprangling of sugarbeet roots. Greenhouse experiment No. 2.

| Treatment[1] | | Roots sprangled |
|---|---|---|
| Manure | Soil | |
| | | % |
| S | S | 100[a2] |
| NS | S | 97[a] |
| S | NS | 100[a] |
| NS | NS | 100[a] |
| 0 | S | 0[b] |
| 0 | NS | 3[b] |

[1] S = sterilized, NS = nonsterilized, 0 = none added.
[2] Means followed by the same letter are not significantly different at the 5% level.

soil-manure mixtures, other nonpathogenic contamination undoubtedly occurred.

*Experiment 3.* Beets grown in soil containing leached manure had the same incidence of sprangling as those in nonleached manure; however, roots tended to be less severely sprangled in treatments using leached manure (Table 3).

Table 3.—Effect of leaching of manure on sprangling of sugarbeet roots. Greenhouse experiment No. 3.

| Manure treatment[1] | Classification of roots based on expression of sprangling | | |
|---|---|---|---|
| | Mild | Severe | Total |
| | % | % | % |
| S-L | 30[a2] | 70[a] | 100[a] |
| NS-L | 36[a] | 64[a] | 100[a] |
| S-NL | 21[b] | 75[a b] | 96[a] |
| NS-NL | 12[c] | 88[b] | 100[a] |
| Check | 4[c] | 0[c] | 4[b] |

[1] S = sterilized, NS = nonsterilized, L = leached, NL = nonleached, Check = no manure added.
[2] Means followed by the same letter are not significantly different at the 5% level.

*Experiment 4.* Irrigation with both manure leachates induced some sprangling, but only the leachate from sterilized manure caused a significantly greater incidence of sprangling than the tap water check (Table 4). This experiment demonstrated that a substance(s) causing sprangling can be leached from manure.

Many nitrogenous mineral fertilizers and other nitrogen compounds are capable of causing injury to crop plants. The toxicity of these materials is due largely to free ammonia (1,2,3,4,6). Several reports indicate that the injury induced by animal manures may be associated with ammonia. For example, Grogan and Zink (3) reported that injury to lettuce caused by manure was similar to that caused by inorganic fertilizers containing free ammonia. Raleigh (5) found that branching of carrot roots caused by urine could not be distinguished from that caused by

Table 4.—Effect of manure leachates on sprangling of sugarbeet roots. Greenhouse experiment No. 4.

| Treatment[1] | Roots sprangled |
|---|---|
| | % |
| A | 20[b2] |
| B | 13[bc] |
| C | 0[c] |
| D | 68[a] |

[1] A = watered with leachate from sterilized manure,
B = watered with leachate from nonsterilized manure,
C = watered with tap water,
D = soil-manure mixture (100 tons manure per acre) watered with tap water.
[2] Means followed by the same letter are not significantly different at the 5% level.

urea, ammonium hydroxide and ammonium carbonate. The urine fraction is the chief source of ammonia in manure. Certain compounds in urine release gaseous ammonia as a decomposition product.

## Summary

Field applications of manure at rates of 40 tons per acre or higher were associated with a high incidence of sprangling. These rates are generally much higher than those used commercially. For comparable treatments, plants grown in the greenhouse had a higher incidence of sprangling than those in field plots.

Sterilized manure caused the same incidence of sprangling as nonsterilized manure, indicating that microorganisms in manure are not the direct cause of sprangling.

When leached manure was used in manure-soil mixtures, sprangling tended to be less severe. Irrigating seedlings with a manure leachate resulted in some sprangled roots.

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