Soil Deficiencies as Related to Sugar-Beet Seed Production in the Willamette Valley, Oregon

GOLDEN L. STOKER¹

Soils Suitable for Beet-Seed Growing

Beet-seed growing in the Willamette Valley, Oregon, has been confined to three soil series, namely, the Newberg, Chehalis, and Willamette. The first two series are relatively new soils, geologically speaking. They are called river-bottom soils as they have been deposited along the present river channels. These two soils are very productive and have a porous subsoil. The Willamette series is one of the old Valley-filling soils, and in general the subsoil is porous enough to permit water to percolate.

This soil characteristic is very essential for over-wintering beets in the Willamette Valley as the average yearly precipitation is approximately 40 inches, mostly in the form of rainfall. In general, the texture and structure of the other soil series are not suitable for beet-seed production.

Due to climatic conditions and the parent material from which the soils were formed, the soils of the Valley are deficient in some plant foods.

The writer was very much impressed by the first spring in the Willamette Valley. One thing that was very noticeable and striking was the general yellow color of crops. For a period many of the grainfields, cornfields, and other crops were yellow, and lacked vigor. Later as the amount of precipitation decreased and the temperature increased, the crops became more vigorous and the yellow color disappeared.

Nitrogen Deficiency

Although grass and other plants grow abundantly during the winter months, the cultivated soils of the Willamette Valley are generally low in humus. Climatic conditions are not conducive to rapid nitrate formation, consequently the nitrogen supply is limited for crops such as sugar-beet seed. The slow nitrification is due largely to the wet, cold winters and springs, followed by dry summers during which moisture is a limiting factor.

Some of the first observations of nitrogen deficiency on sugar beets for seed in the Willamette Valley were made in the fall of 1938. One commercial field (Chambers field) of 3.5 acres was planted September 3, 1938. Approximately 1.5 acres of the beets were preceded by corn which was abandoned because of a poor stand.

Agronomist, West Coast Beet Seed Company.

Vetch for seed preceded the beets on the remainder of the field. The vetch was combined and the straw plowed under. The land was immediately prepared and planted to beets. The beets were side-dressed with 150 pounds of ammo-phos 16-20, September 24 and 26. The rainfall was insufficient for a period following fertilization to make the fertilizer available. The beets on the cornland grew normally but a very peculiar condition developed in the part of the field that had been in vetch. The beets came up normally but grew very slowly. By October 12 the plants were small and distinctly yellow. One and two leaves of many plants dropped off, and other plants died. Rains which followed made the fertilizer available and the beets turned green and made a noticeable growth the last part of November and early December.

Several theories were advanced as to the cause, and nitrogen deficiency which was substantiated by conditions in other fields, proved to be the principal factor involved.

That nitrogen was the cause was borne out in two other fields planted the same season in which ammo-phos was applied with the seed. In one field, fertilizer was not drilled in one of the four rows for a few rounds. The fertilized beets grew faster and were considerably larger by late fall. Approximately the week of October 23 to 29 all of the beets turned yellow. Nitrogen-carrying fertilizers were applied November 4, and by November 28 the beets had responded as evidenced by the green color and less frost injury.

In the other field, it was apparent which direction the drill traveled by checking the end of the rows. Every alternate four rows were green out to the end of the row, whereas the adjoining four were yellow and very small for a distance of approximately 4 feet, the distance it took for the fertilizer to start sowing.

Beets following a crop of Austrian field peas were planted (August 21) the following season on the Chambers farm adjoining the vetch field described above. Knowing that a nitrogen deficiency existed, and having had good results by drilling fertilizer with the seed, the grower was advised to apply ammo-phos 16-20 with the seed. Fortunately, a rain which followed planting prevented any delayed germination due to 75 pounds per acre of the fertilizer, and a good stand was secured. (Later observations in other fields demonstrated that germination of the seed was delayed when a nitrogenous fertilizer was applied with the seed during the dry season.) A few rows in various parts of the field were not fertilized. The fertilized beets were green and apparently grew normally while the unfertilized beets grew slowly and were a vellowish-white color. The vellow color disappeared later in the fall after the beets responded to a side-dressing of ammonium phosphate, but the difference in size was still apparent the following spring.

Beets planted the following year (1940) on this farm were fertilized by means of the beet drill immediately preceding planting. The seed was sown as near as possible within a couple of inches of the fertilizer. Several places over the field where the seed and fertilizer were widely spaced, the beets on the four rows were smaller and yellow. Beets on the row only a foot from the small yellow beets, due to narrow guess rows, were green and grew normally.

Spring Applications of Nitrogen

Although fall applications of nitrogenous fertilizers have given very striking responses, spring applications have given far greater results. Beets with a continuous stand will not resume proper growth in the spring until commercial nitrogen is applied.

A general application of 200 pounds of ammonium sulfate was recommended for beet-seed fields in the spring of 1939. However, one field planted September 8, which had no fall nitrogen, received two spring applications. The first application consisted of 150-pound mixture of ammo-phos 16-20 and ammonium sulfate, and the second. 150 pounds of ammonium sulfate. These beets were small and yellow when the first fertilizer was applied March 30, but by the last of May they had a healthy green color, and were more vigorous than the other later plantings that received 200 pounds.

One hundred thirty pounds of ammonium phosphate 16-20 and 320 pounds ammonium sulfate per acre were used in two applications April 5 and May 1 on a small field with a poor stand. These beets were green and vigorous, but they did not produce a large vegetative growth, largely due to the late fertilization. However, one of the most desirable results was that the vegetation remained green until harvest and the seedballs were large, green, and heavy compared to smaller straw-colored seedballs of other fields.

During this same spring the rates of nitrogen were varied in two fields. One field was an early August planting on Chehalis soil. Ammonium sulfate was applied in strips at the rates of 150, 300, and 450 pounds per acre. One strip of ammo-phos 16-20 was also applied at the rate of 150 pounds per acre. Yields were not obtained but the various strips were easily determined through the growing season by the color and growth of the foliage. The larger quantities of nitrogen produced greener foliage and more growth than the smaller amounts.

The other field which was an early September planting on Newberg soil, gave the greatest response to an increased nitrogen supply. The spring ammonium-sulfate application was doubled to 400 pounds per acre on two strips. Again yield data are not available. However, the results were so apparent that any one who saw the field was convinced as to the value of the additional nitrogen. The additional nitrogen increased the vegetative growth, improved the color, increased the fruiting capacity of the plant, and ripened the seed more uniformly, The field was threshed across the nitrogen strips, and according to the grower, the heavy nitrogen strips produced at least one-third more seed. Strips in these fields and other fields that received a spring application of only 200 pounds of ammonium sulfate had turned a light green-to-yellow color by blooming time and continued to turn lighter in color until harvest.

In order to determine if this yellow condition could be corrected by a late application of nitrogen, four rows through a field were sidedressed with ammonium sulfate at an average rate of 245 pounds per acre. The nitrogen was applied May 24 while the plants were blooming. An irrigation followed and by June 12, the foliage of the four rows was greener, and the plants had made more growth than the plants on either side. A difference in weight of the seed-bearing area of the plants could be detected by June 30. As the seed became matured, the increased weight of the seed on the four rows had pulled the tops of the plants down, whereas the plants on either side remained erect. The seedballs of the four rows were large and remained green in color until maturity.

Nitrogen was applied the following season as late as June 14 (1940) with similar results.

As a result of the above observations and demonstrations, heavier spring applications of nitrogen were recommended for 1941. Some growers doubled the 1940 spring application of nitrogen, making a total of approximately 400 pounds of ammonium sulfate per acre. With the exception of one field deficient in boron, the larger spring applications resulted in the heaviest yields of the Valley, regardless of planting date. The average yields produced by these growers ranged from 2,750 to 3,000 pounds per acre which were higher than any yields produced by growers who applied 300 pounds or less of ammonium sulfate. One hundred twenty pounds of ammonium sulfate applied to one field through the water during the first irrigation gave very good results, However, the total spring application was only 300 pounds per acre of ammonium sulfate.

Such striking nitrogen responses are obtained through the reproductive season that differences in the quantity of nitrogen are very apparent. Mistakes and conditions incidental to applying fertilizer usually provide opportunities for the growers to observe the nitrogen response. For example, in one field the operator unintentionally fertilized one row twice. Noticing his mistake he left a row unfertilized so that the cultivating corresponded with the drilling. The beets in the row with the double amount of nitrogen grew more vigorously than those in the rows on either side. The beets of the unfertilized row were yellow and the growth was very uneven. Because of the single rows the differences became less as the season advanced. During the past season (1941) a general application of 400 pounds of ammonium sulfate per acre was recommended. Five and six hundred pounds were recommended and applied to individual fields. Some fields received all of the nitrogen in the early spring, and others received approximately 60 to 80 percent in the early spring and the remainder with the first irrigation.

The overhead sprinkling type of irrigation used in the Willamette Valley provides a very easy and effective method of applying nitrogen when the beets are approaching the bloom stage. The fertilizer is dissolved in a barrel of water and the suction of the intake pipe draws the solution through a tube into the irrigation system.

As reported, nitrogen has been applied in the late spring or early summer on an experimental basis, but this past season is the first time it has been recommended and applied commercially. Although experimental data are not available to show the results of such a practice, the visible change in color of the plants following application, and the yields of seed secured are rather conclusive as to results. A few fields turned especially light in color (yellow) as they approached the bloom stage. This was particularly true of the very thick stands. Knowing that these fields would continue to deteriorate and show more evidence of nitrogen starvation, additional nitrogen was applied through the irrigation water. Within a week to 10 days the beets had begun to turn green.

This method of applying nitrogen to beets grown for seed in the Willamette Valley looks very promising as a means of supplying the plant with sufficient nitrogen during the fruiting period. Increased amounts of early spring nitrogen have helped to supply the plant throughout the growing season. However, the growth of the inflorescence has not been in proportion to the increased stem and leaf growth. This relationship seems to be influenced by the season and time of application.

Sulfur Deficiency

A light-green to a yellowish-green color of the sugar-beet seed foliage is common and has been general throughout the Willamette Valley. Early observations revealed that nitrogen played an important part in the color and growth of the plants. Larger and later applications of ammonium sulfate improved the color and growth. However, other elements were thought to be lacking.

The marked response in growth and color of legumes that received a spring application of gypsum, the practice of which is general in the Willamette Valley, stimulated the thought that beets may possibly respond to sulfur. In the fall of 1939, an experimental plot was planted in cooperation with Bion Tolman, Assistant Agronomist, Division of Sugar Plant Investigation, Bureau of Plant Industry, United States Department of Agriculture. Sulfur was applied alone and in combination with other fertilizers on the Newberg soil series near Jefferson, Oregon. Agricultural sulfur was applied prior to planting at the rate of 94 pounds per acre.

The first response to sulfur was visible during¹ the last of September when the beets in general were beginning to show need for moisture. On September 26, beets in the sulfur plots were greener than where sulfur had not been applied. The sulfur-deficiency plots were distinctly a yellow color and the beets were noticeably smaller. Plants within the plots varied. Some were almost a normal green while others were a distinct yellow. This color distinction was of short duration. Rains followed and the beets turned a green color.

The color difference was again apparent in the spring after the plants began to respond to the spring application of nitrogen. Thirteen days after the April 0 application of nitrogen, a slight difference in the color of different plots was noticeable and by April 22. the color differences were well defined. The beets of the sulfurdeficiency plots that turned yellow in the fall were again yellow, and in addition to these, the beets in the treble-superphosphate plots were yellow, indicating that the sulfur supplied by the treble superphosphate had been exhausted. The beets in the sulfur plots grew vigorously, bolted uniformly, and the leaves were a waxy green color, while the beets in the no-sulfur plots were yellow, and individual leaves of a few plants even turned white. This difference of color was very apparent until May 9, after which the color difference became less noticeable. By May 13 the sulfur-deficiency plots were more difficult to distinguish as individual seedstalks grew above the average plants of the plots and were a greener color, which practically obliterated the yellow color of the other plants as viewed from a distance.

The sulfur-deficient- plants lacked vigor, the foliage was yellow, the leaves small, and fewer plants entered into seed production. The yellowing was accompanied by a breakdown of the leaf tissue and leaf spot was very prevalent. As the season advanced many leaves died. Many plants developed floral bracts and remained vegetative. These vegetative plants maintained a yellowish-green color until harvest.

A very important relationship of sulfur to nitrogen was apparent. No response was obtained from sulfur when the spring nitrogen was omitted. In the absence of nitrogen, the sulfur plots could not be distinguished from the no-sulfur plots. This observation was confirmed by the yields as shown in table 1.

The need for sulfur in the production of sugar-beet seed in the Willamette Valley is evident by the increased yields obtained when sulfur is added (table 1).

Treat- ment No.	Plant- iog date	Nitrogen application	No sulfur	04 ib. sulfur, fali
··	Sept. 7	\$18 lb. NaNOs in fall, plus	1,310	1,672
		330 lb. NaNOs in spring		
2	Aug. 28	333 lb. NaNOs in fall, plus		
		330 lb. NaNO ₅ in spring	1,823	2,061
3	Aug. 28	100 (b. NuNG)s fall; no N in spring	1,073	1,901
	yield of s	ulfur plots	1,235	1,678

Table 1.—Pounds of clean seed per acre from replicated plot test in which three nitrogen treatments were used with and without addition of sulfur to the soil, Lamb experimental plot, Jefferson, Oregon 1939-40.

Boron Deficiency

Boron-deficiency symptoms of sugar beets have been described and reported in many localities, However, the symptoms are somewhat modified by winter temperatures that beets are subjected to by the overwintering method of producing seed.

Injury of the seedstalk, which later proved to be boron deficiency, was first observed in the Willamette Valley in the summer of 1938² However, the first boron deficiency was observed on the root, crown, and leaves of beets the winter of 1939-40.

One of the first responses to boron treatment, and one which was reported in the July 1941 issue of the Journal of American Society of Agronomy, was observed November 14, 1939. The leaves of the beets that received 30 pounds of borax per acre prior to planting were a normal green while the ones that received no boron were badly frosted. Beets which had received lime but no boron showed the most severe frost damage. The lowest temperature recorded at the Corvallis Weather Bureau Station that preceded this observation was 31° F., November 10.

As the winter progressed, and following periods of colder weather, other boron-deficiency symptoms appeared. Boron-deficiency symptoms were more striking and most prevalent on larger beets planted on the Willamette soil series.

Single beets in the row with a space on either side were more susceptible to frost injury, and the more common boron-deficiency symptoms. The abundance and degree of frost-injured leaves served as a guide to fields or areas in fields where plants with more advanced symptoms could readily be found. Beets in the experimental plot near Harrisburg that received an application of boron prior to planting remained green and continued to grow during the relatively

^aSeedstock injury was observed at Corvallis in 1938 by George T. Scott, Manager of West Coast Beet Seed Company, F. W. Owen, and Charles Price, Geneticist and Associate Agronomist, respectively, Division of Sugar Plant Investigations, Bureau of Plant Industry, U.S. Department of Agriculture.

mild winter. This statement can be substantiated by weight determinations taken by Myron Stout³ February 2, 1940, and reported in his annual report. His analysis revealed a marked difference in size of beets that were shipped to him from the experimental plot near Harrisburg. He reports the average weight of beets from the noboron plots as 75 grams and the boron fertilized 235 grams. The leaves of the beets in the experimental plot that had not received an application of borax were badly frosted, and the only green growth that remained by spring was the young center leaves of some of the plants.

Although all deficiency symptoms appeared in the field at the same time, one could find plants showing various stages of boron deficiency. The first noticeable symptoms were a thickening, dwarfing, and crinkling of leaves which were very brittle and would break when folded back between the fingers. The petioles were shortened and often contained a rust-colored cross checking on the concave side. Where the stand was thinner, it was common to find the leaves had flattened out, giving the plant a rosette appearance. Then the tips of the youngest center leaves turned black. Finally the entire growing point died, and the outer older leaves became badly frosted. After the center leaves became black in color they decomposed and left the crown exposed. As the winter season advanced many of the petioles of the older leaves turned black at the base and decomposed. Many plants were devoid of leaves and the crown was all that could be seen at the ground surface.

During the late winter or early spring when the plants resumed growth, new buds appeared on the crowns of the plants where the leaves had decomposed and disappeared.

Symptoms on Roots

During the winter period when the boron-deficiency symptoms were apparent on the leaves, many of the roots were showing a breakdown of the outer root tissue. The initial stage of the break-down was a discoloration and break-down of the tissue immediately under the epidermis. Then the epidermis would break or decompose, leaving a reddish-brown decomposed material or canker area. This decomposition was confined to the outer tissue.

The size and number of such areas varied on different roots from one small area to several, and in some cases the root was completely girdled. The canker usually started near the crown of the beet. The canker was commonly associated with plants that were most severely damaged by frost and had lost the center leaves. However, a few plants with apparently normal leaves had canker and many with severely injured terminal buds did not have canker.

³Assistant Physiologist, Division of Sugar Plant Investigations, Bureau of Plant Industry, U. S. Department of Agriculture.

Deficiency Symptoms on Seedstalks

Borax was applied January 22 and 23, at rates of 22 and 24 pounds per acre on two fields of the Willamette soil series that were most severely injured. Areas without any boron were left in the field as checks.

As spring approached new growth appeared. Beets in which the center leaves had blackened and decomposed, and even many that were completely devoid of leaves produced new multiple buds. The canker on the roots dried and calloused over. The value of the January application of borax was not noticeable until the first week of June, at which time a very striking condition appeared in the area that did not receive the January application. The upper part of the seedstalks turned black in color which stopped the terminal growth. Later many plants made some recovery as evidenced by the secondary growth from the lateral buds below the injured area, forming a witches' broom type of plant. The tips of this secondary growth later turned a brown-to-black color. In one field, all of the beets on the area where borax was not applied in January exhibited some symptoms of boron deficiency.

Greenhouse Trials

To obtain some advance information as to the response that could be expected from applying borax in varying amounts to injured plants, and also to determine if the blackened condition of the seedstalk that had been observed the previous season was due to boron deficiency, some greenhouse trials were conducted. Normal plants and various stages of diseased plants were potted in soil taken from the field and placed in the greenhouse January 30, 1940. All plants started to grow, but diseased plants produced multiple-crown growth.

Two vigorous growing plants of comparable size were taken from a plot that received boron in the fall. One was potted in soil taken from the plot where the beets were obtained, and the other from a no-boron plot. A solution of nitrogen, potassium, and phosphorus was applied to both plants February 23 to keep them in a thrifty growing condition. The plant potted in soil to which boron had been added grew normally. By February 29 the newer leaves of the plant potted in soil to which no boron had been applied were short in comparison to width. By March 25 the plant had made a good growth, although the leaves were somewhat abnormal. A large seedstalk developed which was slower in growth than the plant supplied with boron. By May 14 the tip of the seedstalk very suddenly turned black. The leaves at the growing point were as green at the above date as they were before the stalk turned black.

It was noted during the greenhouse trials that the plants potted in soil to which no boron had been added were subject to rapid wilting. Field observations indicated that drought accentuated the development of boron-deficiency symptoms.