Reprinted from Proceedings of the
AMERICAN SOCIETY FOR HORTICULTURAL SCIENCE
Vol. 37, 1939

Problems in Vegetable and Small Fruit Production on Toxic Orchard Soils of Central Washington[1]

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THE fruit growers in the various orchard districts of Washington are confronted with the problem of the economical utilization of land from which old orchard trees have recently been removed. Growers in the early days of tree removal obtained very poor results when such orchard lands were planted to vegetable and small fruit crops. Snyder (4) observed that in 30 gardens planted on old apple orchard land in Washington, no single vegetable made consistent, satisfactory yields and in most cases were a failure. Root crops, with the exception of beets, did fairly well, especially the second or third year after the trees had been removed. Morris (3) reported difficulty in reestablishing alfalfa cover crops in 25- to 30-year-old Washington apple orchards. He believed much of the trouble resulted from lead arsenate accumulations in the surface soil. Investigations with soils from several fruit areas indicate that the arsenic content of these soils is often quite high and is probably responsible for the death of certain crops planted on the soils or for their poor growth and low yields. Vandecaveye, Horner, and Keyton (5) found the greatest concentration of readily soluble arsenic in the top 6 inches of soil and that the degree of injury exhibited by the plants in the experiment was proportional to the concentration of readily soluble arsenic. No marked toxic effects upon plant growth were evident when the concentration of readily soluble arsenic in the soil was less than 1 part per million, but toxic action was severe when the concentrations were 3 to 5 parts per million and more. The arsenic accumulation in Washington orchard soils is a result of the heavy spray applications of lead arsenate in the control of codling moth on apples and pears.

Arsenic injury to crops has been reported by other investigators. Headden (2) found two distinct forms of root rot on apple and pear trees in Colorado orchards eventually causing death, which he believed partly resulted from the toxic effect of soluble arsenic in the soils. The arsenic accumulation resulted from applications of calcium and lead arsenate used in the control of codling moth. Albert (1) reported injury to plants grown on soils previously planted to cotton that annually had been heavily sprayed with calcium arsenate for control of Boll weevil. He found that additions of ferrous sulphate to arsenic-toxic soils benefited subsequent crop growth and that red clay soils relatively high in iron compounds have a much greater capacity to render arsenates non-toxic than gray, sandy soils low in iron. His use of iron compounds in South Carolina soils have not always given definite, consistent results. Later work by Albert shows that the phosphate ion (PO_4) increased the solubility of arsenic and that arsenic toxicity was most pronounced when heavy applications of superphosphate were made.

[1]Published as Scientific Paper No. 435, College of Agriculture and Agricultural Experiment Station, State College of Washington.

Outline of Studies

In the spring of 1939, the Division of Horticulture of the Agricultural Experiment Station, with the cooperation of the Extension Service of the State College of Washington, initiated studies of the problem of toxic orchard soils from which trees had been removed. In order to aid the grower in solving his problem and thus enable him to get some returns from his old orchard land, three demonstration plots of approximately ½ acre each in size were laid out in the Wenatchee area on soils of varying soluble arsenic content and each area planted to the comparable small fruits, vegetables or cover crop plants. One plot was on a heavy clay loam soil that had been out of apple trees for about 7 years, the soil testing 2.0 parts per million soluble arsenic. The trees were 35 years old when removed and had received heavy applications of lead arsenate each year up to the time of their removal. No crop, other than weeds and volunteer grass, had grown on this land since removing the trees.

A second plot was located in the Delabarre apple orchard near Wenatchee, on a coarse sandy loam soil. The 25-year-old Staymen Winesap apple trees were pulled from this tract in December 1937. The trees had been heavily sprayed with lead arsenate for codling moth control up to the time of their removal. No crop was planted following tree removal until the demonstration plots were established. While the soluble arsenic content of this soil tested only 2.0 parts per million, growth of planted crops were in no case as satisfactory as that of comparable plants in the plot longest out of orchard.

A third plot was located at the Von Osten farm, East Wenatchee, on an Ephrata fine sandy loam soil testing 2.5 parts per million soluble arsenic. Jonathan apple trees in this orchard were 30 years old when removed and annually had been heavily sprayed with lead arsenate up to their removal in May 1939.

The soil in each of the three plots was analyzed for its arsenic content by the Division of Soils of the State College. While slightly larger amounts of arsenic were found in the soil just out of orchard, it is difficult to explain upon the basis of parts per million of soluble arsenic reported the vast differences in plant response in the three plots.

Each plot was divided into four equal parts, of approximately ⅛ acre (50 feet x 104 feet) each. Two of the four parts of each plot received cow manure at the rate of 16 tons per acre. To one of these manured areas actual nitrogen at the rate of 50 pounds per acre was applied in the form of ammonium sulphate to aid in the decomposition of the straw, and to supplement the nitrogen available in the manure. The second manured area received no commercial fertilizer. The plots were then plowed to a depth of approximately 8 inches and harrowed to a fine state of tilth. Before the final harrowing, one section of each plot to which manure had not been applied received ammonium phosphate at the rate of 40 pounds of actual nitrogen and 60 pounds of actual phosphorus per acre. The soil of the fourth section received 50 pounds actual nitrogen per acre applied in the form of ammonium sulphate.

The section in each plot to which ammonium phosphate was applied

and the one to which only manure was added were each planted to the same kind and varieties of small fruits and vegetables in 1939. The remaining two sections in each plot, the one to which manure and ammonium sulphate were applied and the other to which ammonium sulphate only was added, were planted to spring rye at the rate of 40 pounds per acre and Markton oats at the rate of 60 pounds per acre the last week in March 1937, except the Von Osten plot which was seeded April 3. The rye and oats were grown as green manure crops to increase the organic matter in the soil and to determine if the arsenic toxicity to subsequently planted small fruits and vegetables could be thus reduced. In early July, following heading, a heavy stand of rye and oats was plowed under on each plot and sufficient ammonium sulphate to give 50 pounds of actual nitrogen per acre was again applied to aid in decomposition of the vegetation. In late August and early September these areas were planted to Rosen rye at the rate of 60 pounds per acre. In the spring of 1940, all four sections of each plot will be plowed and planted to comparable small fruit and vegetable crops.

All varieties of small fruits and vegetables were replicated once in 1939 on the section of each plot treated with ammonium phosphate and the one treated with manure only. The kinds planted were grapes, raspberries, Boysenberry, strawberries, asparagus, sweet corn, tomatoes, snap beans, peas, lima beans, onions, and potatoes. Only commercially important varieties suitable for canning and freezing or that had some market value were planted.

Preliminary Results

The results of the 1939 plantings may be summarized as follows: Rye, on all plots, proved to be very resistant to arsenic toxicity, making an excellent plant growth. Markton oats, while somewhat resistant, made a much slower plant growth than did rye. The thinnest stand of rye was on the most toxic soil, but because of a delay in getting the stumps pulled from this land the rye was not seeded as early as on the other two plots. Little growth differences existed between rye planted on manured and non-manured areas except in the plot longest out of orchard, where rye was superior on areas receiving manure.

The various small fruit and vegetable varieties gave the best growth performance in the plot longest out of trees. The growth of plants, generally speaking, was next best on the plot out of trees 2 years, while the poorest growth was on land just out of orchard.

Plants that appeared to do equally well on all three plots were potatoes, asparagus, and tomatoes. The tomatoes, on land just out of old trees, were very slow in maturing their fruit, as the plants were seriously stunted until middle July, after which they recovered and made an excellent growth. While many fruits ripened, the vines were loaded with green tomatoes when killed by frost. On the least toxic plot the vines were vigorous and bore a heavy crop of fruit, a total of 800 pounds being harvested. Of this amount 500 pounds were harvested from the manured plot and 300 pounds from the plot receiving

ammonium phosphate. The plot out of orchard 2 years produced 450 pounds of ripe tomatoes, half being picked from the manured and half from the commercial fertilizer area. On the plot longest out of orchard, grapes, raspberries, strawberries, Boysenberry, asparagus, tomatoes and potatoes all made a satisfactoy plant development, the growth being about the same on the two sections. In fact all plants on this soil were nearly normal in their development with strawberries making an exceptionally fine plant growth. Of the various crops planted in this plot, snap beans, lima beans, peas and onion transplants made the poorest showing, the lima bean seed rotting in the soil. Apparently the lima bean seed is easily injured by the arsenic in the soil. While this plot was the only one of the three from which green beans and peas were harvested, the plants were not entirely normal and the yields were low. Onion transplants turned yellow and died within 6 weeks after planting. Mature onion bulbs, planted for seed development, made a satisfactory growth.

On the plot out of orchard 2 years, grapes, Boysenberry, asparagus, tomatoes and potatoes responded fairly well. Raspberries and strawberries grew well for a short time following their planting but were nearly all dead by the end of the summer. Grapes, Boysenberry and asparagus made a fair growth but snap beans and peas only grew a few inches high and then died. The lima bean seed rotted in the soil. Corn seed germinated well but the growth of plants was very uneven. No plants were normal at maturity.

In the plot just out of orchard, the various grape varieties, the Boysenberry and asparagus plants were making only a mediocre growth compared with the same varieties in the other two plots. Raspberry and strawberry plants grew for a short time following planting but by the end of summer only a few raspberry plants were alive and there were no living strawberry plants. Peas, snap beans and corn all failed to make any growth after emerging from the ground, while the lima bean seed rotted. The onion transplants turned yellow and were all dead 4 weeks after planting. Bulb onions produced a good crop of seed. Potatoes and tomatoes were the only crops harvested.

Summary

In summarizing the results after 1 year's observations, of the kinds of small fruits and vegetables grown, potatoes appear to be a safe crop to plant in soil just out of heavily sprayed orchards. Other crops that remained alive and made some growth are asparagus and grapes. Tomatoes, after persisting in a stunted condition for awhile, finally made a fairly desirable plant growth, although the fruit ripened late. Onion bulbs planted for seed production were promising. Rye, both spring and fall varieties, likewise made a satisfactory growth. Legumes, such as beans and peas, appeared to be the most adversely affected by soil toxicity. It also seemed that the longer the soil was out of heavily sprayed orchards the better the plants responded.

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