California Avocado Society 1955 Yearbook 39: 193-201

PHOSPHATE RESPONSE IN AVOCADO TREES

A. R. C. Haas and Joseph N. Brusca
Plant Physiologist and Senior Laboratory Technician, University of California, Citrus Experiment Station, Riverside.

The authors of this article do not wish to imply that an avocado orchard will be benefited by the inclusion of phosphorus in the fertilizer practice. Consult your farm advisors as to fertilizer recommendations.

(Improvement in tree growth indicated in sand cultures as the phosphate concentration was increased)

Phosphate tests were conducted in which the concentration of nitrogen in the nutrient solution was kept uniform. This was because our previous results have shown that the phosphorus content in the leaves of avocado seedlings that received similar phosphate concentrations in soil cultures increased as the concentration of nitrogen increased in the nutrient solution. The increased nitrogen increased the production and phosphorus content of the leaves while decreasing the phosphorus content in the rootlets. Avocado trees always receive some form of nitrogen fertilization. An increased nitrogen fertilizer program would increase the phosphorus requirements of the leaves. Our studies have shown that the skin, pulp, and seed of avocado fruit contain considerable phosphorus. In citrus culture the absorption of phosphorus is sometimes facilitated by the application of phosphate to the roots and that of appropriate nitrogen to the leaves.

With a given level of nitrogen in silica sand cultures, a series of tests were made of the effectiveness of phosphate in increasing avocado tree growth before the occurrence of fruiting.

The nutrient solution in all cases consisted of distilled water containing one and one-half times the concentration of the stock solutions A and B used in Hoagland's nutrient solution. To this culture solution were added—parts per million—: .2 of boron, manganese, zinc, and iron, .1 of copper, 3 of aluminum—as the citrate, and 5 of molybdenum. Additions of calcium acid phosphate solution were made to the culture solution in order to obtain various levels of phosphate. All cultures—silica sand—were provided with drainage and distilled water.

Some tests were made with seedlings from the propagation beds, whereas others were conducted with budded trees. Avocado seedlings including the varieties commonly used as rootstocks, were grown with Hoagland's nutrient solution in small containers of soil in the lath house until ready for budding. The seedlings at all times appeared healthy and free of symptoms. A healthy Fuerte-Carr avocado tree in the Citrus Experiment Station orchard supplied the budwood. The budded trees were grown in the lath house until ready—about 12 to 15 inches tall and with a number of mature leaves—for planting bareroot in the cultures, any remaining portion of the seed being discarded.

On February 4, 1953, a Fuerte-Carr avocado tree budded on Caliente-Mex. rootstock was planted in each of seven cultures—12 inches in diameter by 12 inches deep—in the glasshouse. The concentrations of phosphate in the nutrient solution were: 0, 6.56, 13.13, 26.25, 52.5, 105, and 210 parts per million. On March 23, 1954, the tops had the appearance seen in figure 1 and the roots as seen in figure 2. Growth in the tops and roots improved as the concentration of phosphate in the nutrient solution was increased. Table 1 gives the weights of the various portions of the trees. Columns 6 and 7 indicate that with a given level of nitrogen in the nutrient solution, the growth of the tops and rootstock portions were greatest at the three highest phosphate concentrations.

Fig. 1. Improvement in the tops of Fuerte-Carr avocado trees budded on Caliente-Mex. rootstocks and grown in the glasshouse in cultures the nutrient solutions of which contained a similar nitrogen content but—left to right—increasing concentrations of phosphate.

Fig. 2. Left to right: effect of increasing concentrations of phosphate on the growth of Caliente-Mex. avocado rootstocks budded to Fuerte-Carr tops and grown in the glasshouse.

Table. 1. Number and weight of leaves, trunk length of top, weight of trunk of top and its branches, and dry matter of rootstock below the bud union in relation to the concentration of phosphate added in the form of calcium acid phosphate to the nutrient solution.

Culture No.	Phosphate concentration in culture solution; parts per million	No. of leaves produced	Fresh wt. of leaves; grams	Trunk length; inches	Total fresh wt. of tops; grams	Total dry wt. of rootstocks; grams
1	0	105	149	53	285	125
2	6.56	178	265	69	601	128
3	13.13	216	307	78	675	146
4	26.25	194	251	67	582	105
5	52.50	242	350	69	738	191
6	105.00	272	392	84	923	175
7	210.00	225	384	85	870	186

The leaves of the culture that received no phosphate were light yellowish-green as were also the trunk and branches once the shortage of phosphate within the tree became acute. A characteristic common to other glasshouse cultures of Fuerte-Carr avocado tops on various root-stocks, the nutrient solution of which contained no phosphate, was the earlier initial production of new top growth with its leaves remaining a yellowish-green and the apparent retardation or failure of the tree to continue growing. Low concentrations of phosphate—under glasshouse conditions—were adequate for healthy growth, the extent of which was commensurate with the concentration, of phosphate in the nutrient solution.

The lack of a dark green color in phosphate-deficient avocado trees under glasshouse conditions can be seen in Fuerte-Carr avocado trees budded on Harman-Mex. rootstocks and grown in three-gallon-capacity cultures. To the left in figure 3 is shown the appearance on November 16, 1953, of the culture that received no phosphate, whereas to the right is shown the culture the nutrient solution of which contained 6.56 parts per million of phosphate in the series: 0, 6.56, 26.2, 52.4, 105, and 210. Note the dark green color of the leaves when the culture solution contained 6.56 parts per million of phosphate in contrast with the paleness of the mature uppermost leaves of the culture lacking phosphate. In both cultures the very lowest leaves attached to the trunk are dark green and were present at the time of planting. On March 19, 1954, the same two trees appeared as shown in figure 4 after both cultures had completed and matured their growth. The appearance of the tree grown without phosphorus in its culture solution could easily be mistaken for symptoms of nitrogen deficiency even though there was always a uniformly large available supply of nitrogen. When 105 parts per million of phosphate—the content in Hoagland's solution—was added to the nutrient solution that previously contained none, its application gradually increased the green color of the tops and resulted in *a* healthier resumption of growth.

Fig. 4. The same two trees as shown in fig. 3, 4 months later after both cultures had completed and matured their growth.

Fig. 3. Left, shows Fuerte-Carr avocado tree budded on Harman-Mex. rootstock where no phosphate was added to the nutrient solution. The tree on the right was grown in a solution containing 6.56 parts per million of phosphate.

Apparently an abundance of nitrogen is of little or no value for the health of an avocado tree unless there is some phosphate available. As shown in figure 1 for glasshouse conditions, a low phosphate concentration in the nutrient solution may suffice to keep the leaves green although considerable phosphate is required in order to obtain a maximum growth with a high and uniform level of nitrogen supply. To this phosphorus requirement for growth should be added the phosphorus requirement for fruit production. Thus under glasshouse conditions in soil cultures grown with a uniform level of phosphate and increasing nitrogen concentrations, growth of the tops was increased and in the present silica sand cultures with a uniform level of nitrogen and increasing phosphate concentrations, growth of the tops also was increased. Nitrogen and phosphorus thus appear to be complementary to one another in promoting healthy avocado tree growth.

The inclusion of Caliente—Mex. rootstocks in the tests was fortunate in that an important observation was made in regard to sun-blotch in avocado trees. All of the Caliente—Mex. avocado seed were purchased as a lot from *a* reliable avocado seed dealer. The seed were selected for uniformity and were grown as potential rootstocks in a manner similar to the other seed. No evidence of sun-blotch appeared in any of the seedlings. All the seedlings to be budded were budded at the same time with budwood from a selected healthy Fuerte-Carr-Hybrid tree as previously mentioned. The budding of the Caliente-Mex. avocado seedlings resulted in excellent trees with no indications of sunblotch symptoms. Eight of these trees were grown in silica sand cultures to a height of eight or more feet with no indications of sunblotch. When pruned back to a height of eighteen inches with no leaves or branches remaining, the newly produced branches on two of these trees showed reddish-yellow streak symptoms typical of sunblotch.

These results are reported because seedlings affected with sun-blotch without showing symptoms when planted in the field, have been shown by others to produce symptoms on the growth obtained by budding with healthy buds. In the present observations, sunblotch symptoms were evident neither in the seedlings before nor after the budding with healthy buds, but appeared on new growth following the severe pruning back of the trunk of the budded tree. The results raise the question of the means necessary to cause expression of sunblotch symptoms.

With avocado trees on various rootstocks or with avocado seedlings, the maximum growth usually was obtained at a high but not always at the same high phosphate concentration, dependent on such factors as the size of the culture container that would restrict root-growth, the nature of the rootstock variety, size of attached seed, whether grown in the glasshouse or out-of-door, and on the nitrogen concentration. Although there is considerable variability in avocado seedlings, several series of cultures were conducted in the glasshouse to test the effect of phosphate concentrations on growth. An avocado seedling of the Nowell-Hybrid-variety was planted in each three-gallon capacity culture. The following parts per million of phosphate were added to the culture solution: 0, 15.5, 31, 62, 93, 124, 155, 186, 210, 262.5, and 315. The height-in inches-of the seedlings produced were: 18, 34, 34, 31, 40, 34, 52, 72, 56, 53, and 70. Leaf fresh weights-grams-were: 35, 69, 57, 52, 67, 58, 117, 156, 87, 71, and 130. The dry matter of the roots when no phosphate was supplied was 7 grams; the maximum—45 grams—occurred at the 155 level, whereas 33 grams was produced at the 315 level.

Phosphate tests were also conducted out-of-doors in full sunlight and subject to many conditions of weather. The hardened budded trees grown in the previously described manner were planted bareroot in the cultures on February 16, 1953. In each of eight 12-gallon capacity earthenware jars was planted a Fuerte-Carr avocado tree budded on Mexicola-Mex. rootstock. To the culture solution was added: 0, 3.28, 6.56, 13.12, 26.25, 42.5, 105, and 210 parts per million phosphate. On January 12, 1954, the leaves, trunk, and branches, when no phosphate was supplied, were yellowish-green; at the 3.28 ppm level the leaves showed a slight burn; at the 6.56 and 13.12 level there was considerable leaf burn—figure

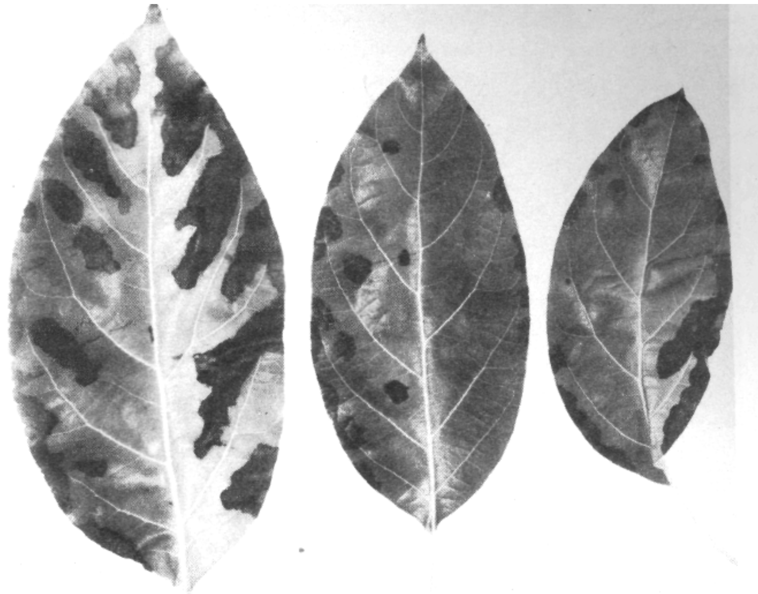

Fig. 5. Leaf burn produced during January and March in Fuerte-Carr avocado trees on Mexicola-Mex. rootstock grown in out-of-door cultures the nutrient solution of which contained inadequate phosphate. Leaves of low phosphate cultures appear as though nitrogen deficient although the culture solution contained adequate nitrogen.

5—whereas at higher levels the leaves were free of burn. On March 1, 1954, at the 13.12 level there was considerable leaf burn.

The high temperatures in July, 1954, were accompanied by sunburn in leaves and on September 1, 1954, the cultures were protected by lath except on their eastern exposure. Recovery was rapid and the growth as prior to the sunburn was improved as the concentration of phosphate was increased. In figure 6, right to left, culture nos. 2, 3, and 4, on November 16, 1954, were similar in appearance and slightly taller, of better leaf color and of more dense growth than culture No. 1 that received no phosphate. Beginning with No. 5—26.25 ppm—the increase in green color and tree growth was very pronounced.

Mexicola-Mex. avocado seedlings with seeds attached, when grown in the glasshouse in three-gallon capacity cultures with a nutrient containing: 0, 6.56, 13.125, 26.25, 52.5, 105, 157.5, and 210 ppm phosphate, showed maximum growth at the 105 level, whereas at 52.5 or higher levels the growth was greatly superior to the lower phosphate levels.

Fig. 6. Increased growth and darker green color in leaves of Fuerte-Carr avocado trees on Mexicola-Mex. rootstock grown out-of-doors in twelve-gallon capacity cultures, the nutrient solution of which contained —right to left—the following phosphate content: 0, 3.28, 6.56, 13.12, 26.25, 52.5, 105, and 210 parts per million.

Fig. 7. Growth of Fuerte-Carr avocado trees on Dickinson-Guat. rootstock in out-of-door cultures the nutrient solution of which contained right to left: 0, 13.12, 52.5, and 210 parts per million phosphate.

Fuerte-Carr avocado trees on Dickinson-Guat. rootstock were planted on February 16, 1953, in out-of-door containers 20 inches in diameter by 26 inches deep. These cultures were grown in a manner similar to that of the trees out-of-doors on Mexicola-Mex. rootstock. The phosphate levels in the nutrient were: 0, 13.12, 52.5, and 210 parts per million. On April 2, 1954, all of the trees were making new growth except the culture receiving no phosphate. After being subjected to high temperatures of summer and then protected by lath after September 1, 1954, the growth on November 16, 1954, still showed the beneficial effect of increasing the phosphate.