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Variations in the Phosphorus and Potassium Content of the Foliage From Fuerte Avocado Groves*

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A study to determine the phosphorous and potassium status, by means of leaf diagnosis, of 26 Fuerte avocado orchards in Southern California was started in June 1944. Sixteen groves in the Vista and Escondido districts of San Diego County, and 10 groves in the La Habra area of Orange and Los Angeles Counties were sampled. One purpose of the study was to determine if the main cycle (spring) of growth could be sampled, under field conditions, throughout the season. As there were little or no data on the role of phosphorus and potassium in avocado tree fertilization, other factors were considered important in the development of a leaf sampling technique. The first, was to determine whether leaf-petioles or leaf-blades were most indicative of the nutrient status of the plant. The second, was to study the effect of past fertilization and cultural practices on the phosphorus and potassium in the tree. The effect of fruiting on these elements was also considered of interest.

PROCEDURE:

Between June 1, 1944, and June 1, 1945, ten sets of leaf samples were collected at 4 to 7 week intervals from 41 locations in the 26 groves sampled. Sampling areas were chosen in relation to tree uniformity, bearing behavior, soil conditions, and past cultural and fertilization practices. Ten trees were marked at each location and five leaves were collected at random from the outside of each tree. The leaves from the ten trees were composited at each sampling date. During the sampling period, basal mature leaves were taken from the 1944 spring cycle growth.

The leaf samples were separated at time of picking into leaf-petioles and leaf-blades. The samples were then dried at 80 degrees Centigrade and ground in a Wiley Mill to pass the 40 mesh screen. The petioles and blades were analyzed separately. Potassium was determined by ashing the finely ground material, precipitating with sodium cobaltinitrite and titrating the precipitate with potassium permanganate. Two percent acetic acid soluble phosphate-phosphorus (inorganic) was determined colorimetrically by the ammonium molybdate, stannous chloride method.

The analytical results on 6 groves, that represent the range in phosphorus and potassium values found in the 26 groves sampled, will be given. The nutrient content of samples collected from fertilizer plots established on Ranch C in 1943 are also included. All of the groves are located in San Diego County on hill side residual soils derived from granitic parent material. With the exception of grove C, which was seven years old at the beginning of sampling, the groves were 15 years old or older. The trees in Grove P were slightly stunted, taut the tree appearance in all other areas included was excellent when the first samples were taken.

TABLE 1—Percent Potassium and Parts Per Million Phosphate-Phosphorus, on dry weight basis, in Leaf-Blade and Leaf-Petiole Samples Collected from Six Fuerte Avocado Groves

Grove & Sample	6-1-44	6-26	8-8	9-15	10-15	12-25	2-5-45	3-18	4-26	6-1-45
Percent Potassium in Petioles										
A-1	2.68	2.61	2.16	2.15	1.82	2.16	1.92	1.86	1.90	1.85
A-2	2.51	2.16	1.76	1.61	1.71	1.62	1.37	1.40	1.34	1.34
B	1.93	1.30	.76	.59	.46	.52	.39	.44	.40	.24
C	1.31	1.06	.63	.63	.44	.39	.26	.27	.24	.20
D	1.91	1.72	1.06	1.02	.93	.67	.60	.51	.43	.36
E	—	1.10	1.07	.83	.71	.63	.56	.44	.32	.26
F	2.86	2.47	1.59	1.34	1.38	1.30	1.24	.83	.98	.97
Percent Potassium in Blades										
A-1	—	1.45	1.22	1.09	1.07	1.02	.86	.74	.73	.70
A-2	—	1.33	1.02	.87	.84	.85	.70	.59	.56	.54
B	1.29	.91	.61	.56	.44	.38	.20	.34	.30	.26
C	.85	.73	.61	.49	.51	.49	.39	.40	.34	.27
D	1.08	.96	.74	.65	.59	.59	.58	.51	.40	.34
E	.94	.78	.80	.57	.54	.48	.48	.34	.30	.26
F	1.25	1.04	.88	.75	.75	.71	.63	.50	.48	.45
Parts Per Million Phosphate—Phosphorus in Petioles										
A-1	1795	2555	2575	2590	2355	2095	1970	1765	1775	1795
A-2	1630	2165	2145	2115	1995	1820	1635	1490	1480	1500
B	2190	1620	1220	1040	855	605	335	460	370	240
C	1370	1250	1240	1375	990	820	620	595	455	370
D	815	630	615	635	535	370	345	260	260	240
E	—	1370	1720	1720	1675	1235	1260	740	660	615
F	965	800	625	600	345	250	320	245	200	170
Parts Per Million Phosphate—Phosphorus in Blades										
A-1	—	1245	1025	840	720	850	615	600	580	555
A-2	—	1045	795	625	625	685	460	445	450	450
B	875	835	600	400	330	330	190	275	260	195
C	940	605	500	410	405	440	350	370	285	275
D	795	535	365	400	455	420	270	265	270	260
E	795	740	645	600	545	520	380	300	300	315
F	750	450	275	315	285	290	200	225	215	195

Grove & Sample No.	Fertilizer, Cultural Program And Production Record Of Groves Sampled
A-1 A-2 Vista, Calif.	25-35 pounds of 6-9-6 and 4-10-10 per tree per year for 12 years. Non-cultivation and irrigated with permanent sprinklers. Average yield since 1938, 4-6 tons per acre per year.
B Vista, Calif.	Nitrogenous fertilizers prior to 1943; since 1943 15-20 pounds of 8-8-4 per tree per year. Grove cultivated and irrigated by furrows. Average yield since 1938, 4-5 tons per acre per year.
C Escondido, Calif.	Two to three pounds of nitrogen per year plus heavy applications of manure. Grove cultivated and irrigated with portable sprinklers. No production record available.
D Escondido, Calif.	Two pounds of nitrogen per tree per year for past 14 years. Past four years received additional pound of phosphoric acid per tree per year. Grove cultivated and irrigated by furrows. Average yield since 1936, 4 tons per acre per year.
E Escondido, Calif.	20-30 pounds of mixed and nitrogenous fertilizers per tree per year. Grove non-cultivated and irrigated with permanent sprinklers. Average yield since 1937, 4-6 tons per acre per year.
F Vista, Calif.	Nitrogenous fertilizers and manure. Grove cultivated and irrigated by furrows. Production average has been low.

RESULTS:

1—Changes in Composition of Petioles and Blades During Sampling Period.

The analytical data show that marked changes in the potassium and phosphorus content in both petioles and blades occurred during the dates of sampling. Table I illustrates the change in amounts with age, as well as the variation between groves of low and high nutrient content. The trend of both elements, on a dry weight basis, was downward as the age of the growth increased.

In groves of high as well as groves of low nutrient content there is a direct relationship between the age of growth sampled and the phosphorus and potassium content in the leaf-blade. This same condition holds true in the leaf-petiole tissue from groves that tend to be in the lower ranges in relation to phosphorus and potassium. In groves of high nutrient content, as shown by leaf analyses, the trend in the leaf-petiole with increasing age is downward, but there is some fluctuation during the season (Grove A-1, A-2), The analytical results indicate that representative samples of the 1944 spring cycle growth were obtained throughout the sampling period.

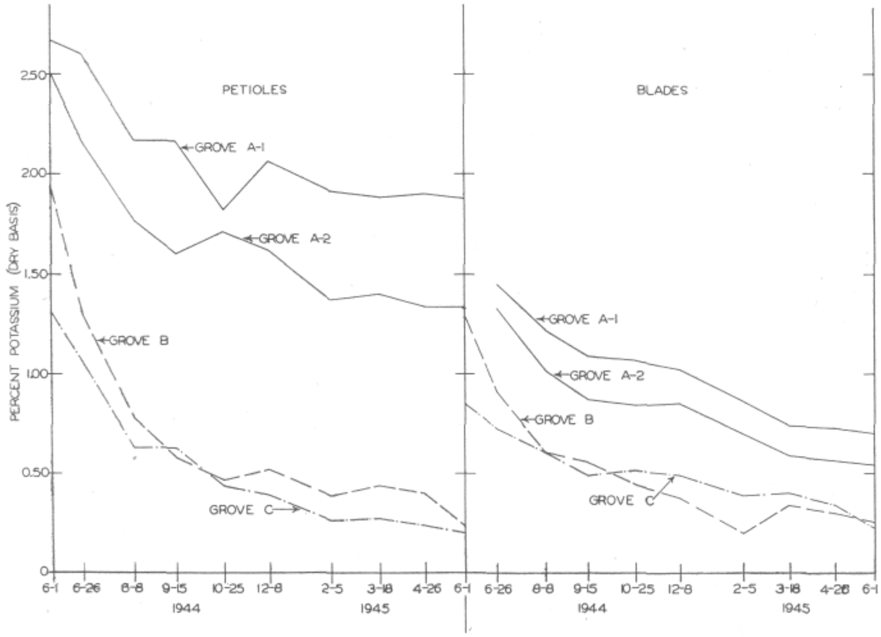

Figure 1

2—Comparison of Phosphorus and Potassium in Blades and Petioles.

The greatest variation of phosphorus and potassium between groves of low and high nutrient content occurs in the leaf-petiole samples. A consistent difference is also found in the leaf-blade tissue, but it is of less magnitude than in the corresponding leaf-petiole material.

For the period June 1, 1944, to June 1, 1945, Fig. 1 shows the changes in potassium that occurred in the leaf-blade and leaf-petiole samples. On June 26, 1944, at which time the growth sampled was approximately 3 months old, the range in potassium between groves of high and low nutrient content was from 1.06 percent to 2.61 percent in the petioles. At the same date the range in the corresponding blade samples was from 0.73 percent to 1.45 percent potassium. Eleven months later, when the growth sampled was 14 months old, the range in potassium was from 0.20 percent to 1.95 percent in the petioles, and from 0.27 percent to 0.70 percent in the blades.

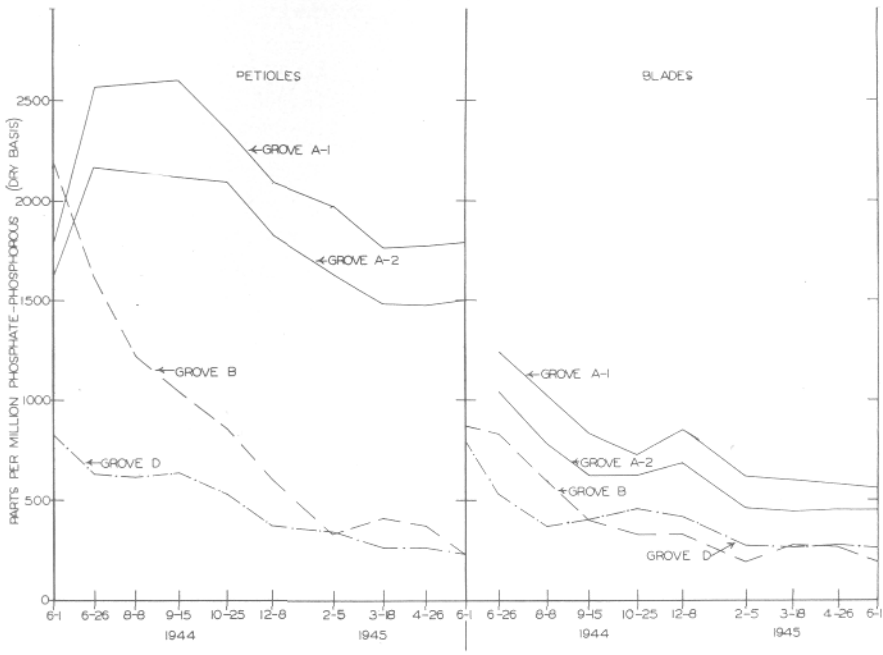

Figure 2

Fig. 2 illustrates the changes in the amount of phosphate-phosphorus during the period from June 1, 1944, to June 1, 1945. In the samples collected June 26, 1944, the range in parts per million phosphate-phosphorus, on the dry-weight basis, was from 630 p.p.m. to 2555 p.p.m. in the petioles, and from 525 p.p.m to 1245 p.p.m in the blades. At the time of the June 1, 1945, sampling the range in phosphate-phosphorus was from 240 p.p.m. to 1795 p.p.m. in the petioles, and from 260 p.p.m to 555 p.p.m. in the blades.

It is of interest to note that in groves with a low nutrient content in the foliage, the amount of potassium may become less in the petioles than in the blades. This condition also occurs in groves of low phosphorus content. At present, it seems reasonable to assume that the leaf-petiole acts as a reservoir for phosphorus and potassium. If the root absorption is greater than the needs of the scion, nutrients will build up in the petioles and remain higher than in the blades throughout the season. Conversely, the leaf-blade will take the nutrients at the expense of the leaf-petiole if the needs of the top exceed root uptake.

Future investigations in the development and application of the leaf analysis technique to avocado fertilization, the relation of concentration of nutrients between the petiole and blade may prove to be an important guide.

3—Effect of Orchard Fertilization Practices on the Amounts of Phosphorus and Potassium in Avocado Trees.

Due to the variance of many factors in avocado culture, such as soil conditions, methods of irrigation and cultivation, it is difficult to determine the actual effect of varying fertilizer practices on the leaf content of phosphorus and potassium in different groves. However, in the leaf analysis survey of the 26 groves with all other factors being as near equal as possible, those groves that had received fertilizers containing phosphorus and potassium as a regular program were highest in these elements.

The effect of differences in fertilizer practices on avocado trees can be most clearly studied by comparing the nutrient concentrations found in Grove A-1 and A-2, and Grove B (Figs. 1 and 2). The orchards were planted at the same time with trees from the same source, and both have had high production records. The orchards are adjoining and the only variables, except for fertilization, have been in the methods of irrigation and cultivation. The trees in Grove B have deteriorated rapidly in the last 8 months. Whether this is a result of heavy production and the lack of adequate fertilization in the past can not be accurately determined at present. However, the difference in the nutrient levels in the two orchards lend emphasis to the belief that inadequate fertilization may have been a contributing factor to the present condition of Grove B.

4—Effect of Fruiting on the Phosphorus and Potassium Leaf Content.

Individual tree production records have been kept for a number of years on Grove A. At each sampling date samples were collected from five trees that had been low producers in the past, and had a small crop in June, 1944 (Figs. 1 and 2, Curve A-l). The phosphorus and potassium content of these trees were compared to samples collected from five trees in the same orchard that had high production records in the past, and had a heavy set of fruit at the time of sampling (Figs. 1 and 2, Curve A-2). The trees are all the same age, comparable in size and appearance and have received the same care. During the sampling period, the concentration of both phosphorus and potassium was higher in the low producing trees than in the high producers. To check on this phase of the work, four other locations were chosen, at which separate samples were taken from low and high producing trees. Table 2 illustrates the results obtained from these areas. The results indicate that there is a tendency for heavy fruiting to lower the concentration of phosphorus and potassium in the avocado tree. Lilleland and Brown (1) found that the size of the crop on Muir peach trees affected the amount of potassium in the trees. Cameron and Bialoglowski (2) found that throughout most of the year the size of the crop on avocado trees had no significant effect on the amount of nitrogen in the tree. The influence of heavy fruiting on the mineral content of the tree, in relation to the alternate bearing characteristics of the Fuerte avocado, should be studied in more detail.

TABLE 2—Effect of Fruiting on the Phosphorus and Potassium Content in Leaf-Blade and Leaf-Petiole Samples

Grove	4-25-45 Heavy Crop	4-25-45 Light Crop	6-1-45 Heavy Crop	6-1-45 Light Crop
Percent Potassium in Blades				
G	0.63	0.67	0.56	0.79
H	0.80	0.89	0.65	0.74
I	0.40	0.52	0.28	0.30
J	0.52	0.54	0.51	0.62
Percent Potassium in Petioles				
G	1.56	1.71	1.36	1.82
H	1.83	1.92	1.68	1.91
I	0.58	0.68	0.40	0.56
J	0.75	0.93	0.63	1.08
Parts Per Million Phosphate—Phosphorus in Blades				
G	455	475	440	465
H	430	450	390	455
I	300	325	305	350
J	295	460	285	425
Parts Per Million Phosphate—Phosphorus in etioles				
G	1460	1610	1440	1625
H	865	1345	830	1200
I	655	755	640	690
J	580	1315	600	1280

5—Fertilizer Test Plot

In the summer of 1943 four plots of 10 trees each were selected for fertilization studies in Grove C. The trees were 6 years old at the beginning of the experiment and growing on a residual granitic soil mapped as Vista loam. The plots are cultivated and irrigated with portable sprinklers.

Two applications of fertilizer were made prior to and during the sampling period. The treatments were as follows:

FERTILIZER TREATMENT

Plot	June 1943	July 1944
N	10# $(NH_4)_2SO_4$	11# $(NH_4)_2SO_4$
NPK	2# $(NH_4)_2SO_4$ 10# amm. phos. (16-20-0) 20# K_2SO_4	20# amm. phos. (11-48-0) 10# K_2SO_4
NP	2# $(NH_4)_2SO_4$ 10# amm. phos. (16-20-0)	20# amm. phos. (11-48-0)
NK	10# $(NH_4)_2SO_4$ 20# K_2SO_4	11# $(NH_4)_2SO_4$ 10# K_2SO_4

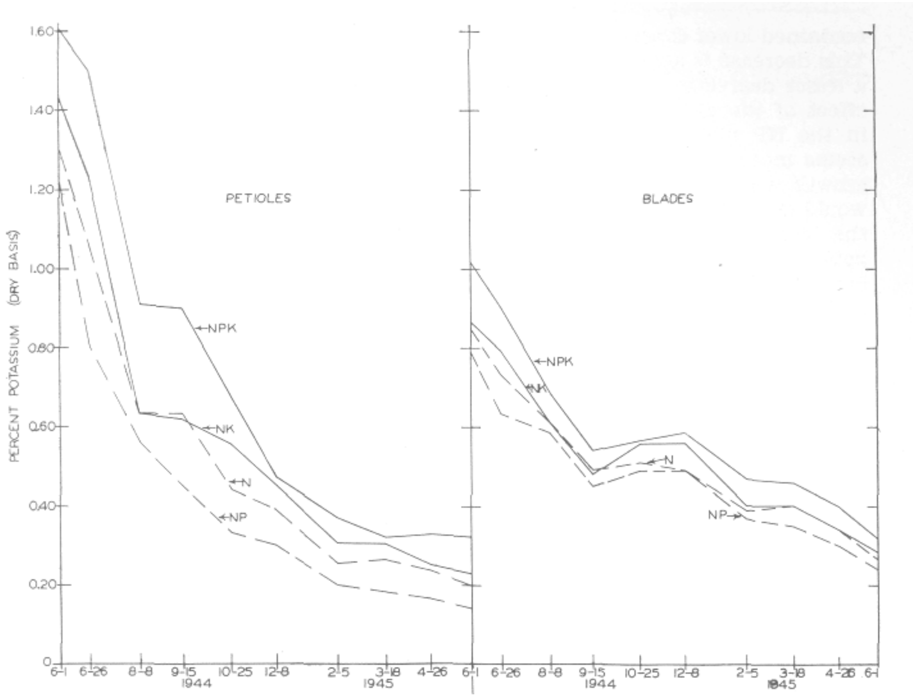

Figure 3

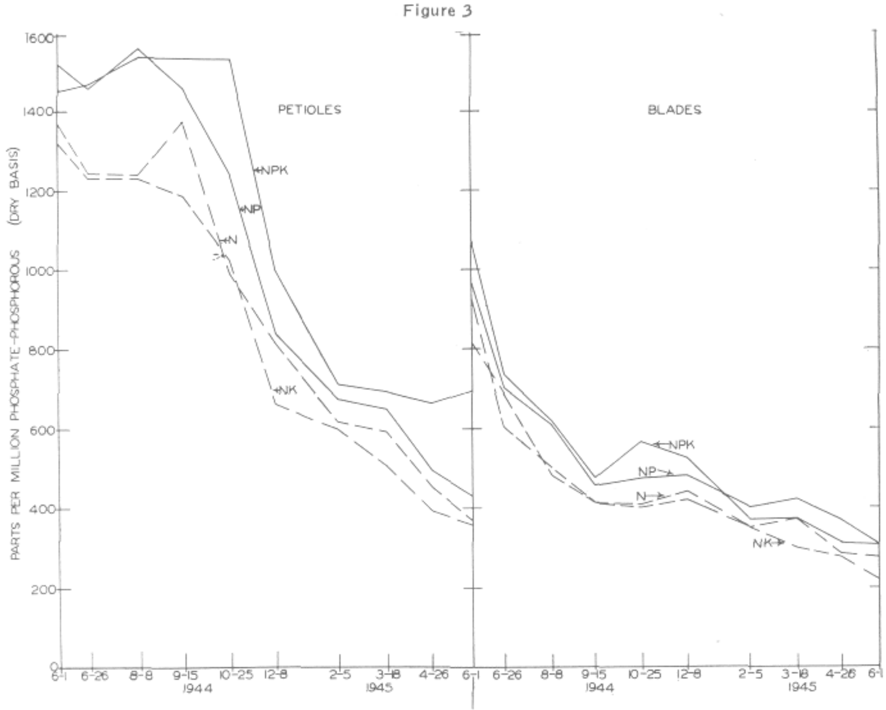

Figure 4

A comparison of nutrient content in the leaf samples collected from the fertilizer plots during the sampling period is illustrated in Fig. 3 for potassium, and in Fig. 4 for phosphorus. Using the N plot as an index for comparison, the leaf content of potassium is low and phosphorus is medium compared to the other groves sampled.

Potassium accumulation, as shown by both petiole and blade analyses, was greatest in the trees that had received phosphorus as well as potassium fertilizer. During most of the same season, leaf-petiole samples from the NK. plot contained slightly higher amounts of potassium than leaf-petiole samples from the N plot. The corresponding leaf-blade samples from the same plots showed no difference. The effect of phosphorus fertilization under the conditions of the experiment is striking. The trees in the NP plot contained lower concentrations of potassium than the trees in the other plots. This decrease is shown most clearly in the petiole samples, but also occurs to a lesser degree in the blades. The condition may be due to an antagonistic effect of the phosphorus on potassium absorption by the roots of the trees in the NP plot. However, as the trees are normally low in potassium, it seems more probable that the addition of phosphorus alone stimulated top growth which materially lowered the potassium content in the trees. This would occur if the available potassium in the soil was not sufficient to meet the increased needs of the trees. The amount of potassium in the leaf-petioles became less than in corresponding leaf-blade samples during September in the NP plot, in October in the N and NK plots and not until November in the NPK plot.

Fig. 4 illustrates the phosphate-phosphorus content in the trees receiving different fertilizer treatments. The plots receiving phosphate fertilizers were higher in this element than in the plots that received no phosphate application. This holds true throughout the sampling period in both leaf-petiole and leaf-blade samples. The most marked increase in phosphorus accumulation occurred in the leaf-petiole samples.

Three additional test plots have been established in groves of low potassium and phosphorus leaf content. At present there are no data available showing the leaf content of these elements that constitutes a deficiency in avocado orchards. However, wide variations have been found in phosphorus and potassium levels in the groves sampled. Until more definite optimum levels have been established, groves sampled in the future can be compared to groves already sampled on the basis of low, medium or high amounts of phosphorus and potassium.

SUMMARY:

(1) It has been found that representative leaf samples can be obtained from the spring cycle growth of Fuerte trees throughout the growing season.

(2) The trend of potassium and phosphorus, in petioles and blades is downward as the age of the growth increases. In the groves sampled, wide variations of phosphorus and potassium were found between groves of low and high nutrient content.

(3) The leaf-petiole is most indicative of the phosphorus and potassium status of the plant. The relation of concentration of nutrients between petiole and blade may be the best guide in the interpretation of leaf analysis results.

(4) In comparable avocado groves, those that have received fertilizers containing phosphorus and potassium tend to have higher concentrations of these elements in the trees than groves that have received mainly nitrogenous fertilizers.

(5) Available data indicate that heavy fruiting lowers the reserve of phosphorus and potassium in the tree. This may be one factor in the alternate bearing characteristics of the avocado trees.

ACKNOWLEDGEMENTS:

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**Mr. Fullmer's technical paper adds to our knowledge of the changes in the amounts of potassium and phosphorus present in avocado leaves during the season. .Wore work along this line is needed before we may correct y judge the critical or optimum content of these elements with respect to yield. Growers should be cautious about jumping to conclusions with reference to benefits to be derived from the use of phosphoric acid or potash until or unless local trials show measurable improvement in yield, quality of fruit, or regularity in bearing behavior. (Editor)*

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