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A Preliminary Report on Phosphorus Deficiency of Hass Avocado

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Abstract

Preliminary data from two small scale (40-60 trees each) field trials involving Hass variety avocados indicate two distinct causes leading to phosphorus (P) deficiency. It is suggested that an adequate level of leaf P in spring-flush leaves sampled in the mid-August to the mid-October period for Hass is 0.10% P on a dry weight basis, and that the apparent discrepancy from the previously published leaf value of 0.08% P is due to the behaviour of the cultivar Hass in this regard.

Introduction

Phosphorus (P) deficiency in field grown avocados has not been recorded to date (1,2), although symptoms from greenhouse experiments are known (3, 4, 5). A 1981 survey of commercial avocado groves in the San Diego County-Rancho California area (5) reported that 6.8% of the samples contained less than 0.08% leaf P, and that 23.8% of the samples contained less than 0.10% leaf P. Thus, the percentage of low P status groves in this area is seen to be significant.

Experimental Design

Two separate Hass avocado groves were selected for these experiments based on the severity of the deficiency as determined by leaf analysis and inspection and the willingness of the owner to allow, or to carry out, the experiment. Grove No. 1 is located in Rancho California in Riverside County, and Grove No. 2 is located near Ramona in San Diego County.

In both groves, treatments were applied on a row basis to minimize interference with normal grove operations. However, the rows were chosen 90 as to cross the irrigation laterals at a large angle in an attempt to evenly distribute any water or fertilizer supply effects associated with the irrigation system.

In Grove No. 1, the trees were 20 months old at the time the treatments were applied in Feb. of 1983. The objective in this grove was to demonstrate the existence of phosphorus deficiency, and possibly potassium (K) deficiency, in the field. Accordingly, nitrogen, zinc, and water applications were as uniform as possible. The treatments consisted of two rows of control (no additional applications), two rows of +P, and two rows of +P and +K. The actual numbers of trees involved were: control = 13, +P = 11, and+P and +K = 15. In 1983, the treatments consisted of +P = 0.15 pounds of P_2O_5 per tree; and +P and +K = 0.15 pounds of P_2O_5 and 0.15 pounds of K_2O per tree (the % P reported on a fertilizer bag is actually expressed as P_2O_5 equivalent). In 1984, the P and K were increased to 0.6 pounds of P_2O_5 and K_2O per tree. In 1985, only zinc and nitrogen were applied.

The parameters measured include leaf and soil analysis and a photographic record of the growth response. Because of the discretion available to a photographer, several individuals have visited this grove. The pertinent University personnel include Dr. Bender (San Diego County farm advisor), Dr. Arpaia (Extension Subtropical Horticulturist), and Dr. Embleton (Professor of Horticultural Science, UCR). Yield measurements have been planned, but the trees are just beginning to bear fruit.

Grove No. 2 consisted of Hass avocado trees that are of bearing age (approximately 8-10 years old). The objective in this grove was to observe tree response under conditions of low phosphorus supply and acidic soils (pH sat. paste = 3.6-5.5). The spacing of treatments was similar to that in Grove No. 1, but the ten tree treatments consisted of:

1. No fertilizer.
2. Nitrogen only (calcium nitrate).
3. Nitrogen and lime (calcium nitrate).
4. Phosphorus only (triple superphosphate).
5. Nitrogen and phosphorus (ammonium phosphate).
6. Nitrogen, phosphorus, and potassium (15-15-15).

The fertilizers containing nitrogen ranged from 14.5 to 16% N, and were considered to be equal when equal amounts of material were applied. Six applications of four pounds of material (treatment 4 = 1.5 pounds of material) per application were made between September 1984 and July 1985. The total amount of P_2O_5 per treatment annually was:

1. None.
2. None.
3. None.
4. 4.1 pounds P_2O_5 per tree.
5. 4.8 pounds P_2O_5 per tree.
6. 3.6 pounds P_2O_5 per tree.

The parameters measured in Grove No. 2 are similar to Grove No. 1, and the individuals visiting Grove No. 2 include Dr. Jarrell (Prof, of Soil Science, UCR) in addition to those mentioned for Grove No. 1.

Results and Discussion Grove No. 1

Figure 1 shows the growth response of a nitrogen-only row (left) and an ammonium phosphate row (right). Figure 2 shows the growth response of a nitrogen-only row (left) and a +P and +K row (right). In both cases, a lack of P has severely reduced new growth and the trees are declining. To date, the addition of K with P has shown no benefit over P alone.

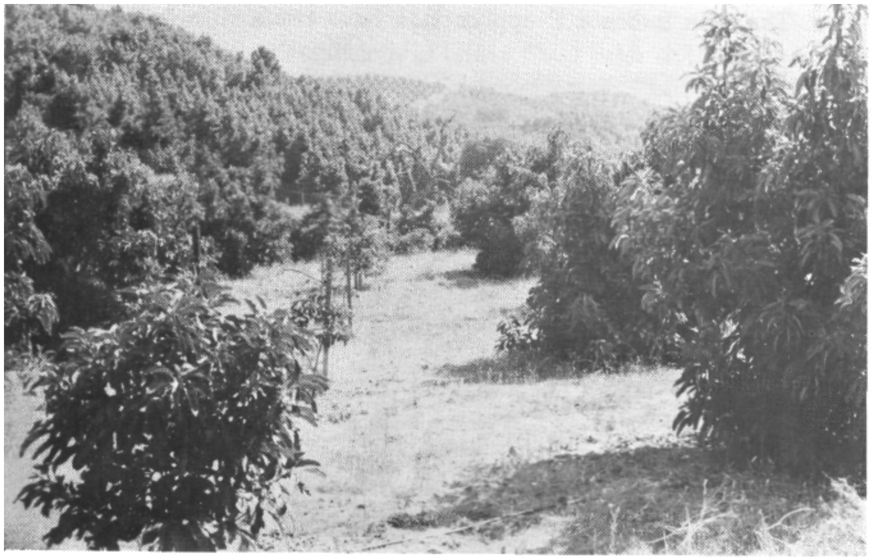

Figure 1. Growth response of a nitrogen-only row (left) and an ammonium phosphate row (right).

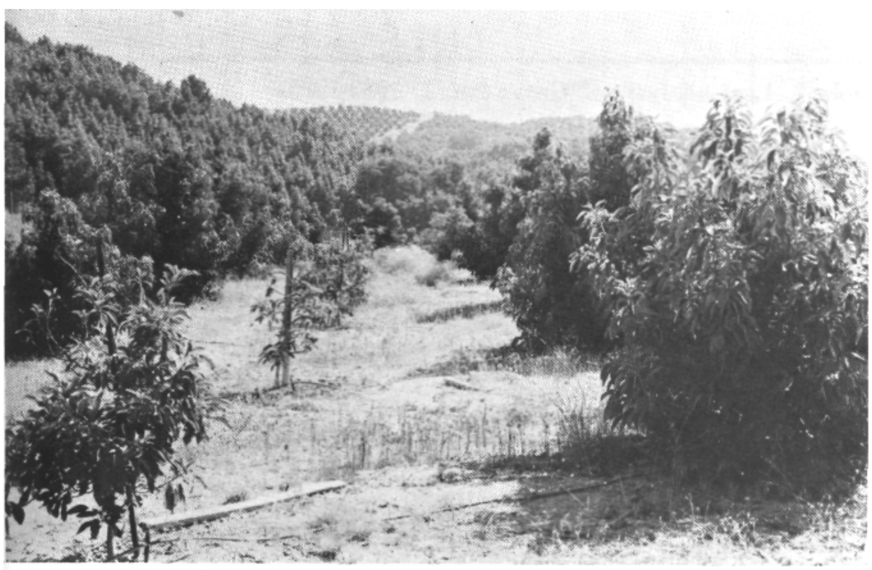

Figure 2. Growth response of a nitrogen-only row (left) and a nitrogen, phosphorus, and potassium row (right).

Figure 3 shows a normal size avocado leaf (in hand), compared to the frequently reduced size leaf (right) of a P deficient tree. The randomly distributed patch of necrosis typical of P deficient leaves from greenhouse experiments is also shown in Figure 3, but it is seldom found in this grove.

Table 1 presents leaf analysis data for Grove No. 1 in the 1983-1985 period. The data indicate P applications have resulted in leaf P levels greater than or equal to 0.12%, while the controls were less than or equal to 0.075% leaf P. The 1985 data for the control are not comparable due to the young age of the leaves sampled. It is the author's opinion that the low leaf nitrogen in the controls is a result of P deficiency and does not reflect an insufficient supply of nitrogen. Leaf K does not appear to be a strict function of applied K.

Tables 2 and 3 reflect conditions in Grove No. 1 prior to the beginning of this experiment. Table 2 indicates low nitrogen and P in the leaf tissue of the poor trees, relative to the healthy trees in a different part of the grove.

Figure 3. Normal size avocado leaf (in hand), compared to the frequently reduced size leaf (right) of a P deficient tree.

Table 1. Leaf analysis of Grove No. 1, 1983-1985.

YEAR	TREATMENT	N%	P%	K%	Zn ppm
1983	Control	2.27	0.075	0.46	47
	+P	2.30	0.145	0.40	35
	+P +K	2.35	0.135	0.51	36
1984	Control	1.50	0.050	0.63	26
	+P	2.19	0.165	0.61	28
	+P +K	2.10	0.155	0.82	22
1985	Control*	1.60	0.100	0.52	30
	+P	2.10	0.120	0.35	21
	+P +K	1.90	0.120	0.43	20

* In 1985 the control trees had dropped their older leaves, resulting in leaves younger than 4-6 months old being used for analysis.

Table 2. Leaf and soil analysis from poor and healthy trees in Grove No. 1 prior to the experiment. Soil samples were collected from the root ball. Leaves sampled were 4-6 months old.

Leaf Sample	%											
	N	P	K	Ca	Mg	Na	Cl	Zn	Fe	Mn	Cu	B
Poor	1.21	0.05	0.50	1.15	0.69	0.01	0.29	48	88	137	5	50
Healthy	2.02	0.10	0.60	1.66	0.71	0.01	0.16	44	110	315	7	50

Soil Sample*	ppm						mg/ l		dS/ m			
	NO_3 -N	P	K	Ca	Mg	Na	Cl	B	pH	EC	SAR	Sat. %
Poor	3	3	55	2040	600	205	68	0.5	6.8	0.7	2.4	40
Healthy	3	5	55	1320	260	130	68	0.5	7.5	0.8	2.0	33

* NO_3 -N on a 1:5 water extract; P Olsen method; K, Ca, Mg, Na on an 1:10 ammonium acetate extract; Cl, B, and EC on the saturation extract.

The leaf P value of 0.10% in the healthy trees is the lowest level found in this grove that was associated with acceptable growth of these young trees. The soil analysis in Table 2 shows low, but not deficient, P and K values in the root ball of these trees that were 18 months old at that time. Table 3 indicates deficient P throughout the grove and deficient K in the part of the grove where the trees were performing poorly (lines 3 and 6). However, acid digestion of the 0.5 normal sodium bicarbonate extract for P revealed organic P associated with the healthy parts of the grove that is missing from the poor parts of the grove (line 4 of Table 3).

Summary of Grove No. 1

This grove has displayed a very strong growth response to P applications due to a lack of this element in the soil. Portions of this grove are growing at an acceptable rate without P applications; but these areas have a visible organic component, and an associated organic P fraction in the soil. The lowest leaf P level observed that was associated with acceptable growth was 0.10% in these non-bearing trees.

Table 3. Soil analysis of poor and healthy areas of Grove No. 1 prior to the experiment. Soil samples were collected between tree rows.

	Soil Sample					
	Poor			Healthy		
ppm	0-2"	2-8"	8-24"	0-2"	2-8"	8-24"
1. NO_3 -N	< 1	< 1	< 1	< 1	< 1	< 1
2. NH_4 -N	< 1	< 1	< 1	2	< 1	< 1
3. P	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
4. P	< 0.3	< 0.3	< 0.3	0.3	0.8	< 0.3
5. P	10	12	12	22	16	10
6. K	<10	<10	<10	95	10	<10
7. Zn	3.6	0.6	0.6	3.2	1.0	0.3
8. Fe	6.2	7.0	7.0	9.6	11.0	11.0
9. Mn	5.8	7.2	4.6	11.0	11.0	5.6
10. Cu	0.6	0.7	0.8	0.8	0.7	0.5
%						
11. O. M.	3.2	3.6	2.7	3.8	4.0	2.2
12. pH	6.7	6.6	6.6	6.3	6.3	6.1
13. EC	0.2	0.2	0.4	0.3	0.2	0.2

1. 1:5 water extract; 2. 1:10 KCl extract; 3. 1:20 $NaHCO_3$ extract; 4. 1:20 $NaHCO_3$ extract, followed by sulfuric-nitric acid digest; 5. 1:5 sulfuric-nitric digest; 6. 1:10 ammonium acetate extract; 7. -10. 1:2 DTPA extract; 11. Loss on ignition; 12. Sat. paste; 13. Sat. extract, dS/ m.

Grove No. 2

The growth response of Hass avocado trees to P in this grove was difficult to photograph in black and white due to the larger size of these trees (lack of contrast). As a compromise, branches have been photographed. Figure 4 illustrates typical top growth of P treated trees, while Figure 5 is an example of sparse growth that occurred on the top branches of about half of the trees lacking P.

While leaf density of the middle branches of all treatments was roughly similar, the leaves of the lower branches frequently show symptoms of P deficiency in treatments where P was withheld. The randomly distributed patches of necrosis visible on three of the leaves in Figure 6 are similar to that described in greenhouse studies (3, 5).

Table 4 presents leaf and soil data from grove No. 2 for the period 1982-1985. The data for 1985 are the results of treatments applied in 1984-1985 as previously described. The 1985 data show that trees receiving P had leaf P values greater than or equal to 0.10%. These data also show that trees not receiving P (and exhibiting deficiency symptoms) have leaf P values of less than or equal to 0.08%. Therefore, the critical leaf P for the conditions in this grove in 1985 must be between 0.08 and 0.10%, using deficiency symptoms as criteria.

The data from 1982 to 1984 in Table 4 exemplify the decline of leaf F from 0.11% to 0.06% as being concurrent with the change in soil pH iron 6.1 to 3.6. The soil acidification, in turn, is related to the use of inexpensive ammonium-derived fertilizers in conjunction with a low alkalinity (Lake Cuyamaca) irrigation water.

Figure 4. Typical top growth of mature, P treated trees.

Figure 5. Sparse growth that occurred on the top branches of about half of the mature trees lacking P.

Figure 6. Randomly distributed patches of necrosis on the leaves of phosphorus deficient trees.

Summary of Grove No. 2

This grove has developed P deficiency in response to extreme soil acidification. Leaf P values as high as 0.08% are associated with í deficiency symptoms, and leaf P values as low as 0.10% are associated with visually acceptable growth in this grove.

Table 4. Soil and plant tissue analysis of Grove No. 2 for 1982-1985.

Year/ Treatment	Leaf				Soil
	%			ppm	
	N	P	K	Zn	pH
1982	2.02	0.11	1.00	82	6.1
1983	2.15	0.09	0.90	82	5.6
1984					
Weak	2.04	0.04	1.33	115	3.6
Healthy	2.08	0.07	1.57	73	3.6
Burned	2.12	0.06	1.90	130	3.6
Healthy	2.04	0.06	1.40	133	5.5
1985					
Control	2.05	0.07	0.70	104	4.9
+N	2.28	0.07	0.72	89	4.1
N+lime	2.50	0.08	1.15	114	4.4
P	2.34	0.12	0.72	118	5.4
N+P	2.76	0.10	1.18	171	4.0
N+P+K	2.85	0.12	1.06	140	4.9

Acknowledgements

Identification of potential experimental sites and plant and soil analysis were provided by Richard Marrocco of Fallbrook Ag-Laboratory. The author also wishes to thank Charles Kollmeyer and Warren Henry for the use of their respective avocado groves, fertilizer, labor, and continuing cooperation.

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Commentary about the Paper Titled "A Preliminary Report on Phosphorus Deficiency of Haas Avocado" by Jonathan E. Tracy.

I have observed the progress of the experiments reported by Tracy and concur with his conclusion that a leaf phosphorus value below 0.10% on a dry weight basis in spring-cycle leaves sampled in the mid-August to mid-October period likely indicates phosphorus deficiency for the Hass avocado. Although a fruit yield increase from added phosphorus has not been documented as yet, it is very likely that control trees in orchard No. 1 will not survive to come into bearing. In orchard No. 2 the vegetative response to additions of phosphorus is clear.

The phosphorus leaf analysis guides which were published by the University of California were based upon experimental data from the Fuerte variety. Over a ten-year period, no vegetative or yield responses were observed within the range of 0.07 to 0.75% *leaf phosphorus.*

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