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POTASSIUM FERTILIZER EXPERIMENT WITH AVOCADO TREES ON HEAVY SOILS

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INTRODUCTION

Potassium fertilization of avocado trees is not recommended at present, except in cases where foliar analysis indicates potassium deficiency. Investigations carried out in Israel with trees grown on light soil, as well as work on avocado nutrition in California, have proven that although potassium fertilization raises the percentage of potassium in the leaves, it does not enhance tree growth, increase yields, or improve fruit quality (3, 4). A single paper from South Africa records a certain increase in yields as a result of potassium fertilization over an eight-year period (6).

In view of the extensive areas being planted to avocado on heavy soils, the question arose as to the effect of potassium on avocado trees cultivated on this type of soil. High sensitivity of avocado trees to salinity, combined with potassium fixation in the soil, led to the conclusion that fertilizers characterized by high potassium concentration, high solubility and a low salinity index, suit our purpose better than those containing; sulfur or chlorine. Potassium nitrate was found most suitable on all counts for the purpose of our investigations (2).

The objectives of the experiment were to test the effect of potassium fertilization on tree growth, yield and fruit quality of the avocado, and to test different amounts of KNO_3 in comparison with K_2SO_4, when phosphorus is not a limiting factor.

MATERIALS AND METHODS

The experiment was started in the summer of 1968 at the 'Akko Experiment Station, in an orchard planted in 1963, and was continued for seven years. The soil was a low-lime grumusol with 60% clay. Sprinkler irrigation under the tree canopy was applied during the dry season.

The experiment was conducted in randomized blocks with six replications. Each plot comprised eight trees (two each of the cultivars Ettinger, Fuerte, Nabal and Hass). The trees of each cultivar were of the same combination of stock (Mexican) and scion. The levels of nitrogen, phosphorus and potassium in the experimental plots were particularly low beneath the 30-cm layer (Table 1), which suited the purpose of the experiment. Before starting the experiment the area was fertilized with 1000 kg/ha superphosphate.

Three KNO_3 treatments were given: 400, 800 and 1200 kg/ha, which were compared with 890 kg/ha K_2SO_4 (equivalent to 800 kg/ha KNO_3), and with control to which no potassium fertilizer was applied. The fertilizers were scattered on the soil surface twice yearly in equal portions, in June and in August. Until 1970, the nitrogen was complemented by urea and subsequently by ammonium nitrate with lime. The following measurements and tests were made:

a. Recording the tree's growth process by measuring the trunk circumference, and calculating the increase in the trunk cross-sectional area. The height of the tree was also measured.

b. Yields. The crop of each tree was weighed. In years when yields were satisfactory, the fruit was graded according to size in the packing house.

In the winter of 1972/73, seven cold nights with minimum temperatures of -2.2°C were registered in the experimental plantation. The frost resulted in fruit drop of the Hass cultivar. The effect of potassium fertilization on fruit drop was recorded.

Representative uniformly sized fruits of the Ettinger and Fuerte cvs. were analyzed for their oil content*

c. Foliar analysis*. Leaves of cultivars Fuerte and Hass were sampled each year in the autumn for analysis of potassium content. In 1971-1973, the effect of fertilizer treatments on the content of ten additional elements was also examined.

With certain crops conductive tissues are preferred for sampling to determine the potassium content of the plant (7). In autumn 1974 an experiment was carried out, aimed at comparing the sampling of petioles and bark of trunks with the customary technique of sampling entire leaves (petioles + blade). The samples were taken from trees fertilized with 1200 kg/ha KNO_3 and from controls.

RESULTS

Effect of Potassium Fertilizer on the Tree and its Growth

The effect of potassium fertilizer on tree development was expressed in the tree height (Table 2), and on the trunk's cross-sectional area (Table 3). Treatment with 1200 kg/ha KNO_3 always produced the highest trees. The greatest increment in the trunk's cross-sectional area was found in the cultivars Fuerte and Nabal; Ettinger was not affected, while Hass trees had the greatest increment in trunk cross-sectional area with K_2SO_4 treatment. The difference between the effect of K_2SO_4 and of an equivalent amount of KNO_3 was not significant.

Yields

At the beginning of the experiment the trees gradually entered the fruit-bearing stage. Ettinger, Fuerte and Nabal cultivars produced satisfactory yields starting with the fourth year of experimentation (1971), and Hass in the year before these. Potassium fertilization had no effect on yields (Table 4).

Ettinger was sorted in the packing house in five out of six experiment years; the other cultivars were sorted only four times. High rates of fertilizer resulted in a certain increase in the size of Nabal, Fuerte and Hass fruit (Table 5). In the two last cultivars this tendency was apparent with KNO_3 as well as with K_2SO_4 fertilizer. No regularity was observed in the behavior of Ettinger.

Oil analyses made with uniformly sized fruit of the Ettinger and Fuerte cultivars showed that potassium fertilization did not influence the percentage of oil in the fruit.

There was considerable drop of Hass fruit following night frosts in the winter of 1972/73. An increase in the rate of $KN0_3$ fertilization resulted in only a slight decrease in the percentage of fruit drop (Table 6).

Foliar Analysis

Potassium content in leaves of both cultivars (Fuerte and Hass) was generally above the critical level. The only exception was observed with the Hass cultivar in 1967 and 1968, when the K content was below 0.8%. A gradual rise in potassium, reaching a level of about 1.0%, was registered with the two cultivars in autumn 1974. The slight differences among the fertilizer treatments were found to be non-significant (Figure 1).

Potassium fertilizer treatments had no effect on the level of other elements with the exception of Zn. Potassium fertilization resulted in a decrease in the Zn level in Fuerte leaves in the three years of sampling. With Hass the effect was not clear.

In a sampling experiment where petioles and trunk bark were compared with leaf blade+petiole, it was found that the trunk bark could not be used to express effects of fertilizations (Table 7). Petiole sampling was not preferable to the usual blade sampling.

* *Foliar analysis and oil tests were made in cooperation with R. Spodheim, Div. of Subtropical Horticulture, Agricultural Research Organization.*

Discussion

This work demonstrates for the first time the effect of potassium on avocado tree growth. The effect was expressed mainly in tree height, the greatest height being recorded in trees treated with 1200 kg/ha KNO_3. Fertilizing with K_2SO_4 had a similar effect.

Interaction between canopy development and fruit-bearing capacity of avocado is well known (9). Despite the influence on tree growth, no effect on yields was recorded during the seven years of experimentation. In some cultivars, potassium fertilization increased fruit size. According to Lahav *et al.,* (8), increase in fruit size is apt to have a special significance for the Hass cultivar, which is distinguished by excess productivity combined with small-sized fruits. Other investigators, however, did not report results pointing to a similar effect of potassium (3).

In view of the relationship between fertilization and cold tolerance (1), it was interesting to observe the behavior of avocado trees in the plantation after the cold wave in the winter of 1972/73. Fertilizing with high rates of KNO_3 was found to lower slightly fruit drop of the Hass cultivar. It is suggested that special attention be given to study the effect of fertilization on avocado tree cold tolerance.

Foliar analysis confirmed the avocado tree's lack of response to mineral nutrition. The fact that potassium content in the plant tissues was unaffected by the rate of potassium fertilizer applied, points to a possibly inadequate and imprecise sampling method used for the determination of this element in avocado trees.

Despite a lack of response of other elements to potassium fertilization, the antagonism between potassium and zinc found in leaf analysis of the Fuerte cultivar is noteworthy. Similar results were obtained with citrus trees (10). Special significances should be attached to the K-Zn relationship, in view of their joint function in a number of enzyme systems (5).

TABLE 1. SOIL COMPOSITION (0-150 cm) BEFORE THE START OF THE EXPERIMENT (SPRING 1968).

Soil depth (cm)	E.C. (mmhos/cm)	pH	Nitrate (ppm)	P (ppm)	K (meq/l)	Ca+Mg (meq/l)	− F (Cal/Mol)
0- 15	1.12	7.4	24	31	0.072	6.10	3930
15- 30	0.53	7.6	12	12	0.061	3.58	3880
30- 60	0.50	7.5	7	4	0.030	3.35	4260
60- 90	0.73	7.5	4	3	0.030	3.58	4280
90-120	0.81	7.5	3	3	0.028	3.55	4320
120-150	0.69	7.7	3	2	0.029	1.70	4070

TABLE 2. EFFECT OF POTASSIUM ON INCREASE IN AVOCADO TREE HEIGHT (cm) FROM 1968 TO 1974.

Cultivar	Control	KNO_3 (kg/ha)			K_2SO_4	S.E.	Significance
		400	800	1200	800 kg/ha		
Ettinger	260^{ab}	246^{ab}	261^{ab}	282^{a}	227^{b}	15.5	0.05
Fuerte	143^{b}	147^{ab}	150^{ab}	183^{a}	167^{ab}	13.4	0.05
Nabal	207^{b}	223^{b}	260^{a}	259^{a}	228^{ab}	11.8	0.05
Hass	210^{ab}	187^{b}	242^{ab}	255^{a}	225^{ab}	12.6	0.01
Average	205^{b}	201^{b}	228^{ab}	245^{a}	212^{ab}	11.2	0.05

Values for each cultivar followed by different letters differ significantly at the indicated levels.

TABLE 3. EFFECT OF POTASSIUM ON INCREASE IN AVOCADO TREE CROSS-SECTIONAL AREA (cm^2); FROM SPRING 1968 TO AUTUMN 1974.

Cultivar	Control	KNO_3 (kg/ha)			K_2SO_4	S.E.	Significance
		400	800	1200	890 kg/ha		
Ettinger	294	297	271	290	268	13.5	N.S.
Fuerte	227^{b}	244^{b}	250^{ab}	284^{a}	236^{b}	12.4	0.05
Nabal	341^{b}	378^{ab}	336^{b}	386^{a}	337^{b}	14.1	0.05
Hass	292^{b}	317^{ab}	317^{ab}	322^{ab}	375^{a}	13.9	0.01
Average	288	308	293	320	302	11.3	N.S.

Values for each cultivar followed by different letters differ significantly at the indicated levels; all other differences are non-significant (N.S.).

TABLE 4. EFFECT OF POTASSIUM ON AVERAGE YIELD OF AVOCADO FRUITS (Kg/tree) DURING SIX YEARS (1969-1974).

Cultivar	Control	KNO_3 (kg/ha)			K_2SO_4	S.E.
		400	800	1200	890 kg/ha	
Ettinger	48.8	45.4	46.5	46.2	42.0	5.0
Fuerte	28.0	27.3	25.5	25.5	29.2	3.8
Nabal	40.1	44.4	39.7	44.2	38.9	3.6
Hass	41.3	42.4	37.1	42.5	45.0	3.6
Average	39.6	39.9	37.2	39.6	38.8	1.5

Note: All differences are non-significant.

TABLE 5. EFFECT OF POTASSIUM ON INDIVIDUAL AVOCADO FRUIT WEIGHT (g). (5-YEAR AVG. FOR THE ETTINGER CV.; 4-YEAR AVG. FOR THE OTHER CULTIVARS).

Cultivar	Control	KNO_3 (kg/ha)			K_2SO_4
		400	800	1200	890 kg/ha
Ettinger	306	314	294	300	311
Fuerte	304	299	310	315	311
Nabal	414	416	434	422	416
Hass	198	199	206	206	209

TABLE 6. EFFECT OF POTASSIUM ON FRUIT DROP OF AVOCADO CV. HASS AFTER FROST IN WINTER 1972/73.

Parameter	Control	KNO_3 (kg/ha)			K_2SO_4
		400	800	1200	890 kg/ha
Yield (kg/tree)	36.0	23.4	25.6	33.4	29.8
Drop (kg/tree)	20.3	13.2	4.4	12.6	14.9
% of drop	56.4	56.4	17.2	37.7	50.0

TABLE 7. EFFECT OF POTASSIUM FERTILIZATION ON POTASSIUM CONTENT (% OF DRY MATTER) OF LEAF BLADES AND PETIOLES AND ON THE BARK OF AVOCADO TREES.

Cultivar	Organ sampled	Control	KNO_3 (1200 kg/ha)	Difference	Percentage difference
Fuerte	blade	0.80	0.92	0.12	15.0
	petiole	2.48	2.79	0.31	12.5
	bark	0.81	0.79	–0.02	–2.5
Hass	blade	0.94	0.93	–0.01	–1.1
	bark	0.78	0.74	–0.04	–5.1

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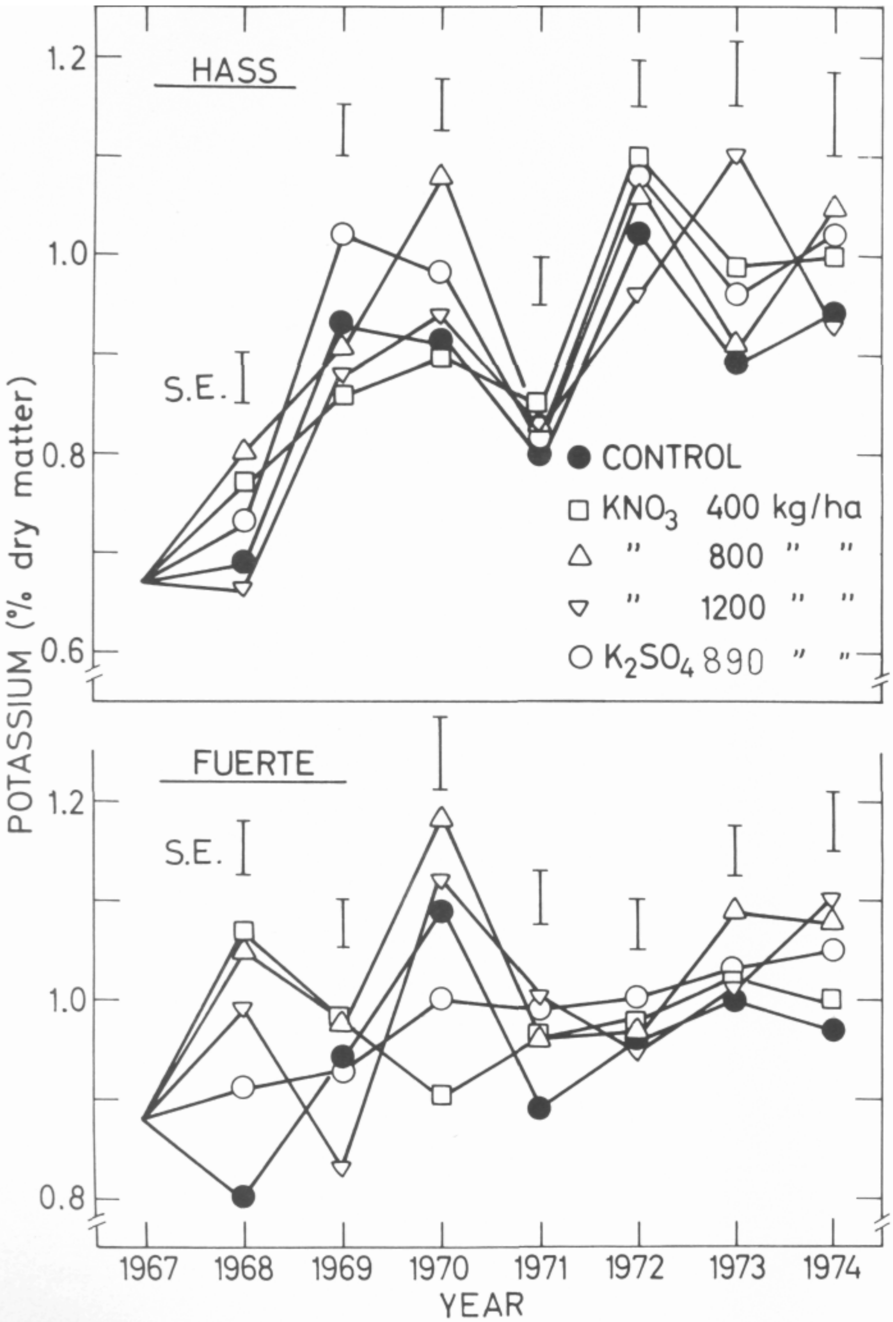

FIGURE 1. Effect of potassium fertilization on K content (% d.m.) of avocado leaves.