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Comparison of different calcium sources on avocado production

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SYNOPSIS
Liming materials and gypsum were shown to increase avocado fruit production when applied annually in moderate amounts, but was detrimental when excessive applications were made. Extractable Al was shown to be a better indicator of lime requirement than soil pH. Positive residual effects were obtained with all treatments to a certain extent. Calcium concentrations in both leaves and fruit were only slightly affected by these treatments, and did not correspond with the effects obtained on yield.

INTRODUCTION

Avocados are mainly grown in high rainfall areas on relatively heavy soils in the Transvaal. Acidification is a serious problem in most orchards and the consequences not always appreciated by growers.

Beneficial effects due to liming have been claimed by several researchers. According to Snyman & Darvas (1982), root rot on young trees was reduced by liming. Broadbent & Baker (1974) claimed that *Phytophthora cinnamomi* did not occur on soils with a Ca status of 2 000 mg kg^{-1}. Koen & Smart (1973) showed that optimal growth and root development for Duke seedlings were obtained at a soil pH (water) of 6,0 to 7,0. Fouché (1981) stated that optimum production occurred in the pH range of 5,8 to 6,5. He also claimed that imbalances of K, Ca and Mg in the soil will enhance pulpspot. Kotzé & Joubert (1978) claimed that calcium silicate was not as efficient as agricultural lime in alleviating soil acidity, and that slaked lime moved more readily in the soil than both calcitic and dolomitic lime.

The purpose of this investigation was to compare the effect of different calcium sources on the production of mature avocado trees grown on a fairly acid soil, and to evaluate these sources in terms of their effects on soil acidity and nutritional value.

MATERIALS AND METHODS

Mature trees, cultivar Edrariol on Guatemalan seedling rootstock, grown on a red clayey soil (Hutton form, Farningham series) in the Burgershall area were used for this investigation. The treatments were as follows: four calcium sources viz dolomitic lime, calcium hydroxide, gypsum and calcium silicate, with three levels of each were compared with each other, as well as with a control (no application). The levels were comparable on either neutralisation value or calcium content. The treatments were applied annually from July 1979 to July 1982. The experiment therefore consisted of four calcium sources with three levels each and a control, replicated four times. Plots consisted of three trees each. The treatments are shown in Table 1. The trees were irrigated with dragline sprinklers, with a cycle length of 10 days. No visible symptoms of *Phytophthora* occurred during the period of investigation.

The trees were fertilised annually according to leaf analysis, to maintain an optimum nutritional status. Yield data were taken annually from 1982 to 1984 as well as soil, leaf and fruit samples for analysis.

TABLE 1 Calcium sources and levels applied (ton ha-1 year-1).

Ca source	Ca content (%)	Levels*		
		1	2	3
Dolomitic lime	37	2,4	4,7	7,1
Ca silicate	34	2,5	5,0	7,5
Gypsum	19	4,5	9,2	13,7
Ca hydroxide	46	1,9	3,7	5,5

*Levels comparable in either Ca status or neutralising ability.

RESULTS

Yield data

In Table 2 the effect of three levels of each of the calcium sources is compared mutually and with the control (no Ca treatment). The final applications were made in 1982; therefore the 1983 data indicate the immediate results of the applications, and 1984 the residual effects.

From the data in Table 2 it is obvious that the highest yields for 1983 were obtained with the middle levels of dolomitic lime, Ca silicate and gypsum. The hydroxide was not significantly better than the control. It is also noteworthy that a decrease in yield occurred with the highest levels of all treatments. The control plot showed a drastic decrease in yield from 64 kg tree^{-1} in 1982 to 16 kg tree^{-1} in 1984.

The residual effect of calcium hydroxide and gypsum were relatively poor, whereas good residual effects were obtained with the highest level of calcium silicate and the middle level of dolomitic lime. The second level of Ca silicate had a very poor residual effect, despite the fact that this was one of the best treatments in both 1982 and 1983. The reason is unknown, although it could be due to alternate bearing after two heavy crops.

In order to explain these differences, soil, leaf and fruit analyses were done.

TABLE 2 The effect of three levels of four different calcium sources on avocado yield(kg tree^{-1}).

Treatment	Level	1982	1983	1984
Control	0	63,8 d*	44,3 c*	15,7 c*
Dolomitic lime	1	70,9 cd	67,8 c	56,1 ab
	2	125,2 a	141,4 a	84,1 a
	3	74,4 cd	49,6 c	50,2 ab
	1	92,2 be	94,1 b	45,0 b

Ca silicate	2	102,1 ab	138,2 a	39,3 b
	3	90,7 bcd	73,0 bc	85,2 a
Ca hydroxide	1	83,2 bcd	60,7 c	36,8 b
	2	81,7 bcd	62,7 c	45,3 b
	3	63,6 d	53,8 c	47,2 ab
Gypsum	1	69,7 cd	65,7 c	33,2 b
	2	103,3 ab	102,8 b	38,4 b
	3	102,6 ab	57,5 c	47,7 ab
LSD P = 0,05		27,7	31,7	37,6
LSD P = 0,01		36,4	41,7	---
CV (%)		23,1	29,4	56,5

*Values within columns with different letters differ at P=0,05.

Soil analysis

Table 3 shows the initial soil composition at the start of the experiment. It is obvious that the soil pH was very low for avocado production (Fouché, 1981), with a very high extractable Al content of 90 mg kg^{-1} in the topsoil and 135 mg kg^{-1} in the subsoil.

TABLE 3 Soil composition before commencement of the experiment

Factor	Topsoil 0-300 mm	Subsoil 300-600 mm
pH (water)	4,8	4,6
Exchangeable cations		
K (mg kg^{-1})	140	65
Ca (mg kg^{-1})	130	90
Mg (mg kg^{-1})	60	30
Resin P (mg kg^{-1})	7	6
Extractable Al (mg kg^{-1})	90	135
Texture (%)		
Coarse sand	27,5	27,0
Fine sand	24,5	23,3
Silt	13,8	11,4
Clay	34,2	38,3

In Table 4 the soil composition for 1983 is shown. These data indicate the final treatment effects after four years of applications (1979 to 1982), as well as the condition of the control plot. The control showed very little difference from the original analysis, indicated in Table 3.

TABLE 4 Effect of three levels of four different treatments on chemical composition of the top (0-300 mm) and subsoil (300-600 mm) (1983 data).

Treatment	Level	pH (water)		Al (mg kg^{-1})		Ca (mg kg^{-1})		Mg (mg kg^{-1})	
		Top	Sub	Top	Sub	Top	Sub	Top	Sub
Control	0	516	4,63	93	158	194	38	59	20
Dolomitic	1	5,40	5,03	59	127	213	75	84	40
lime	2	5,86	5,31	34	103	288	100	125	47
	3	5,60	4,81	65	115	206	69	92	35
Calcium	1	5,54	4,79	79	89	275	88	35	18
silicate	2	5,71	5,04	57	101	438	00	58	25
	3	6,15	5,13	23	137	544	106	54	19
Calcium	1	5,29	4,63	80	142	231	50	36	20
hydroxide	2	5,38	4,84	68	43	331	100	32	18
	3	5,61	5,30	69	90	475	213	29	20
Gypsum	1	4,70	4,59	130	152	250	181	31	23
	2	4,70	4,65	123	123	281	269	25	22
	3	4,74	4,59	122	131	300	250	21	19
LSD P = 0,05		0,40	0,41	50		160	69	23	10
LSD P = 0,01		0,53	0,54	65		210	91	30	14
Cv (%)		5,4	4,64	303		372	398	31,5	29,7

*Levels indicated in Table 1.

pH: It is obvious that relatively small effects on pH were obtained, despite large applications of the different products. Gypsum had no positive effect on the pH; the topsoil showed a significant reduction as compared to the control. The highest pH of 6,15 was obtained with the highest level of calcium silicate. The subsoil pH was only slightly increased by the three liming materials.

Al: The effects of these materials on the extractable aluminium status were similar to the effects on pH. In the top soil, the Al was reduced considerably except in the case of gypsum. The subsoil Al was only slightly affected. It is interesting to note that the two treatments with the highest yield, ie the second dolomitic lime and calcium silicate levels has a relatively low Al content in the topsoil.

A highly significant negative correlation (r = -0,94) was found (Figure 1) between the topsoil Al content of all the plots for 1983 and the yield of each plot for 1984. The lower the Al concentration, the higher the yield, reaching a maximum at less than 20 mg Al kg^{-1} soil. A notable exception was the gypsum treatments (data omitted from Figure 1), where high yields were obtained despite relatively high Al values. A similar trend was observed for the subsoil Al (r = -0,66), although the actual values were relatively high and subsoil Al not that critical.

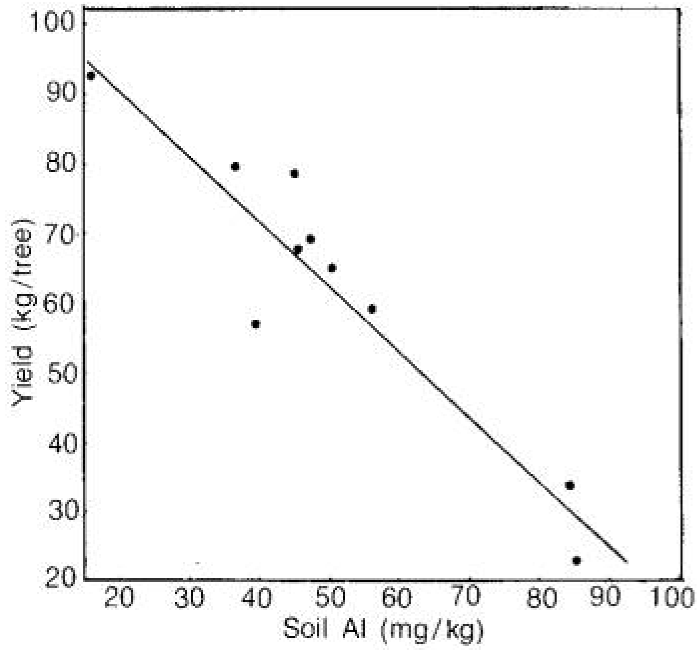

Fig 1 The relationship between topsoil Al concentration and yield 1983/84 season, mean values per treatment ($r = -0{,}94$ and $y = 108{,}93 - 0{,}932x$).

Ca and Mg: The calcium status in the topsoil was increased considerably, especially by the calcium silicate treatments, and to a lesser extent also by calcium hydroxide. Although calcium moved down to the subsoil to a small degree, gypsum showed the highest Ca levels in the subsoil; almost equal to those in the topsoil. Magnesium was increased by dolomitic lime, a Mg carrier, in both top- and subsoil. Calcium silicate which also contains some magnesium, increased the Mg levels in the top soil only. No relationship existed between these elements in the soil and the yield.

Leaf analysis

The concentration of only two macro-elements in the leaves, potassium and calcium, were significantly influenced by the treatments in 1983 (Table 5). The applications of different Ca sources decreased the K concentration, especially at the higher levels. In all cases, K levels of less than 7 g kg^{-1} was reached as compared to the 8,6 g kg^{-1} of the control. Leaf Ca on the other hand had only significantly increased above the control, by the highest level of calcium hydroxide. The other treatments had almost no effect on the leaf Ca concentration.

Fruit analysis

Only K and Ca concentrations in the fruit were significantly affected by the treatments (Table 5). As in the case for leaf K, fruit K was also significantly reduced by most of the Ca applications. Fruit Ca concentration was significantly. increased by the highest levels of both dolomitic lime and gypsum. Surprisingly calcium silicate had no effect at all on the Ca status of the fruit, despite the significant reduction in K status at all levels of application as well as the high Ca levels in the topsoil.

TABLE 5 Effects of the different treatments on leaf and fruit composition (g kg^{-1}) for 1983.

Treatment	Level	Leaf		Fruit	
		K	Ca	K	Ca
Control	0	8,6	11,0	6,9	0,32
Dolomitic lime	1	8,0	8,9	14,4	0,33
	2	7,9	10,5	15,5	0,27
	3	6,6	11,1	13,0	0,45
Calcium silicate	1	8,0	10,7	13,1	0,26
	2	7,5	2,4	13,5	0,31
	3	6,7	0,3	11,9	0,30
Calcium hydroxide	1	8,5	10,1	14,6	0,29
	2	6,0	10,7	11,3	0,38
	3	6,6	15,5	11,5	0,38
Gypsum	1	6,7	9,6	11,5	0,38
	2	7,2	11,7	15,5	0,24
	3	6,9	12,3	11,9	0,43
LSD P = 0,05		1 5	2,6	3,2	0,10
LSD P = 0,01			3,4		0,13
Cv (%)		146	16,7	17,2	20,9

DISCUSSION

Yields were significantly increased by moderate levels of dolomitic lime, Ca silicate and gypsum; and decreased by high levels of these materials, probably due to the antagonistic effect on K uptake (Table 5). Residual effects as compared to the control were obtained with all treatments. Blarney & Nathanson (1977) also found a marked effect of liming on yield of sunflower up to a certain pH, with no benefit above this pH. Iley & Guilford (1979) showed that excess lime could be detrimental to the life of citrus trees. The results of this experiment have shown that high extractable Al, especially in the topsoil, has a detrimental effect on the yield of mature avocado trees. This finding is in agreement with those of Martini, Kochhann, Siqueira & Borkert (1974), who showed that optimum yields with soybeans were obtained when liming reduced the Al concentration in the soil.

Despite relatively high applications of liming materials the change in pH was small, and thus not a very accurate indicator of the lime requirements. Yuan (1976) claimed that soil pH did not accurately indicate the acidity of a particular soil or the quantity of lime required for optimal crop production.

Gypsum induced a considerable increase in subsoil Ca concentration, without changing subsoil pH at all. Most treatments resulted in an increase in subsoil Ca, whereas dolomitic lime also increased subsoil Mg. Kotze & Joubert (1978) claimed that calcium hydroxide was leached downwards to a much larger extent than dolomitic lime and calcium silicate, and is therefore more suitable to alleviate subsoil acidity.

The drastic reduction in yield obtained with the control plot over the three-year period as compared to the treatments, demonstrated the necessity for applying lime (or calcium) to avocado soils with a high Al concentration. The aim should be to reduce the Al levels in the top 300 mm of soil to less than 20 mg kg^{-1}.

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