South African Avocado Growers' Association Yearbook 1989. 12:43-47

Cation distribution during soil profile amelioration with lime and gypsum

R O BARNARD
Department of Soil Science and Plant Nutrition, University of Pretoria, Pretoria 0002

ABSTRACT

Application of gypsum and dolomitic lime in combination appeared to be the best method of raising topsoil pH and increasing Ca in the subsoil, while maintaining Mg (and K) at satisfactory levels, in two avocado soils from Westfalia Estate.

UITTREKSEL

Toediening van gips en dolomitiese kalk in kombinasie, blyk die beste metode te wees om bogrond-pH en Ca in die ondergrond te verhoog, asook om Mg (en K) teen bevredigende vlakke te handhaaf, in twee avokadogronde, afkomstig van Westfalia-landgoed.

INTRODUCTION

In a previous paper (Barnard & Slabbert, 1988) the importance of considering soil depth in avocado soils was emphasized. As a result of an investigation into subsoil conditions on Westfalia Estates, two reference sites were selected for further studies, initially in the laboratory. These were selected on the basis of production history, to provide reasonable differences for an initial study. One was from an orchard with an extremely good production record, while the other was from a 'problem' orchard with extremely poor yield.

In a previous study with the carbonate, oxide, hydroxide, silicate and sulphate of calcium (Barnard, unpublished data), extremely limited neutralization was achieved below the level of original incorporation. In the current study, pertinent amelioration practices were included in a controlled leaching experiment.

MATERIALS AND METHODS

Asbestos columns

Asbestos discs, 100 mm deep and with a diameter of 100 mm, were taped together with masking tape and filled with soil, lightly compacted, to form columns 700 mm deep.

Soil that had been carefully collected on a profile basis was used to fill these columns, to simulate as near as possible, the natural profile.

The asbestos columns were arranged on a layer of quartz gravel in a 4 kg plastic pot and kept in position with more gravel. As each segment was taped in position, the previous segment was filled with soil, until the column had been completed.

The top 100 mm, before being inserted in the column, was thoroughly mixed with a particular chemical or ameliorant. These treatments are given in Table 1.

TABLE 1 Treatments applied in leaching experiment

Treatment number	Treatment applied
1	Control
2	2 t ha^{-1} sulphur
3	2 t ha^{-1} gypsum
4	10 t ha^{-1} gypsum
5	5 t ha^{-1} dolomitic lime
6	20 t ha^{-1} dolomitic lime
7	2 t ha^{-1} gypsum plus 5 t ha^{-1} dolomitic lime

Calculations were on 1 t ha^{-1} surface area basis, but mixed into the top 100 mm depth.

After initial saturation of the profile until leaching commenced, the equivalent of 50 mm precipitation was applied weekly, over a period of six months, to duplicate columns. This resulted in a total precipitation of roughly 1 300 mm. The leachates were not collected or measured.

At the completion of the leaching period of six months, the columns were allowed to dry out for two weeks. The columns were then carefully sampled, in 25 mm increments for the top 300 mm, and thereafter in 50 mm increments. As the columns were systematically dismantled, the respective layers were scraped out to the required depth with a teaspoon and spatula. These samples were air-dried and screened through a 2 mm sieve, prior to chemical analysis.

Soil samples

Soil samples were anlaysed according to standard methods (Bray & Kurtz, 1945; Van Vuuren, 1979 and FSSA, 1980). Ammonium acetate extractable Ca, Mg, K, and Na, and pH (H_2O) values were determined.

Pertinent questions

In evaluating the experimental data obtained, answers to the following questions were sought:

1 What is the vertical distribution of pH (H_20) and cations following different treatments, in the case of the poor and good orchard soils?

2 To what extent can unsatisfactory conditions in the soil profile be improved by

application of suitable amendments?

3 Can nutrient imbalances be aggravated, or even created, as a result of certain ameliorant treatments?

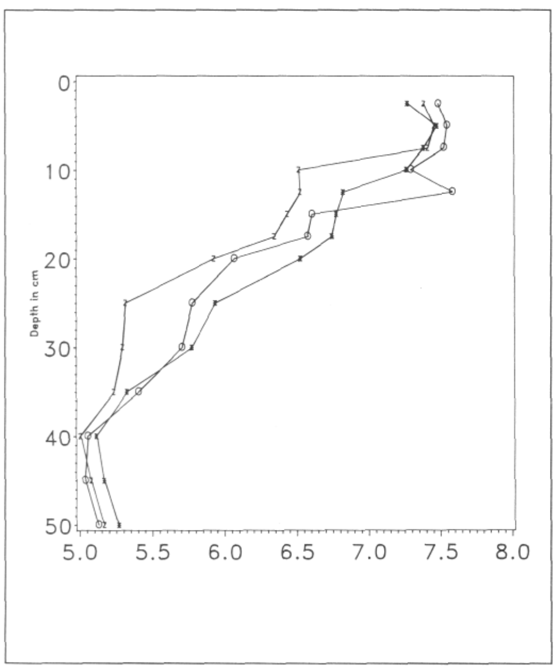
DISCUSSION AND RESULTS

There was a large amount of data available. The means of the duplicate treatments were calculated and the data tabulated. For the purpose of this paper, however, only selected graphical data are presented. The effect of artificial acidification is also not discussed further in this paper.

pH (H_20)

Gypsum application

Addition of 2 t ha^{-1} gypsum on the good orchard soil raised the pH slightly, while the 10 t ha^{-1} had little effect, even lowering it in some zones, as illustrated in Figure 1. This result was similar in the case of the poor orchard soil.



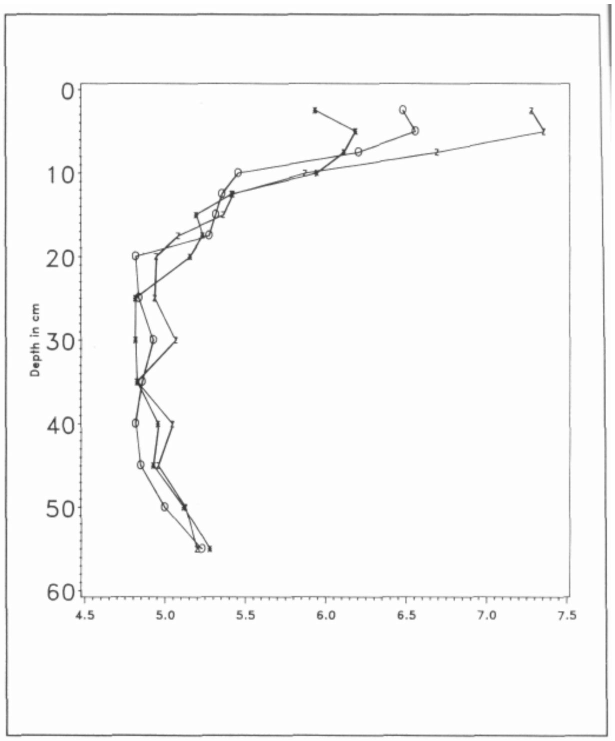
* — Control; O — Gypsum 1; Z — Gypsum 2

Fig 1 Effect of gypsum application in good orchard: pH.

Dolomite application

Application of 5 t and 20 ha^{-1} dolomitic lime raised the pH values of both soils. These pH increases were, however, largely confined to the zone of application, as shown in Figure

2 for the poor orchard soil.



* — Control; O — Dolomite 1; Z — Dolomite 2

Fig 2 Effect of dolomite application in poor orchard: pH.

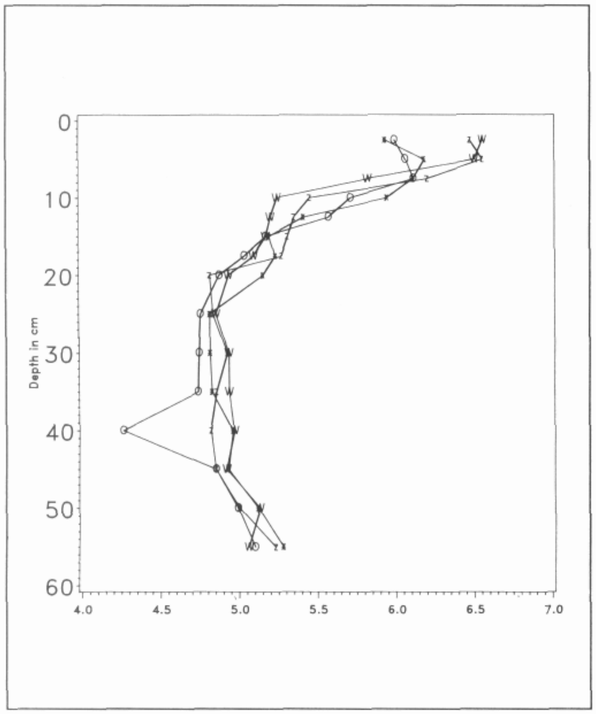
Gypsum + dolomite application

Combination of the lower levels of gypsum (2 t ha^{-1}) and dolomitic lime (5 t ha^{-1}) was largely noticeable in the zone of incorporation, although some effect was noticed lower down the profile. This made this combination the most acceptable and effective, as shown in Figure 3 for the poor orchard soil.

Calcium

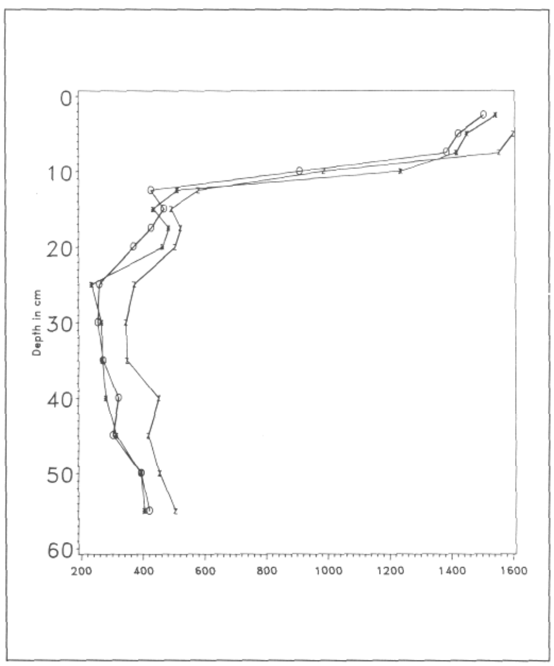
Gypsum application

The higher level of gypsum has a positive effect on increasing Ca levels in the profile, especially in the poor orchard soil, as illustrated in Figure 4.



* — Control; O — Gypsum 1; Z — Dolomite 1;
W — Gypsum 1 + Dolomite 1

Fig 3 Combined effect of gypsum and dolomite in poor orchard: pH.

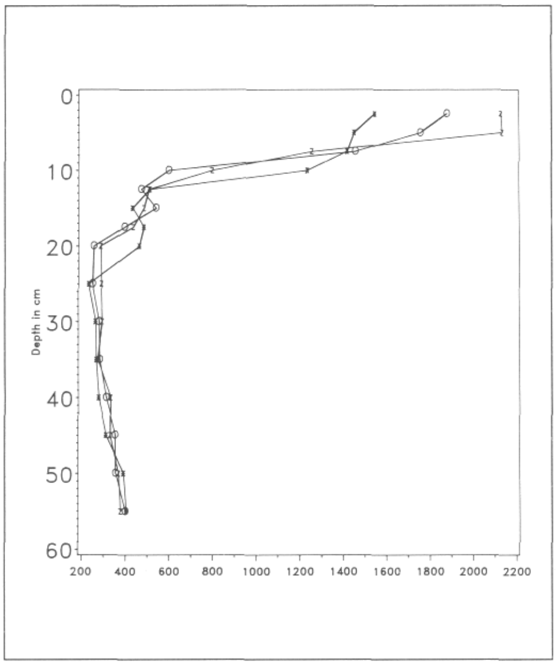


* — Control; O — Gypsum 1; Z — Gypsum 2

Fig 4 Effect of gypsum application in poor orchard: Ca (ppm).

Dolomite application

Dolomite increased the Ca levels in the zone of incorporation, although it also resulted in slightly higher levels right down the profile, as illustrated in Figure 5.

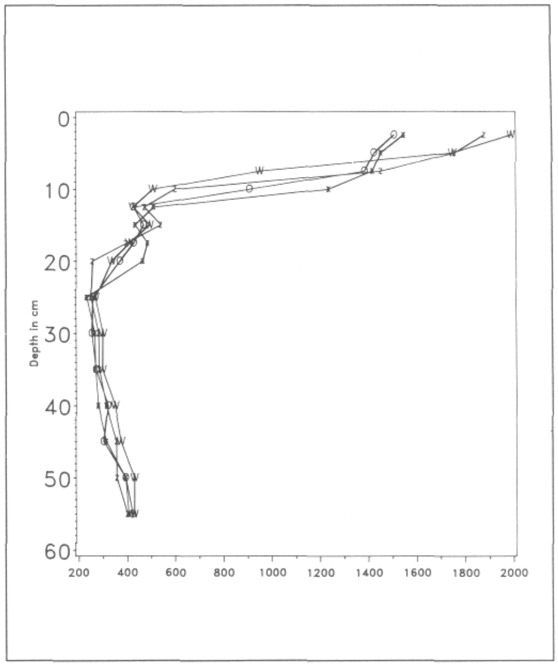


* — Control; O — Dolomite 1; Z — Dolomite 2

Fig 5 Effect of dolomite application in good orchard: Ca (ppm).

Gypsum + dolomite application

Combination of lower levels of gypsum (2 t ha^{-1}) and dolomitic lime (5 t ha^{-1}) resulted in some movement of Ca down the profile. This was especially the case in the poor orchard, as shown in Figure 6.



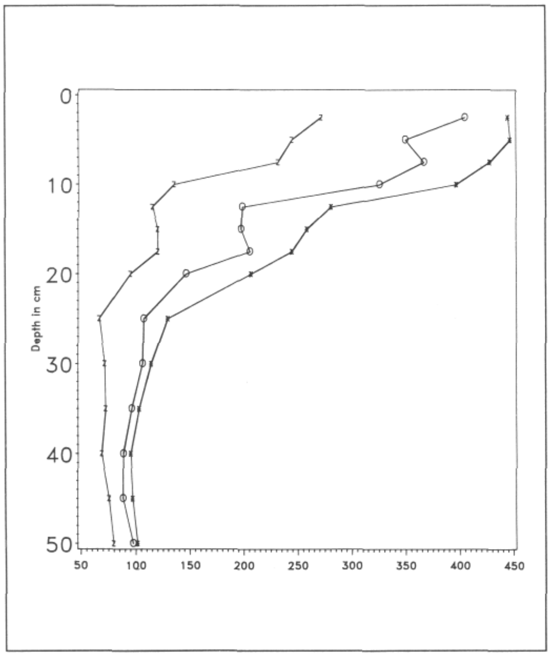
* — Control; O — Gypsum 1; Z — Dolomite 1;
W — Gypsum 1 + Dolomite 1

Fig 6 Combined effect of gypsum and dolomite in poor orchard: Ca (ppm).

Magnesium

Gypsum application

Gypsum, especially at the higher levels of application, resulted in considerable depletion of Mg from the profiles, as illustrated in Figure 7 for soil from the good orchard.



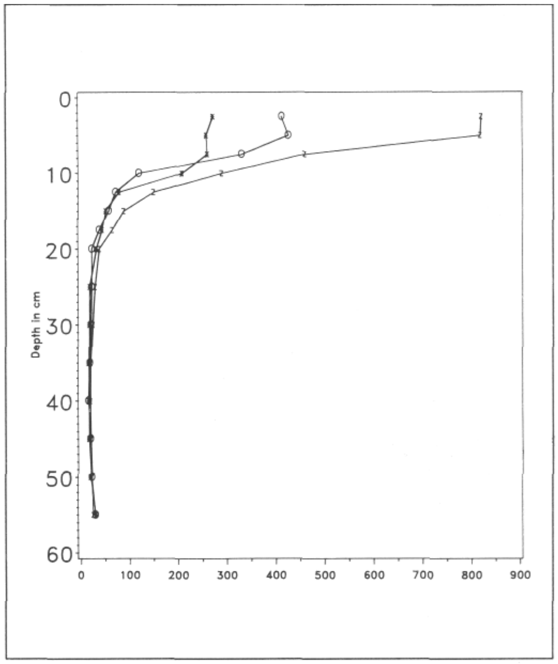
* — Control; O — Gypsum 1; Z — Gypsum 2;

Fig 7 Effect of gypsum application in good orchard: Mg (ppm).

This could obviously have serious applications in some instances, as pointed out by other workers (Reeve & Sumner, 1972; Buyeye, Fey & Mott, 1985; Sumner, Miller, Radcliffe & McCray, 1985), but also clearly illustrated here.

Dolomite application

Mg increased considerably, especially at higher application levels, in the zone of dolomite application, as could be expected. There was, however, also an effect in the next 10 cm, as is clear from Figure 8 for the poor orchard soil.

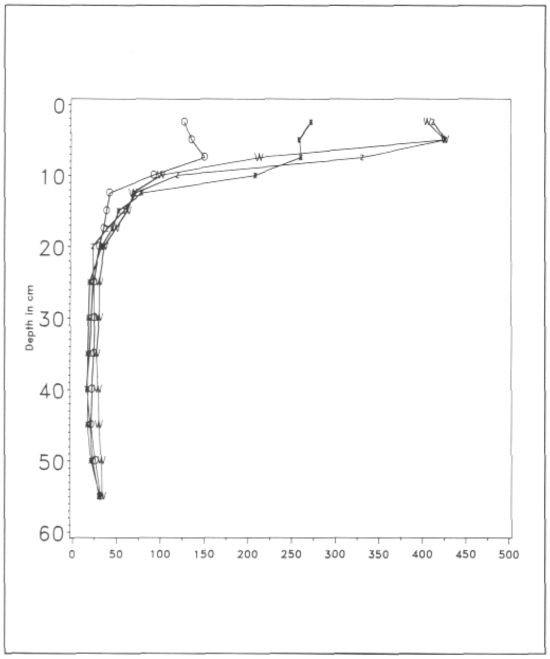


* — Control; O — Dolomite 1; Z — Dolomite 2

Fig 8 Effect of dolomite application in poor orchard: Mg (ppm).

Gypsum + dolomite application

In combination, gypsum and dolomite ensured that higher levels occurred in the zone of incorporation, but also throughout the profile, as shown in Figure 9 for the soil from the poor orchard. The values in the lower layers are still unfortunately low, but this does point to ways of handling this particular type of problem in practice. It is of special importance where gypsum applications are necessary to increase subsoil Ca-levels.



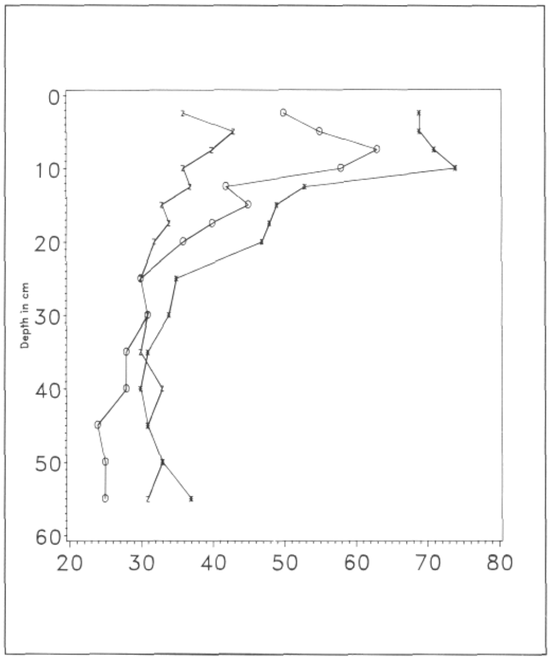
* — Control; O — Gypsum 1; Z — Dolomite 1;
W — Gypsum 1 + Dolomite 1

Fig 9 Combined effect of gypsum and dolomite in poor orchard: Mg (ppm).

Potassium

Gypsum application

There were indications of displacement of K from the upper layers, and even deeper down, especially in the soil from the poor orchard, as illustrated in Figure 10.



* — Control; O — Gypsum 1; Z — Gypsum 2

Fig 10 Effect of gypsym application in poor orchard: K (ppm).

Dolomite application

This appeared to have relatively little noticeable effect on K levels in both soils.

Gypsum + dolomite application

This treatment combination had little real effect on K distribution in the profiles, actually tending towards the best treatment on the soil from the poor orchard, as shown in Figure 11. As far as this aspect is concerned, it therefore appears to be a safe practice.

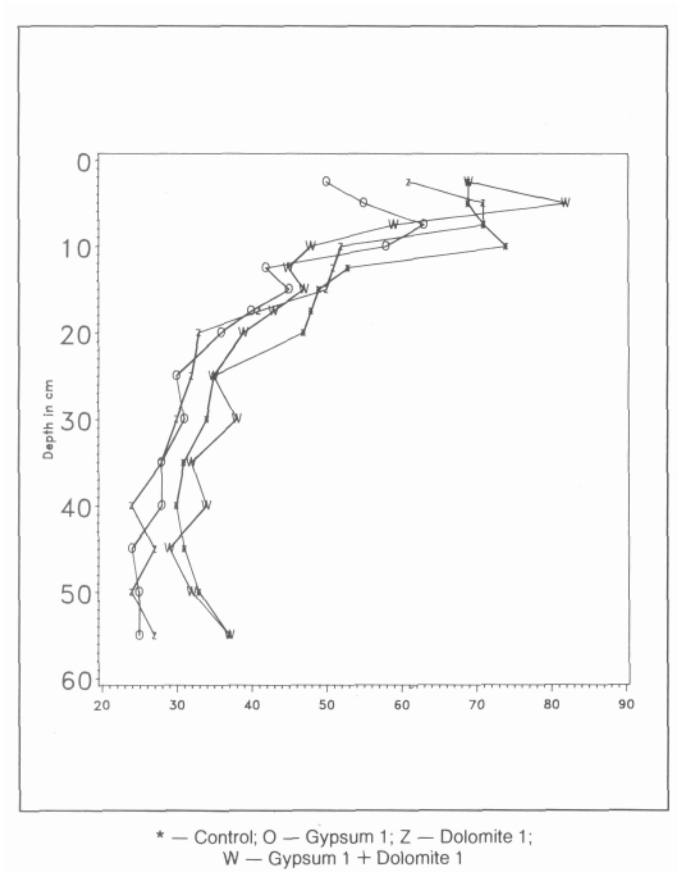


Fig 11 Combined effect of gypsum and dolomite in poor orchard: K (ppm).

CONCLUSIONS AND RECOMMENDATIONS

From the foregoing, the following conclusions and recommendations are apparent. No matter what ameliorant is employed, it is difficult to raise the pH-level except by physical incorporation and mixing.

While low Ca-levels in the subsoil can be raised with gypsum, Mg-levels can be severely depleted at the same time, as well as K-levels, although to a lesser extent.

Where gypsum is used to raise Ca-levels in the subsoil, it is advisable to apply it in combination with dolomitic lime.

In the case of perennial crops especially, it is essential to rectify soil acidification prior to establishment and to restrict it as much as possible thereafter.

ACKNOWLEDGEMENTS

Financial assistance by the South African Avocado Growers' Association, as well as the co-operation of the technical management of Westfalia Estate, is gratefully acknowledged.

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