Best practice nutrition

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Abstract

Coastal soils have inherently low cation exchange capacities (CEC) and must be managed. Best practice nutrition programs are designed to optimize uptake, sustain tree health and fruit development via fertiliser inputs based on the maintenance of specific soil water nutrient parameters. The application of nutrients in excess of the soil's ability to hold them can affect tree health and the environment.

Three properties on three soil types (podzolic, yellow earth, and red earth) were sampled over a 12 month period. Soil water was extracted at weekly intervals from depths of 15cm and 40cm using Mottes tensiometers. Electrical conductivity (EC), pH, nitrate, phosphate, potassium, calcium and magnesium were measured.

Standard deviations (SD) and time series analyses demonstrated the erratic nature of soil nutrient levels across soil types and highlighted the complexity of the management needed to grow on fringe soil types such as gleyed podzolics and yellow earths. Coastal soils will not hold nutrient levels in excess of a prescribed value. Even in the absence of fertiliser inputs phosphate SD ranged from 11.5 to 17.7ppm before returning to equilibrium. Calcium and magnesium reacted in the same way. Nitrate levels were the most difficult to stabilize, with standard deviations of 37.3ppm for yellow earths, compared to 24.8ppm for the podzolic and 17ppm for the kandosol. The red kandosol soil is by far the better growing medium, allowing for lower inputs and a better predictability. The difficulty in keeping within specified nutrient level parameters makes pulse irrigation an imperative on fringe soil types.

Key words

Nutrient movement
Environment
Equilibrium
Luxury levels
Orchard health

Notation and units

Ca	-	calcium
CEC	-	cation exchange capacity
EC	-	electrical conductivity
P	-	phosphate
Mg	-	magnesium
N	-	nitrate
OM	-	organic matter
K	-	potassium
ppm	-	parts per million
SD	-	standard deviation
dS/m		deciSiemens per meter
PSI		phosphate saturation ratio

Introduction

Fertiliser programs are designed to meet the needs of the tree at varying physiological stages. The ability of a fertiliser to coincide with a specific growth stage is dependent on the rate, method and timing of application. Granular fertilisers such as gypsum and sulphate of potash need to be applied at least two months in advance because they are surface applied and subject to erosion. Dirou and Huett (2001) provide a spreadsheet program based on orchard age, potential yield and fruit removal. A six-year-old Hass block with a plant density of 200 trees/ha to achieve a yield of 20 tonne/ha requires 168kg of elemental nitrogen, 38kg phosphorus, 199kg potassium, 82kg calcium and 40kg magnesium. Split applications are applied at specific periods throughout the growing year. If the full recommended complement for a particular period is applied it will exceed the soil's ability to hold it.

The question is: if a soil has an adequate level of a particular nutrient, does it need reapplication to complete the removal and growth equation? Luxury levels will move through the profile, away from the roots, or enter the groundwater. So, just because certain levels are recommended does not infer they are needed.

Fertigation allows the operator flexibility by splitting rates, however nutrient will move through the profile if the irrigation period is exceeded or the operator needs to fill the lower soil profile. Injection is the most desirable methodology; however it too is bonded to achieving specific application rate goals and is subject to misuse if a soil profile needs filling. The inclusion of a little and often is also dependent on whether the soil can hold constant infusions. Irrigating may not always be necessary, or allowable, due to rain. So, the environment and nutrient balance are at risk.

Coastal soils have inherently low cation exchange capacities (CEC). Being aware of the CEC is intrinsic to fertiliser management. Soils deemed suitable for avocado growing – such as krasnozems with CECs greater than 12meq/100g – are limited and expensive in Queensland, Australia. The selection of marginal soil types incurs increased preparation procedures; however, while this is an imperative, it does not improve internal drainage but lowers the watertable. There is little that can change the CEC: therefore it must be managed. The analogy of the jar holding just so much is an empirical truth.

Methods and Materials

Three properties on three soil types were sampled weekly over a 12 month period. Great soil groups are Site 1, a red earth or kandosol; Site 2 a yellow podzolic; and Site 3 a yellow earth. Site 1 is a massive red loamy soil on alluvium. Site 2 a gleyed duplex, and Site 3 grey sandy loam overlying mottled yellow sandy clay. Site 2 and 3 have clay contents of 10% at 30cm increasing to 20% at 60cm. Site 1, the red earth, has a clay content of 20% at 30cm increasing to 30% at 60cm (Wilson 1997). Soil analytical results are listed in Table 1.

Table 1: Soil analytical results

	OM	pH	CEC	EC (1:5)	N%	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)
Red Earth	3.13	5.99	8.8	0.08	0.17	99.2	241.3	805	142.4
Yellow Podzolic	1.66	5.67	5.1	0.38	0.04	78.6	113.8	494	87.6
Yellow Earth	2.16	7.02	7.0	0.13	0.01	202.3	49.5	1084	162.9

Organic matter is very low in all soils. Though the clay component is higher in the red earth, kaolinite, gibbsite and free oxides of iron (e.g. hematite) are the dominant clay minerals. The yellow earth and yellow podzolic have a strong dominance of magnesium at depth. All soils are subject to compaction. Phosphate is high in the red earth and podzolic and very high in the yellow earth. The phosphate saturation ratio is very high in the yellow earth (0.302). The optimum range is 0.062 to 0.23. The red earth is 0.098 and the yellow podzolic is 0.126. All other elements are low to very low.

Soil water analyses

Soil water was extracted at weekly intervals using Mottes tensiometers from depths of 15cm and 40cm and analysed for electrical conductivity (EC). pH, nitrate, phosphate, potassium, calcium and magnesium were measured using a reflectoquant. The sampling dates are same for each site.

Electrical Conductivity (EC)

The electrical conductivity was significantly influenced by fertiliser applications and rainfall. Figure 1 (Yellow Podzolic) shows the reduction in conductivity when fertiliser applications (particularly sulphate of potash) are withdrawn after harvest in April and the cooler period to June. The effect of greater than average rainfall (1129.5mm) from August to December, with 718mm falling in December alone, nearly completely flushed salts. The red earth (Figure 2) did not demonstrate the erratic movement of the yellow earth; however significant leaching occurred during December. An NPK blend (N13P2K22) was surface applied at 100kg/ha in November.

Figure 1 Yelllow Podzolic Electrical Conductivity (dS/m)

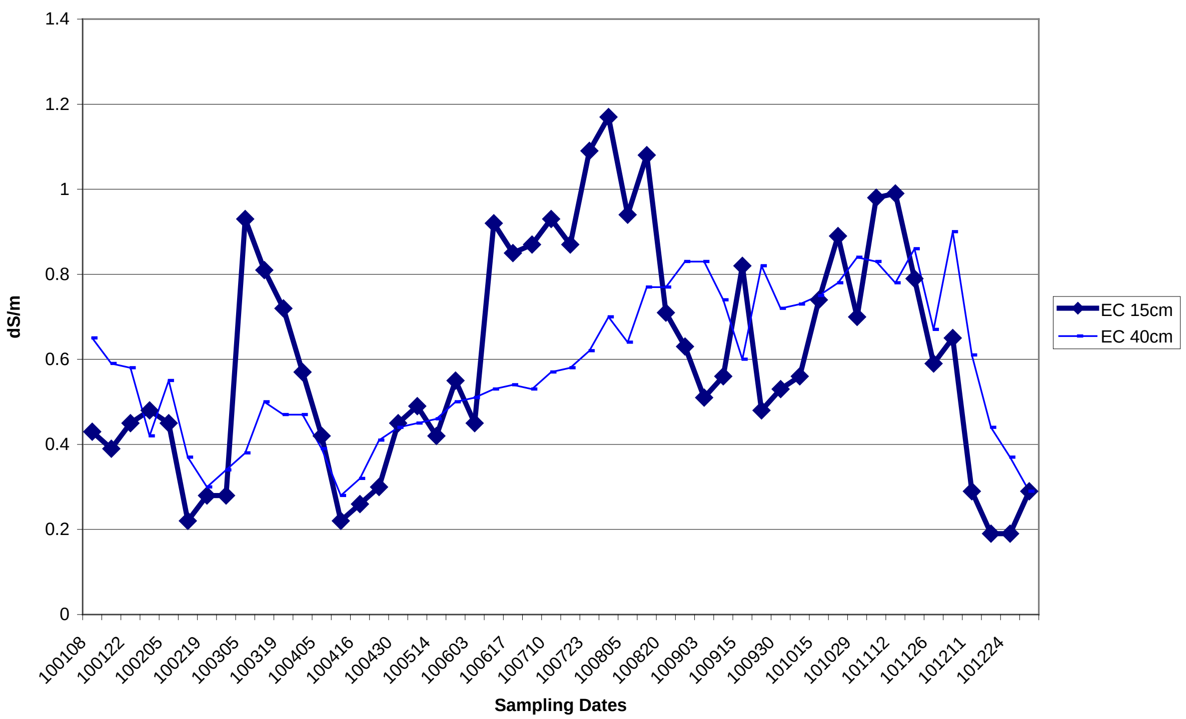
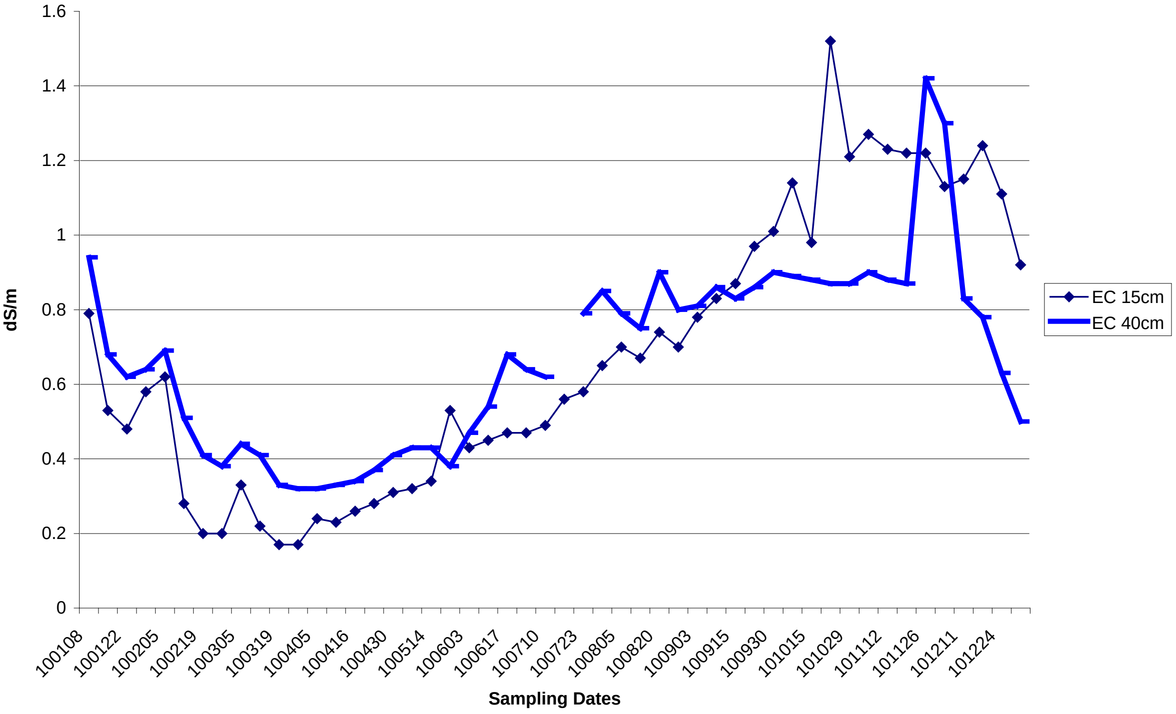


Figure 2 Red Earth Electrical Conductivity (dS/m)



Soil water acidity

Soil water acidity is significantly influenced by the irrigation water quality. Time series analyses (Figures 3, 4 and 5) demonstrate when irrigations are reduced during winter, pH drops at all sites. The water supply for all three properties is derived from a channel. pH levels exceeding 8.0 have been measured.

Figure 3: Red Earth Soil Water pH

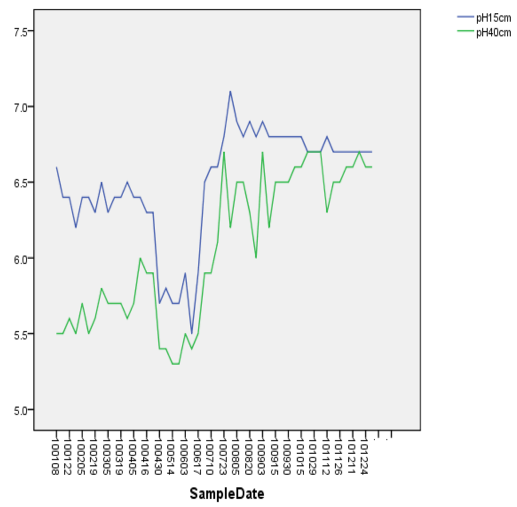


Figure 4: Yellow Podzolic Soil Water pH

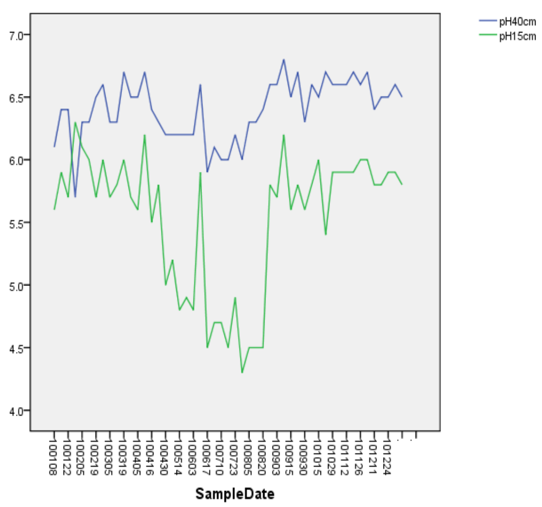
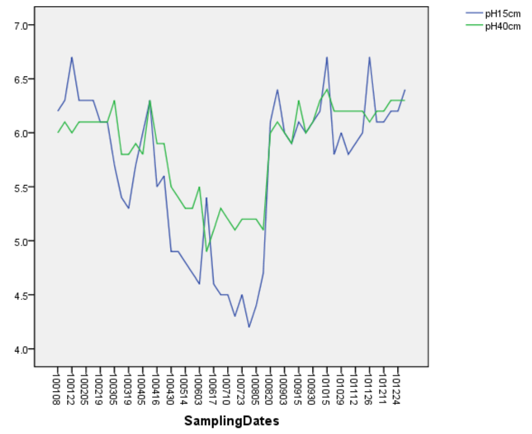


Figure 5: Yellow Earth Soil Water pH



Nitrate

Nitrates moved readily through the profile. To maintain tree vigor, the minimum desired nitrate level was 40ppm. Applications totalling 90kg of elemental nitrogen were made to the yellow earth in January, February, March, July and October 2010. The red earth received 67kg elemental nitrogen in January, March, September, October and November 2010. Standard deviations ranged from 37.6ppm at 15cm and 33.1ppm at 40cm for the yellow earth and 11.6ppm and 10.6ppm for the red earth. The yellow podzolic had standard deviations of 24.8 and 22.3. The inability of the yellow earth to hold moderate nitrate levels is demonstrated in Figure 6. While both the red earth (Figure 7) and yellow earth show significant movement, the yellow earth losses are critical.

Figure 6 Yellow Podzolic Nitrate Levels (ppm)

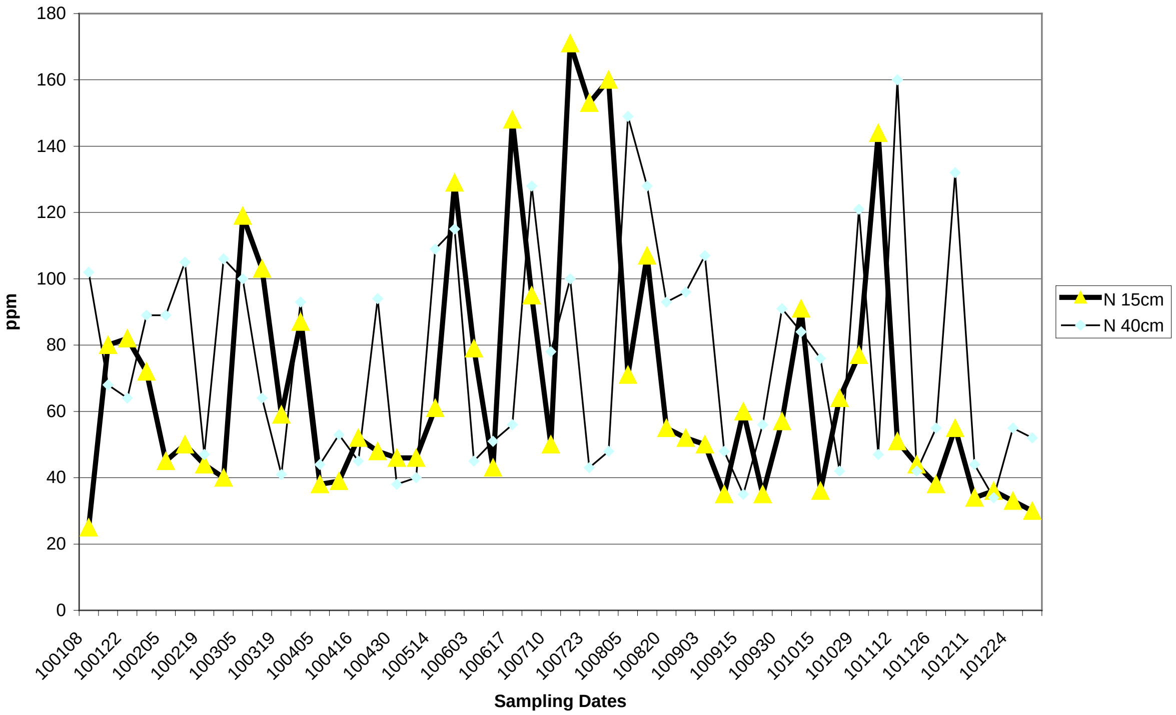
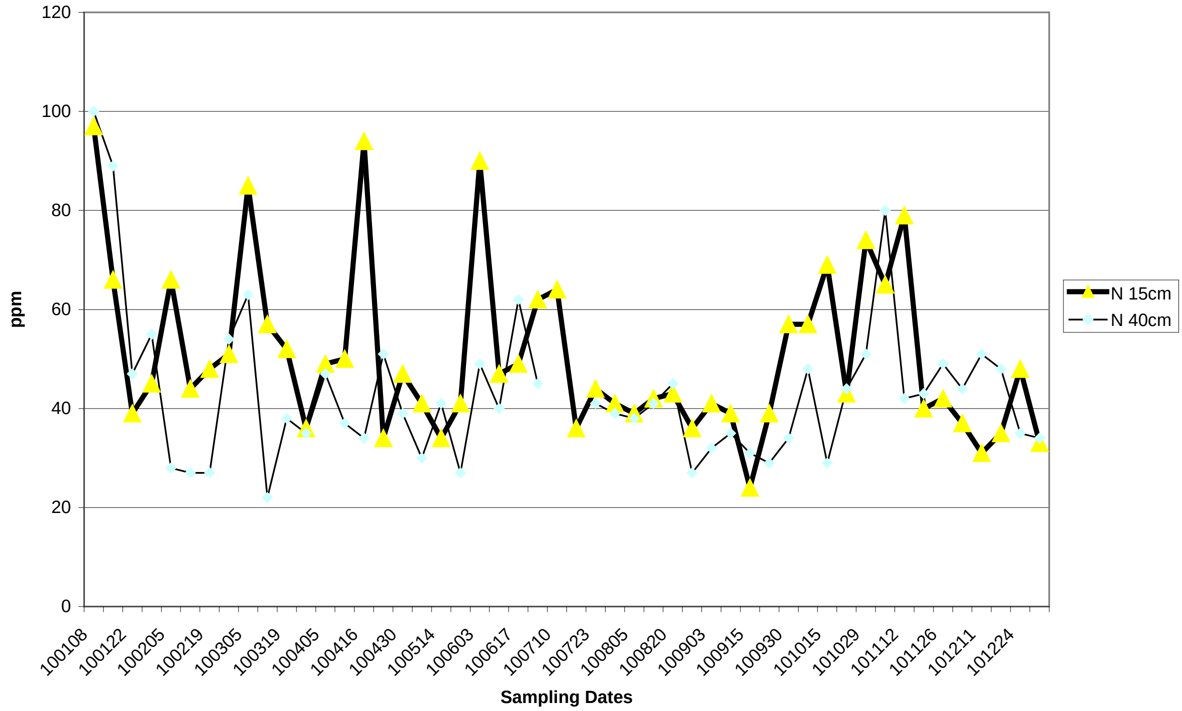


Figure 7 Red Earth Nitrate Levels (ppm)



Phosphate

The red earth site received 3kg elemental phosphorus in November 2010. The greatest movement of phosphate appeared to be at site two, the yellow earth. There is no statistical relationship between surface phosphate levels and subsurface levels (Figure 8), though the introduction of linear trendlines suggests a loss of phosphate in the podzolic (Figure 9). It has a very high soil phosphorus level of 202.3ppm. It received 9.6kg of elemental phosphorus as compost dressing in November 2010. While movement is evident in each of the soils the natural equilibrium approached 40ppm. The phosphate saturation ratio (PSR) was very high in this soil.

Figure 8: Time Series Analyses of Yellow Earth Soil Water Phosphate Levels (15cm and 40cm)

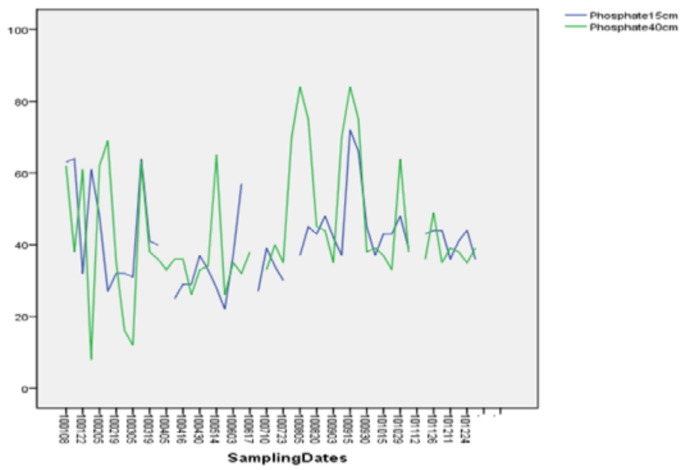
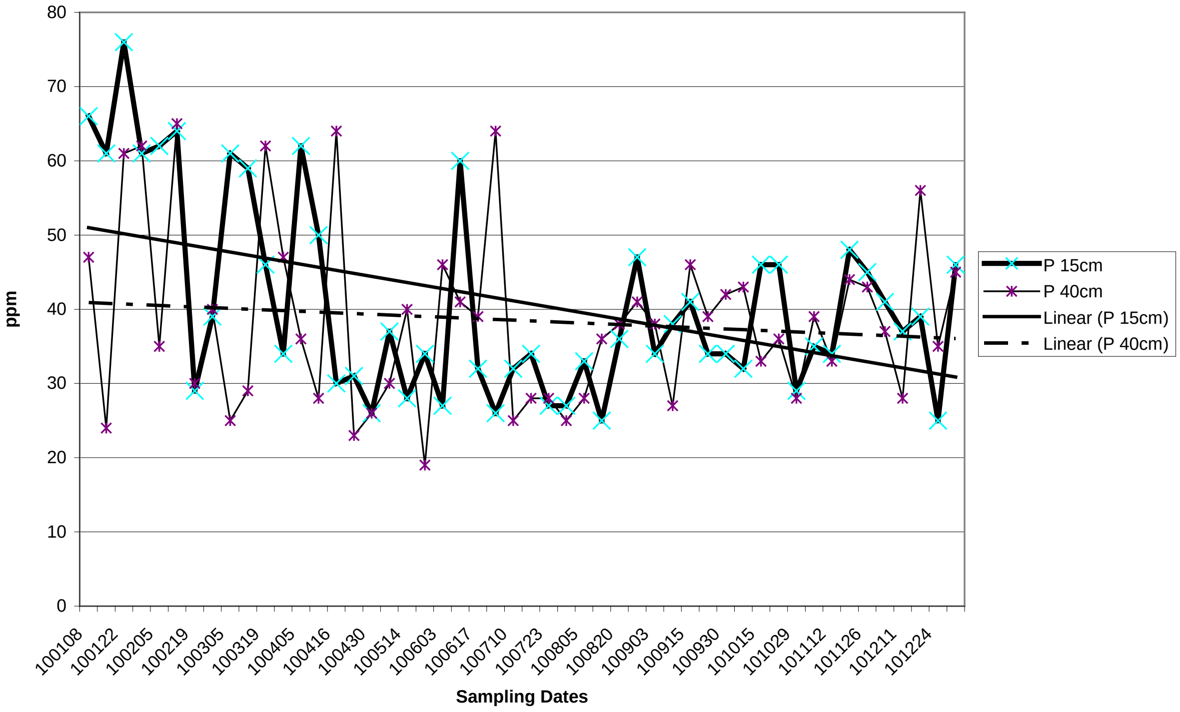


Figure 9 Yellow Earth Phosphate Levels (ppm)



Potassium

Figure 10 demonstrates significant movement of surface potassium (15cm) in the yellow podzolic. A similar result was recorded in the yellow earth. The red earth (Figure 11) shows a linear relationship (R2 0.698) between potassium at 15cm and 40cm and the stability of potassium in higher clay content soils. Fertiliser inputs made in January, March, April and November 2010, aimed to maintain the potassium levels above 5ppm increasing to 10 to 15cm during fruit fill. Significant rainfall events in the latter part of the year significantly influenced the yellow earth and yellow podzolic.

Figure 10 Yellow Podzolic Potassium Levels (ppm)

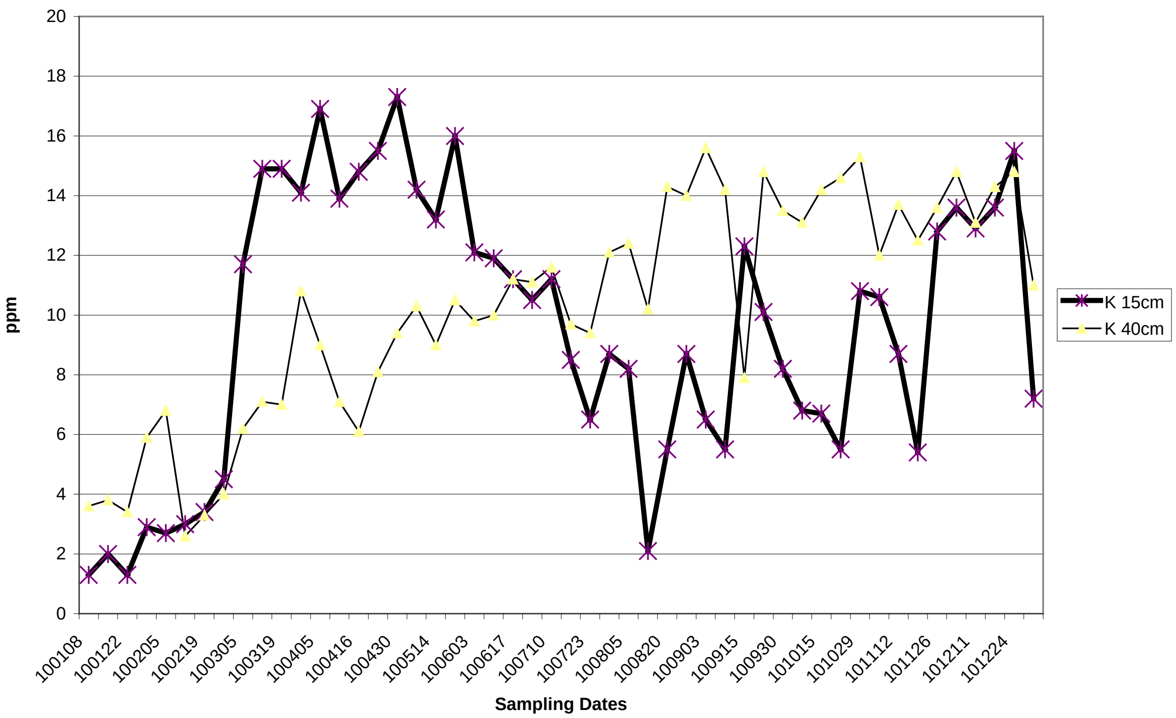
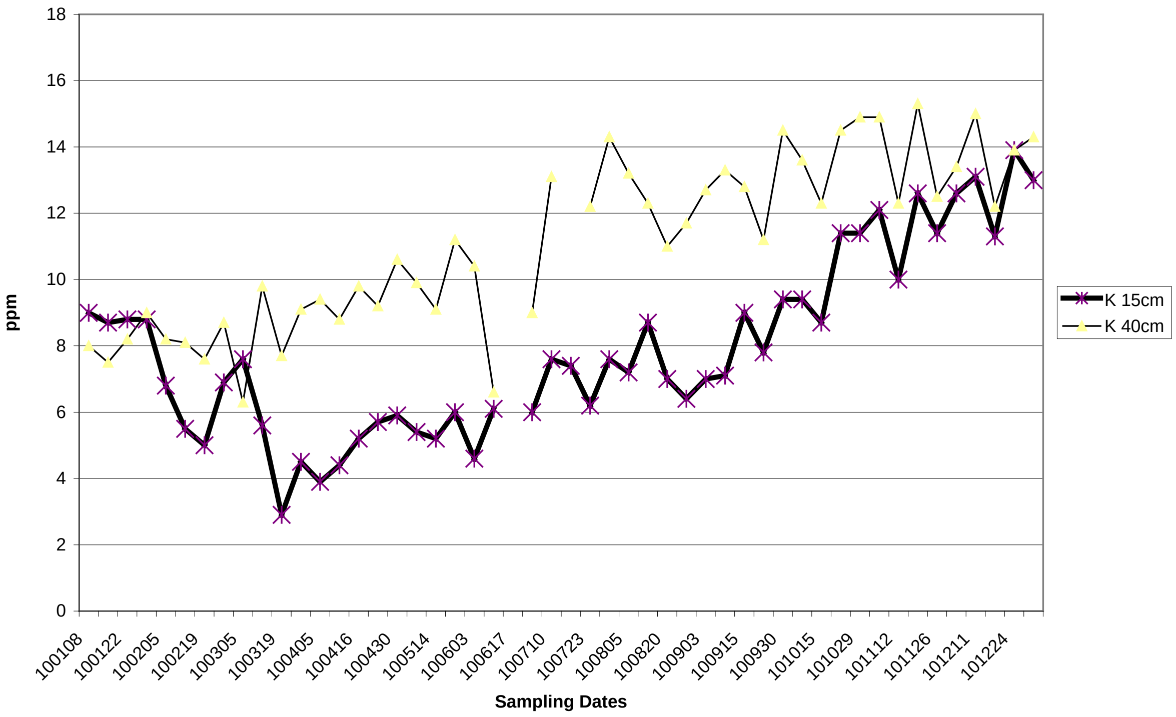


Figure 11 Red Earth Potassium Levels (ppm)



Calcium

Gypsum was banded at three tonne per hectare to the red earth site (Figure 12) in July 2010. The only other form was calcium nitrate in November. The yellow podzolic site (Figure 13) received the same rate in August 2010. Significant rainfall events from August to December are reflected in the seesawing levels. This response also reflects the quality of the material applied. Particle size was variable. The objective to maintain calcium levels approximating 100 to 120ppm during flowering and fruit set was not possible.

Figure 12 Red Earth Calcium Levels (ppm)

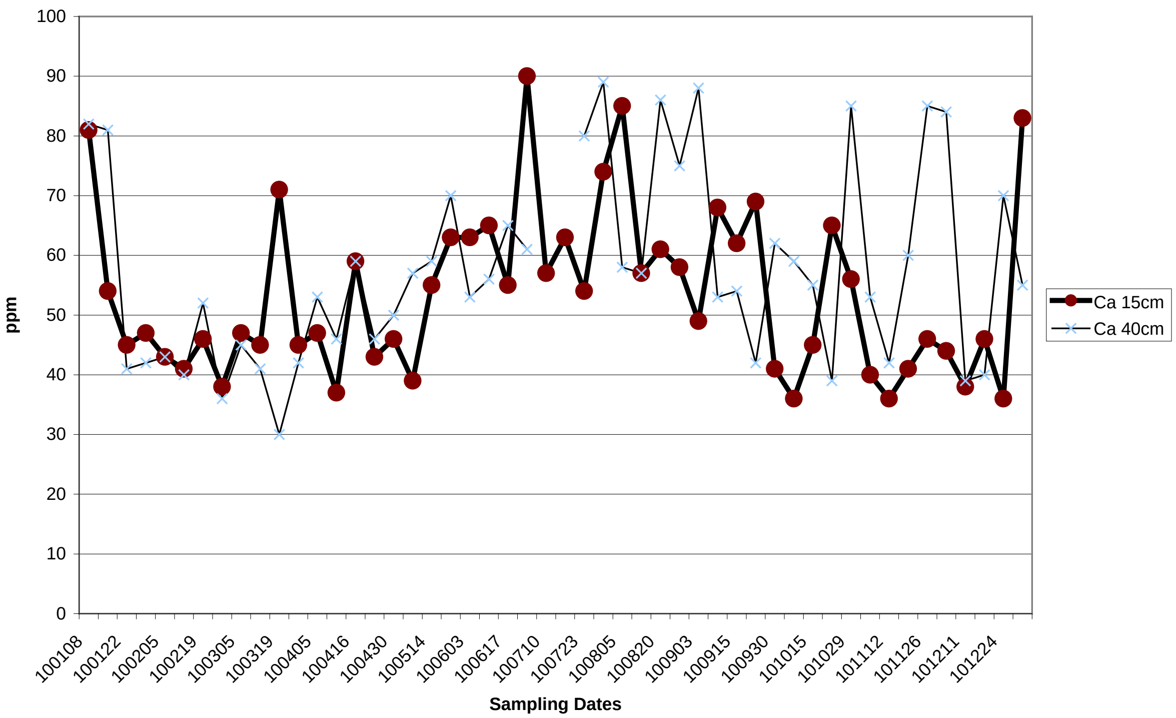
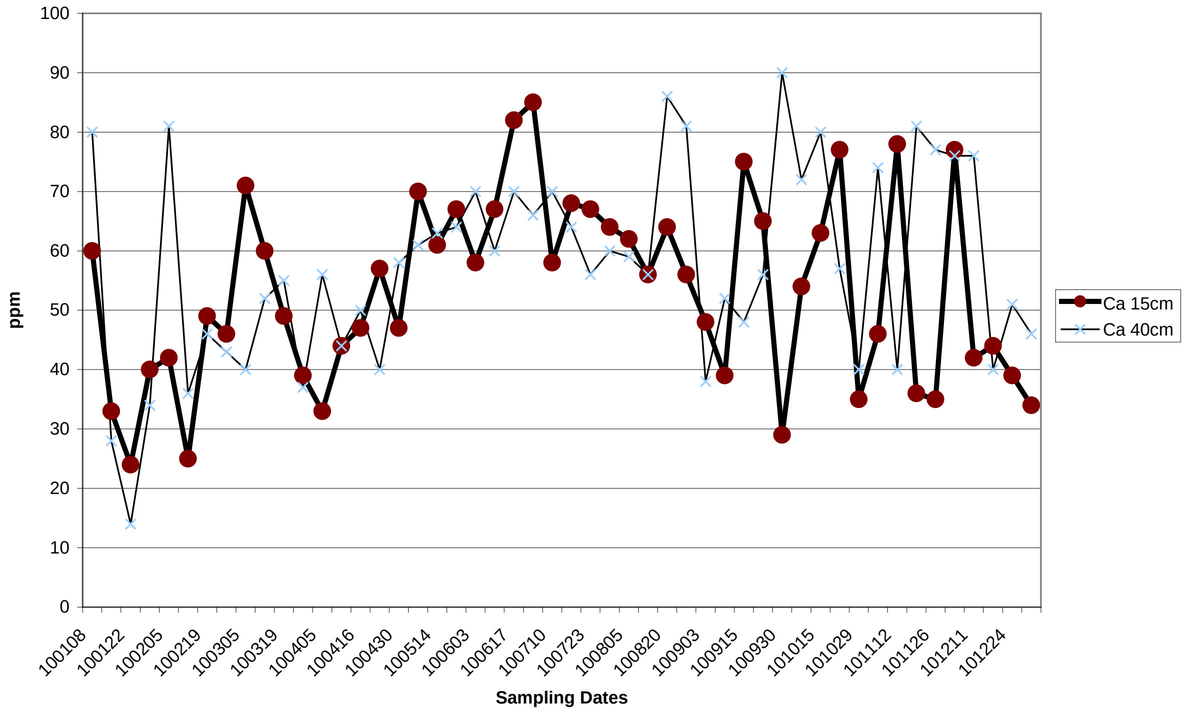


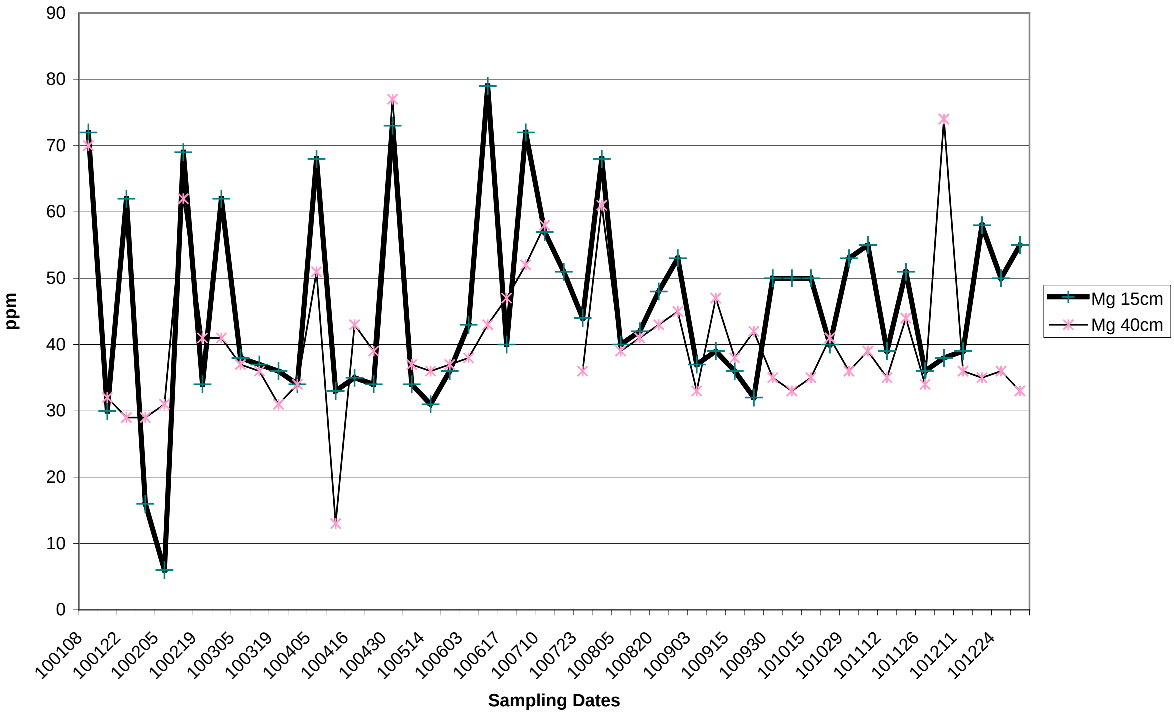
Figure 13 Yellow Podzolic Calcium Levels (ppm)



Magnesium

Magnesium is applied in February and March at 25kg per hectare. The objective of which is to maintain levels at a minimum of 40ppm. There is a significant draw on it during the summer months. All three sites demonstrated the same pattern as seen in the red earth site (Figure 14). In the absence of inputs, levels average 40ppm.

Figure 14 Red Earth Magnesium Levels (ppm)



Conclusions

Optimum yields can be obtained using the formula: "Apply it when it is needed.'' A soil's ability to cope with inputs is dependent on its CEC. With inputs of, 74kg N, 13kg P, 150kg K, 690kg Ca and 7kg Mg from harvest in June 2010 to harvest in June 2011, the red earth produced a yield of 28 tonne per hectare. Less than 1% of trees were affected by the heavy deluge from August 2010 to December 2010. Conversely 50% of trees were lost on the yellow podzolic and 30% affected on the yellow earth due to poor internal drainage.

Establishing soil water nutrient levels which are commensurate with a soils' ability to cope needs time. Sap testing three times per year establishes confidence when setting parameters.

Phosphate ions do not leach, however, the PSI for the yellow earth suggests with excessive soil P levels phosphate is transported through the soil. Additional phosphates on these soils are generally applied in the form of composts. Sugar mill filter press with less than 1ppm P is applied at rates of 20 tonne per hectare exacerbating the environmental problems associated with excess phosphorus.

The higher clay content in the red earth restricted potassium movement through the profile and allowed it to accumulate in both the 15cm and 40cm range, enabling a significant reduction in applications. Significant losses occurred at the other sites when heavy rains were received.

The movement of nitrates through the profile may be smoothed by fertiliser injection. The water pH and EC can be monitored and controlled; however, you still need to know when the jar is full.

Granular fertilisers need time to work. When limited windows are available to us, applications need to start early. Heavy rates of calcium will increase that available calcium to the tree, however, generally it is in excess of the soil's ability to hold it.

Persisting with rigid fertiliser philosophies is wrong, environmentally dangerous and a short term solution to sustainable production. Soil health, not addressed here, is intrinsic to fertility and sustainability. Increasing fertiliser inputs camouflages soil and environmental damage. The selection of the right soil is not always possible, but a knowledge of its capacity to grow avocados is essential.

References

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Wilson, P.R. (1997) *Soils and Agricultural Suitability of Childers Area, Queensland*, Land Resources, Department of Natural Resources.