The OPRAtive Word

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Improved Fertiliser Use on Volcanic Soils in Papua New Guinea

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BACKGROUND:

Volcanic soils (*Andosols*) in West New Britain Province and parts of Oro Province are coarse textured soils. The topsoil is high in organic matter and the soil has many layers of ash and pumice down the soil profile. Annual rainfall, in the regions where oil palm is grown, is in the 3000 – 5000 mm range. As a rule these volcanic soils are freely draining, and even though the rainfall is high, they do not suffer from long periods of water logging. Volcanic soils are well suited to growing oil palm, NBPOL and Hargy Oil Palms in WNBP, and Higaturu Oil Palm in Oro Province, have established successful plantations on these soils. At the end of 2007 there was 107,000 ha of oil palm planted on these soils.

To improve crop production, palms are fertilised with Nitrogen (*N*) (*usually applied as Ammonium Nitrate, Ammonium Chloride or Di-ammonium Phosphate*), Potassium (*K*) (*Muriate of Potash*), Phosphorus (*P*) (*Di-ammonium Phosphate or Triple Superphosphate*), Magnesium (*Mg*) (*Kieserite*) and Boron (*B*) (*Sodium Borate*). The dose of fertiliser applied is determined through interpretation of tissue (*frond 17*) nutrient content and palm age.

Because these volcanic soils are so freely draining, it is recommended to apply those nutrients which leach readily only during the dry season (*Banabas, 2007*).

Special attributes of these volcanic soils in relation to fertiliser use:

- The fertilisers mentioned above have different levels of solubility and depending on the inherent attributes of the soil, will leach and be lost from the root zone at different rates;
- Moderate to very low CEC (*Cation Exchange Capacity*) with variable charge (*this means that the ability of the soil to retain nutrients such as Mg and K is relatively poor*);
- The already low CEC is reduced further as soils become more acidic (*which occurs when acidifying nitrogenous fertilisers are used*);
- Volcanic soils contain allophane and iron oxides that tie-up phosphates (*by forming complexes such as aluminium and iron phosphates which are unavailable to plants*);
- The aluminium in allophane reduces microbial activity in the soil organic matter, which reduces the mineralisation of organic N to ammonium and nitrate.

What is the critical information required when developing a fertiliser strategy on these volcanic soils?

- The rate of leaching of the various nutrients supplied by different fertilisers and how quickly after rain these nutrients are lost below the root zone;
- Which nutrients are tied up in the soil and unavailable to plants;
- Soil attributes such as their inherent nutrient availability (*the Cation Exchange Capacity of the soil*);
- Timing, product selection and placement of fertiliser applications.

This OPRAtive Word considers the issues of nutrient loss and fertiliser placement based on trial work undertaken in an ACIAR funded project on WNB. It makes specific recommendations on fertiliser use and best placement to reduce loss and fixation (*tie-up*).

TRIAL DATA:

Leaching trials were set up at Navo Plantation (*Hargy Oil Palms*) and at Dami Plantation (*NBPOL*). These trials were designed to determine the extent of cation and anion leaching on volcanic soils following the application of specific fertilisers.

Table 1. Fertiliser treatments for leaching trials at Navo, 2007

Fertiliser Treatment	Kg fertiliser applied per plot (4m²)	Cation/Anion kg applied per plot (4m²)	Moles charge/ plot	Cation/Anion tested down the soil profile
Control	None	-	-	Mg, SO_4, K, Cl, NH_4, NO_3
$MgSO_4$ - Kieserite	1.33	Mg 0.23; S 0.31	18.6	Mg, K, SO_4
$MgCO_3$ - FO1	0.91	Mg 0.23	18.6	Mg, K
KCL - MoP	1.46	K 0.7; Cl 0.7	18.6	Mg, K, Cl
NH_4Cl - ammonium chloride	1.00	N 0.25; Cl 0.66	18.6	NH_4, Mg, K, NO_3, Cl

In the leaching trial at Navo, four fertilisers were applied to small plots (*2 x 2m*) in a newly planted area (palms planted one-*year prior to experimentation*). The plots were set up in the relatively undisturbed area in the row between the palms (there was no canopy cover over the plots). Daily rainfall was measured on site. The trial was set up in October 2007 and sampled after 1150mm of rain in December 2007. Soil analysis was undertaken by CSIRO in Townsville, Australia.

The fertiliser treatments applied are described in Table 1.

RESULTS:

Soil acidity: The single application of Ammonium Chloride lowered the soil pH by a full unit (*pH as measured in water*) all the way down the soil profile, compared to the control and other fertil-

iser treatments (*Figure 1*).

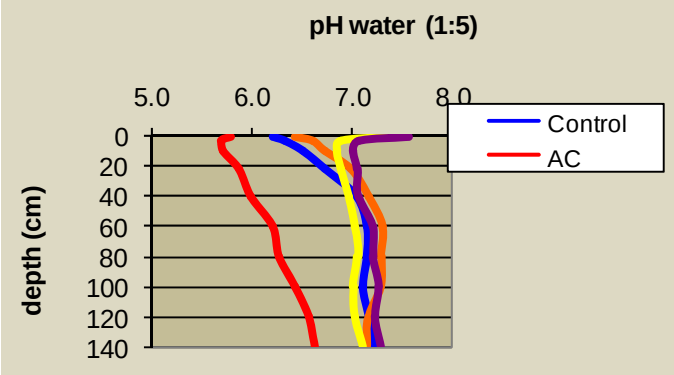

Figure 1. Soil pH following the application of four different fertilisers and an untreated control; measured 2-months and 1150mm of rainfall after application.

The extent of soil acidification was higher than expected after the application of a single dose of Ammonium Chloride. Continued use of acidifying fertilisers such as Ammonium Chloride could result in even lower soil pH over time, which could reduce the availability of nutrients to oil palm. Lowering the soil pH will reduce the availability of phosphorus as phosphate. The extent, rate and ramifications of soil acidification under oil palm on volcanic soils are currently not known. As a matter of urgency these data should be collected so that, practices which reduce soil acidity can be initiated if required.

Leaching of Magnesium: the Mg in Kieserite and FO1 ($MgCO_3$) did not leach appreciably even after 1150mm of rain (*Figure 2*).

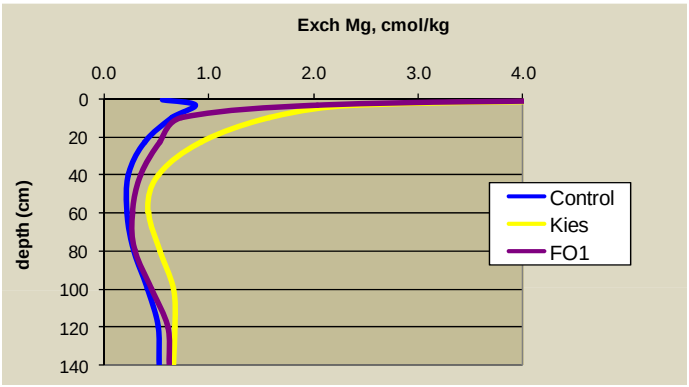

Figure 2. Soil Mg concentration following the application of four different fertilisers and an untreated control; measured 2-months and 1150mm of rainfall after application.

Leaching of Potassium: the K applied in MOP (*Muriate of Potash as KCl*) had leached to the depth of the measured soil profile (*140 cm*), however there were still appreciable levels of K remaining in the topsoil (*Figure 3*).

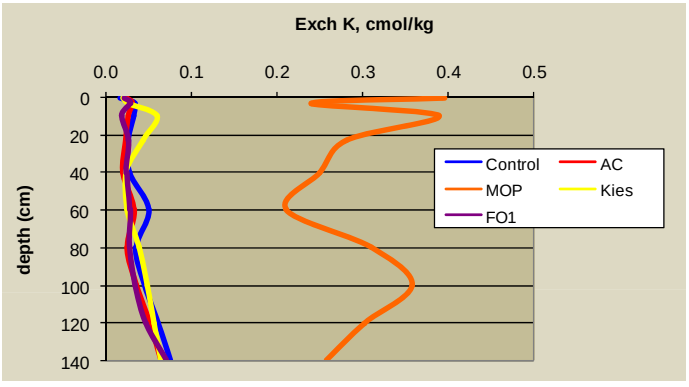

Figure 3. Soil K concentration following the application of four different fertilisers and an untreated control; measured 2-months and 1150mm of rainfall after application.

Leaching of Nitrogen: the N in Ammonium Chloride is oxidised to nitrate by soil micro-organisms. The nitrate level in the topsoil (*0 to 10cm*) was not much different between the AC treated and the control plots, indicating that the N has already leached from the topsoil. There were higher levels of nitrate in the subsoil down to the measured depth of 140cm (*Figure 4*). We expect the remaining nitrate to leach beyond the root zone with continued heavy rain and eventually be out of reach of oil palm roots.

The leaching studies undertaken at Dami (*NBPOL*) provided very similar results. Nitrogen fertiliser was not part of the trial design at Dami, but Magnesium applied as different sources of Mg fertiliser did not leach and the majority of the Mg was still found in the top 20cm of soil. The K in MOP had leached to some extent – similar to what was found in the trial at Navo.

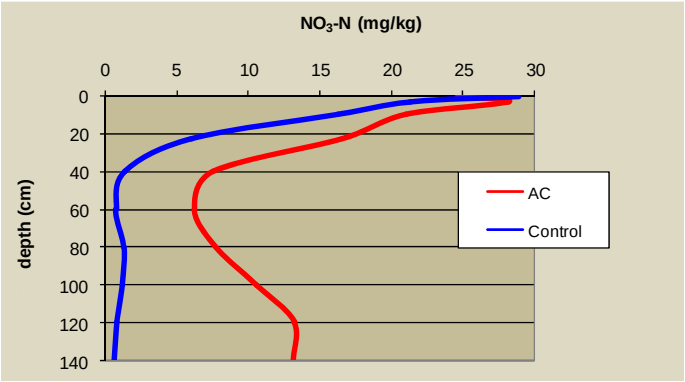

Figure 4. Soil nitrate concentration following the application of ammonium chloride compared to an untreated control; measured 2-months and 1150mm of rainfall after application.

IMPLICATIONS FOR FERTILISER MANAGEMENT

(i) Timing:

N as Nitrate does leach – do not apply N fertilisers during the wet season and apply as several applications during the dry part or the year to reduce the potential for leaching losses (*also see Banabas, 2007*);

K in Muriate of Potash does leach, however at a slower rate compared to N. Do not apply during the wet season and apply in several applications;

Mg in Kieserite does not leach and can be applied at any time of the year (*in a single application*);

The rate of P (*as phosphate*) leaching was not measured in these trials but it is not expected to leach rapidly. Phosphate is more likely to be tied up by allophane in these soils and hence not available to oil palm.

(ii) Fertiliser placement:

From what we have learnt from the leaching studies and an understanding of the properties of volcanic soils in WNB we can identify some practices which will improve nutrient uptake and utilisation.

Phosphate: Apply P on the frond stack

The most important influences of these volcanic soils on P nutrition are that these soils are high in allophane and are likely to be acidifying because of the high use of N based fertilisers. Allophane will bind to phosphate making it unavailable for plant uptake. It is essential to minimise the direct contact of phosphate with the mineral soil (*which is where the allophane is*). In addition, the soil in the area where N is applied is being acidified and hence P in phosphate is becoming less available for uptake. Applying P on the frond stack, in the presence of an abundance of palm feeder roots, where the soil is high in organic matter and low in mineral soil (*hence rela-*

tively lower in allophane content) will ensure that P remains in the available form for longer, enabling more successful uptake by oil palm.

Potassium: Apply MOP to the frond stack

K is leached down the profile but probably not at the same rate as nitrate. It is advisable not to apply MOP during the wet season. To ensure that K uptake by oil palm is not influenced by soil acidification it is better to apply MOP to the frond stack.

Magnesium: Apply Mg to the frond stack

Mg is not leached down the profile and can be applied at any time of the year in a single application. The best place for Kieserite placement is on the frond stack to ensure uptake is not influenced by soil acidification.

Nitrogen: Apply N fertiliser around the outer edge of the weeded circle

We have to ensure we place N fertiliser in the area around the palm where it is least susceptible to leaching and losses from overland flow:

- During high intensity rainfall events significant amount of rain water is channelled along the fronds to the stem, it then runs down the stem and across the Weeded Circle where it is either lost from the palm as runoff or it infiltrates rapidly down into the soil. Placing N fertiliser on the Weeded Circle will encourage losses from runoff and leaching;
- If N is applied onto the Frond Pile it would result in acidification of the soil with negative side effects on the uptake of P, Mg and K;
- The best area to place N fertiliser is on the outer edge of the Weeded Circle. This area receives only about 50% of the rainfall as through-fall so the amount of rain water contributing to leaching is relatively low. This area also receives little or no water from stem flow, so leaching losses would also be relatively lower. The other benefit of this area is that there are still plenty of palm roots in the soil enabling rapid uptake of N by the palm.

The soil in the area receiving the N fertiliser will still acidify but that can be ameliorated, if required, with lime, in the longer term. The rate of soil acidification can be reduced if N fertilisers with lower acidification potential are used. The acidification potential of N fertilisers are:

- Urea and Ammonium Nitrate = LOWEST
- Di-ammonium Phosphate = MODERATE
- Sulphate of Ammonia and Ammonium Chloride = HIGHEST

Urea has some special properties different to the other N fertilisers in that it volatilises (*turns into a gas and is then lost*) quite quickly under some circumstances. If Urea is used as the N source then the best placement is on the weeded circle NOT as a band around the outer edge of the weeded circle.

REFERENCES

Banabas, M (*2007*) Study of nitrogen loss pathways in oil palm (*Elaeis guineensis Jacq*.) growing agro-ecosystems on volcanic ash soils in Papua New Guinea. PhD Thesis, Massey University, Palmerston North NZ.

ACKNOWLEDGEMENTS

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