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59. Controlled release fertilizers - measuring nutrient release rates.
Handreck, K. Australian Horticulture, Oc. 1997, p 51-53. 1997.

Controlled-release fertilisers

MEASURING NUTRIENT RELEASE RATES

Kevin Handreck, FAIH

Overview

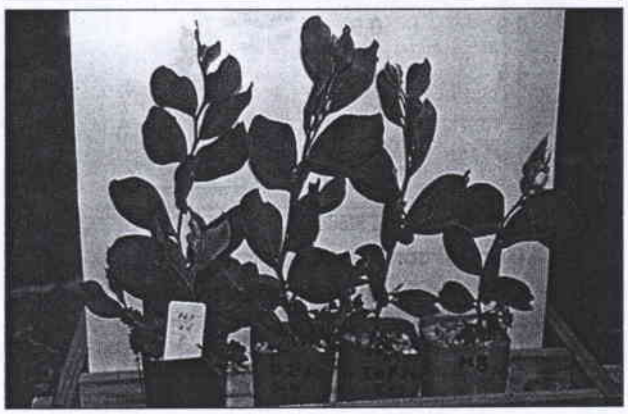
THE RATE of release of potassium from most of the 11 controlled-release fertilisers tested was slightly lower than the rate of release of nitrogen. This difference should not cause any problems in practical situations.

However, early release of phosphorus from all Nutricote and Osmocote products tested was considerably lower than was the rate of nitrogen release. Calculations show how this finding can be used when nursery managers choose fertilisers for different crops and situations.

Controlled (slow)-release fertilisers (CRFs) are available in a multitude of brands, formulations and longevities. A major variation is in nitrogen (N), phosphorus (P) and potassium (K) concentrations, with the ratio of P to N showing the widest variation, to cater for the needs of plants with different P requirements.

Nursery people may generally assume that major nutrients would be released from CRFs in about the same proportions as the stated contents of the granules. The experiment results reported here suggest that this is often not so.

During the running of an experiment in which various phosphorus-sensitive plants were grown with controlled-release fertilisers (CRFs), plant response suggested that P was being released more slowly from some of the CRFs than were the other nutrients. To check this, we determined the rate of release under laboratory conditions of N, P and K from 11 CRFs of widely different P content (Table 1) at 21°C.



Acacia argyrophylla seedlings growing in a pine bark/sand mix to which were added 3.5 grams per litre of the controlled-release fertilisers listed in Table 2. Each tube holds 200 millilitres of mix.

Five-gram samples of the fertilisers were embedded in acid-washed quartz sand held in funnels. Nutrient release was assessed by analysis of leaching water that had been poured through the sand/fertiliser mixture either twice a week (early in the experiment) or once a week (later). Between leachings, the funnels were lightly covered with plastic film to minimise evaporation.

After the last leaching, at 160 days, the granules were crushed and the residual water-soluble N, P and K determined. Leachates were analysed for phosphorus and potassium by inductively coupled plasma spectrometry.

Nitrate and ammonium were determined with an autoanalyser. The urea-nitrogen present in the Macracote products was measured following conversion of the urea to ammonium with urease.

Rate of release of nitrogen

Nutricote products (Figure 1): As expected for fertilisers whose release period is quoted for 25°C, release at 21°C was only 70%-80% at the end of the 70 or 140-day nominal release periods. All 70-day products had similar release patterns.

Osmocote products (Figure 2): All eight to nine-month products released at closely similar rates, with total release reaching about 80% at 160 days. As 160 days is 63% of the nominal 255-day release time at 21°C, the rate of N release was more rapid than the nominated rate. There was a considerable difference between the three to four-month products, with the Improved Osmocote Plus (IOP) releasing much more rapidly than the Osmocote product. Release from the IOP was essentially complete at the end of the nominal release period.

Macracote products (Figure 3): Macracote Brown Plus released its N much more slowly than did the Gold Plus product of nominally similar release period.

Release of potassium

For all products, release of potassium was closely similar to that of N, but slightly slower. Because of this similarity, no data for K are included here.

Rate of release of phosphorus

CRFs have some of their P in water-soluble form and some in a form that is soluble in neutral ammonium citrate (citrate-soluble). It has generally been assumed that the citrate-soluble phosphorus within CRF granules is not available to plants during the nominal release times of these fertilisers: their effective P content is their water-soluble P content.

The data for cumulative P release in Figures 4 to 6 are based on the water-soluble P contents of the products.

Nutricote products (Figure 4): Early release of P from these products was slower than was the release of N, ▶

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Table 1. Some properties of the fertilisers tested.

Product	Symbol used in the figures	N (%)	P total (%)	P water-soluble (%)	P water-soluble/N	K (%)	Nominal months	longevity = days
Nutricote Blue	●	16	4.4	2.1	0.13	8.3	-	140
Nutricote Total	■	18	2.6	1.7	0.09	6.6	-	70
Nutricote Total	▲	13	5.7	4.8	0.37	10.8	-	70
Nutricote Orange	▼	13	5.7	1.3	0.10	9.7	-	70
Osmocote	●	19	2.6	2.0	0.11	10	3-4	105
Improved Osmocote Plus	■	16	3.5	2.6	0.16	10	8-9	255
Improved Osmocote Plus	▲	17	1.6	1.2	0.07	8.7	8-9	255
Osmocote	▼	18	2.6	2.0	0.11	10	8-9	255
Improved Osmocote Plus	◆	15	4.8	3.6	0.24	10.8	3-4	105
Macracote Gold Plus	●	12	4.6	4.4	0.37	10	3-4	105
Macracote Brown Plus	■	18	2.0	1.6	0.09	10	3-4	105

Table 2. Weekly nominal N and P release per tube and calculated (presumed actual) P release for the plants shown in the photograph (see p.51).

Fertiliser	Nominal release time (weeks)	N released per week in each 200 mL tube (mg)	P nominally released per week in each 200 mL tube (mg)	Early weekly P release, based on data provided here (mg/tube)	Early effective P/N ratio of the fertiliser
Nutricote Total, type 7 (18:2.6[1.7]:6.6)	7	18	1.7	0.4	0.022
Osmocote 3-4 mo (19:2.6[2.0]:10)	15	8.9	0.9	0.4	0.045
Improved Osmocote Plus 8-9 mo (18:2.6[2.0]:10)	36	3.3	0.24	0.08	0.024
Nutricote Blue 140-day (16:4.4[2.1]:8.3)	14	8	1.0	0.2	0.025

but by the end of the leaching period, release of P relative to N reached 60 to 85% (Figure 4).

Osmocote products (Figure 5): The patterns of release were similar to those for N, except that at the end of the nominal release periods only 50%-70% of the water-soluble P had been released from the three to four-month products. After 63% of the nominal 255 day release period, the eight to nine-month products had released 45%-60% of their water-soluble P.

The contrast between N and P is seen more clearly in Figure 8. Early in the release period, P was being released at only 0.2 to 0.6 of the rate of N release.

Macracote products (Figure 6): The two products were very different in their P release patterns, with Gold Plus releasing its water-soluble P at a rate that was similar to its release of N. Very slow P release from the Brown Plus product may have been due to clogging of pores in the wax coatings, which were observed to be encrusted with fungal growth at the end of the experimental period.

General comments

The finding that early release of P is much slower than the early release of N from all Nutricote and Osmocote products tested may need to be taken into account when nurseries formulate fertiliser programs, if early P deficiency is to be avoided. The enormous diversity of growing conditions and plants grown in Australian nurseries makes it impossible to give precise guidelines, but the following factors and calculations can be used as a basis by nursery managers.

Phosphorus-to-nitrogen ratio

The total amount of N needed for optimum growth is low for small plants and increases with plant size, but varies widely with plant growth rate. At one end of the spectrum, the weekly amount of N needed by *Petunia* 'Celebrity Salmon' plants being grown from seed ranges from three milligrams in the first week, to 27mg in weeks two to three, to about 140mg in weeks five and six (*Australian Horticulture*, February 1996).

At the other end of the spectrum, the amount of N needed by young *Callistemon brachyandrus* seedlings ranges from 1-3mg/week.

When these optimum amounts of N are supplied, the P needs of 'potted colour' plants will be about 0.15 times the amount of N needed (*Australian Horticulture*, September 1995 and January 1996). Supplying more than is needed can decrease plant quality and flower production.

Woody plants will need P at about 0.08 to 0.15 times their N requirements. The higher the N-drawdown rate of the mix, the closer the optimum P/N ratio will be to 0.15. Supplying more than the optimum amount of P needed for good growth (and assuming that ample N is being supplied) is counterproductive. It produces soft growth that will not harden off until P supply diminishes.

The optimum P supply for P-sensitive plants is less than 0.1 times their N requirements. It can be as low as 0.02 for young seedlings of proteaceous species that are still obtaining P from their cotyledons. The optimum for rooted cuttings and older seedlings of P-sensitive plants is in the range 0.05 to 0.08 (*Australian Horticulture*, in press).

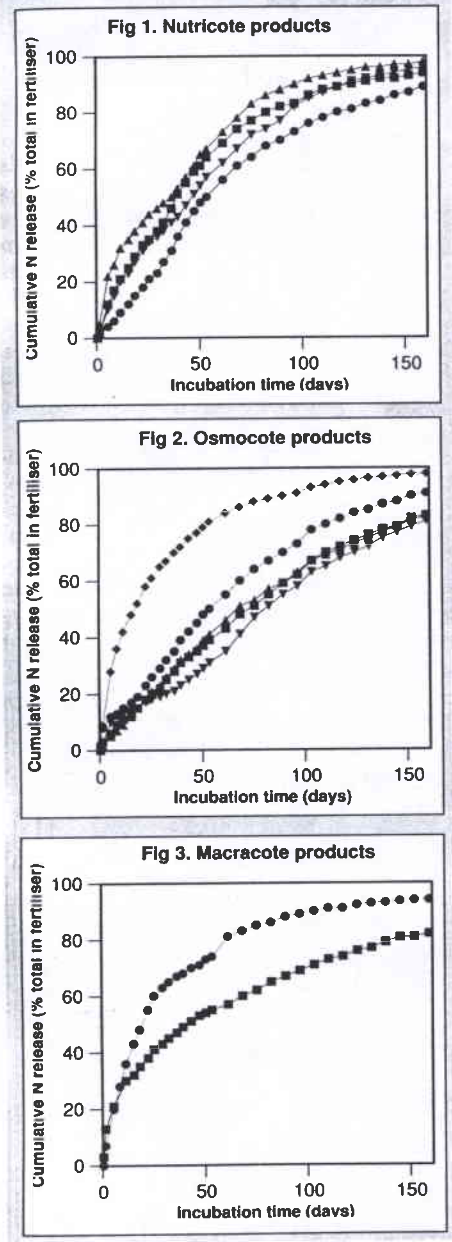
An example comes from an experiment with young tubestock of the supposedly P-sensitive cultivar, *Protea eriifolia* 'Silk n' Satin'. This cultivar showed P-deficiency symptoms when grown with sufficient N for optimum growth, but with a CRF that contained water-soluble P at a nominal 0.07 times N supply. Deficiency developed because the early effective P supply rate of the CRF was only about 0.035 times N supply rate, that is, about half of the nominal rate of supply.

Optimum phosphorus supply

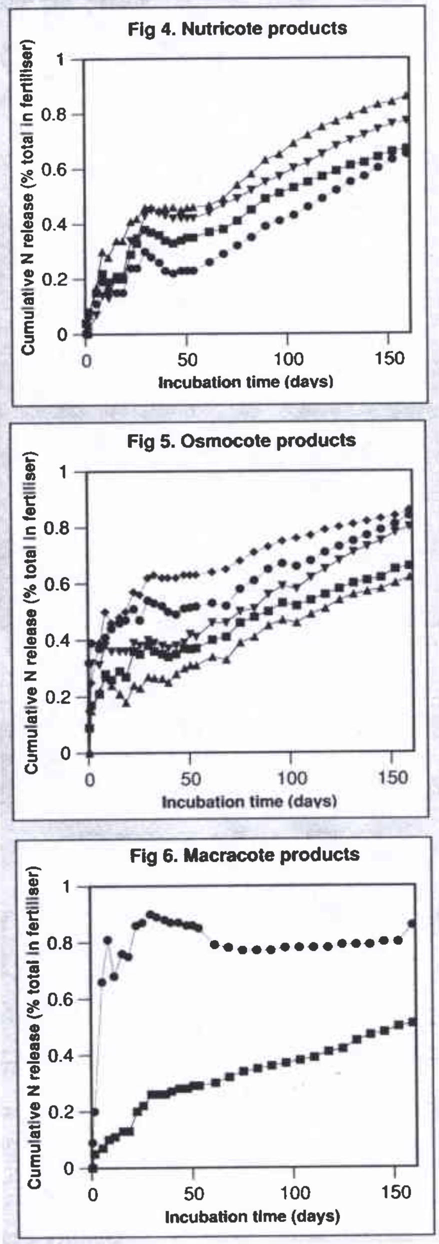
Probably the simplest way of providing an optimum early supply of P is through a combination of pre-plant superphosphate and CRF. Addition of 0.1 to 0.5 kilograms single superphosphate per cubic metre should provide

See Table 1 for nominal P/N ratios and a listing of symbols.

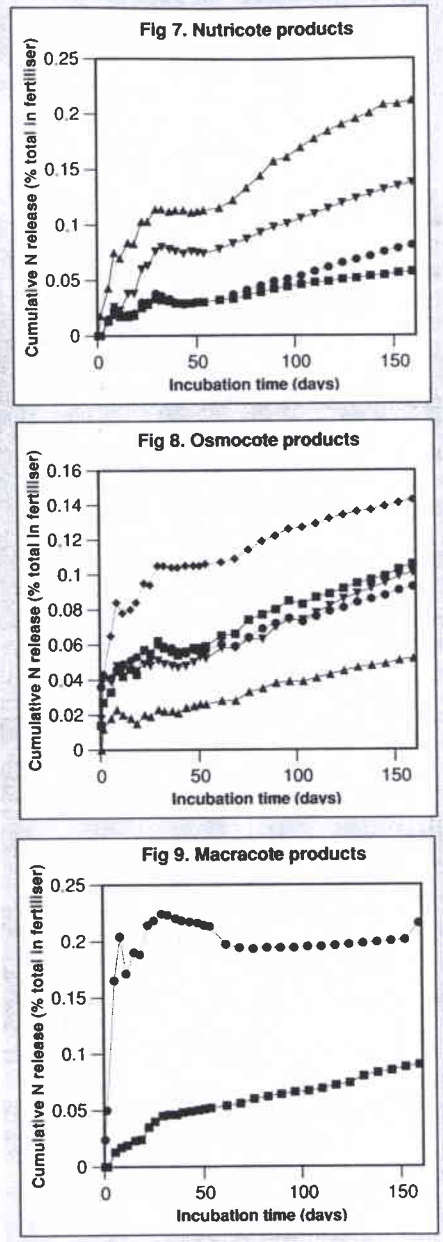
Figures 1 to 3. Cumulative release of N from the fertilisers, expressed as a percentage of their actual N contents. See Table 1 for a listing of symbols.



Figures 4 to 6. Ratios of P released to N released, showing that for most fertilisers, P release lags behind N release. See Table 1 for a listing of symbols.



Figures 7 to 9. Effective P/N ratios of the fertilisers, calculated from actual amounts of P and N released up to the days indicated by the symbols.



sufficient for general lines. Higher rates are wasteful and polluting as much of the extra P will be end up in drainage waters. This pre-plant addition will help satisfy P drawdown and will compensate for early slow release of P from CRFs. Such an addition, sufficient to give 7-14mg/litres P in a DTPA extract of the mix, is recommended for all plants except those that are sensitive to P.

An alternative for situations where there could be a considerable amount of leaching during the early part of the growing period would be to include in the mix about one kilogram per cubic metre of a short-term CRF with a high content (4%-5%) of water-soluble P.

For the seedlings of P-sensitive plants, the addition of 0.1kg single superphosphate per cubic metre a few weeks before potting will partly satisfy the needs of microbial activity. This rate of addition is unlikely to raise the DTPA-extractable P concentration above 2mg/litres, so it is a safe addition rate for these plants.

The photograph gives an example of differing response of *Acacia argyrophylla* (moderately P-sensitive) to four fertilisers of differing longevities and P/N ratios, all added at 3.5gm/litre of mix.

With essentially no soluble P in the potting mix itself, growth was greatest with those fertilisers that released the greatest amounts of N and P each week (Table 2). The optimum weekly rate of N supply was probably slightly more than 8mg per tube and that of P between 0.2 and 0.4mg per tube (giving an effective early P/N ratio of 0.025 to 0.05).