NUTRITIONAL STUDIES WITH POTTING MIXES — SULFUR AND VERMICOMPOSTS: PRELIMINARY RESULTS

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INTRODUCTION

In this paper I give preliminary results from experiments on two aspects of potting mixes. Not all of the relevant analytical data are yet available, nevertheless, the results so far are so clear cut that I am confident that further data will not alter the broad conclusions.

SULFUR

In 1983 I examined (4) the properties of 73 potting mixes bought from retail shops around Australia. They were analysed chemically for their ability to supply nutrients. Plants were grown in them, with Aquasol® being used as a source of nutrients for half of the pots. After the experiment had been terminated, it became clear that the combination of a low level of S in the Aquasol feed (ca. 1 ppm) and low levels in at least some mixes probably limited growth in those mixes. The S levels in 1:1½ volume aqueous extracts of the mixes (1) ranged from 0.6 to 712 ppm (mean 133.6 ± 156.9). At the time, I had no means of interpreting these extraction figures. The experiment described here was designed to provide this interpretation.

Bare-rooted young plants of *Matthiola incana* (cv. Austral stock), *Brassica oleracea* (cv. Lion Heart cabbage), *Tradescantia fluminensis* (wandering jew) and *Brachycome multifida* (rock daisy) were transplanted on January 21, 1985 into 175 mm pots of a mix comprising ground *Pinus radiata* bark and acid-washed quartz sand (3:1 by volume). The mix contained (in g/L) KH_2PO_4 (0.5), NH_4NO_3(0.5), $Ca(NO_3)_2 \cdot 2H_2O$(0.75), KNO_3(0.3), $MgCl_2.6H_2O$(0.3), FeEDTA(0.03), $MnCl_2.4H_2O$(0.02), $CuCl_2.2H_2O$(0.004), $Na_2B_4O_7.10H_2O$(0.002), $(NH_4)_6 Mo_7O_{24} \cdot 4H_2O$ (0.00002), $ZnCl_2$(0.01) and GU-49 (Embecon Corp. — a slow-release source of Fe (0.5). The pH of the mix was 5.3 (1:1½ volume in water), and air-filled porosity was 22%.

Eight pots of each species were assigned at random to each of seven levels of sulfur addition, with the sulfur being added via liquid feeds containing 250 ppm N and 150 ppm K, supplied by ammonium nitrate and potassium nitrate. Levels of 0, 1, 2.5, 5, 10, 15 and 30 ppm S were produced by replacing varying proportions of the ammonium nitrate used with ammonium sulfate. The pots were housed in a shaded, evapora-

tively cooled greenhouse and watered as required with the appropriate solutions.

Samples of mix were taken from the pots on day 16 and days 32-43 (at harvest) and extracted with water (1:1½ by volume [1]) and 0.01 M $Ca(H_2PO_4)_2$ (1:5 by volume, 24 hr shake [2]). Sulfur levels in the calcium phosphate extracts were not correlated with treatments or growth so nothing further will be said about this extractant.

RESULTS AND DISCUSSION

As shown in Figure 1 and Table 1, growth was negligible for all species at the three lowest levels of sulfur application. The data in Figure 3 suggest that for *B.multifida* there must be at least 5 ppm S in a 1:1½ volume extract and for *T.fluminensis* at least 3 ppm S. The relatively large rooted cuttings of *T.fluminensis* used would have brought with them much S, so lessening the need for S from the liquid feed. For maximum growth of these two species, pot drainage water should contain at least 16 ppm S (Figure 4). If a liquid feed is the sole source of S, it should contain at least 20 ppm S.

Figure 1. Some of the cabbage plants at harvest. *From left to right*, the levels of sulfur in the liquid feeds applied were 0, 1, 2.5, 5, 10, 15, and 30 ppm.

Neither the *M.incana* nor the *B.oleracea* plants reached maximum growth rates at the top level of S supplied. A further experiment is in progress to check on the response of these species to higher applications of S, but in the meantime a tentative conclusion for them might be that there should be more than 8 ppm S in a 1:1½ volume extract and 25 ppm S in drainage water. For these minimum levels to be maintained, a liquid feed as sole source of S would need to contain about 35 ppm S.

Table 1. Top growth of test plants as affected by sulfur supply.

S concentration in liquid feed (ppm)	Dry weight of tops (g/pot)			
	Brassica oleracea	*Matthiola incana*	*Brachycome multifida*	*Tradescantia fluminensis*
0	0.97 ± 0.46	0.29 ± 0.09	0.92 ± 0.17	3.92 ± 1.44
1	1.00 ± 0.48	0.36 ± 0.11	0.97 ± 0.25	4.27 ± 0.93
2.5	1.18 ± 0.33	0.35 ± 0.09	1.02 ± 0.19	5.03 ± 0.65
5	1.44 ± 0.34	0.84 ± 0.32	1.16 ± 0.24	7.69 ± 1.95
10	4.13 ± 0.88	2.56 ± 0.40	2.31 ± 0.24	10.30 ± 2.05
15	5.77 ± 0.99	4.25 ± 0.39	3.09 ± 0.82	11.26 ± 1.41
30	6.75 ± 1.75	6.48 ± 1.10	3.59 ± 0.39	11.63 ± 0.81

The species used here may or may not represent the full range of S requirements in plants likely to be grown in pots. If they do, then a liquid feed used as a sole source of S should contain about 40 ppm S, but it could contain rather less if an adequate level of slow-release source of S (e.g. gypsum or a coated fertilizer) is included in the mix — *and replenished as needed*. Further analysis of the data indicates that 1:1.5 volume extracts should contain at least 6 ppm S, drainage waters at least 16 ppm S, and liquid feeds as sole source of S about 30 ppm.

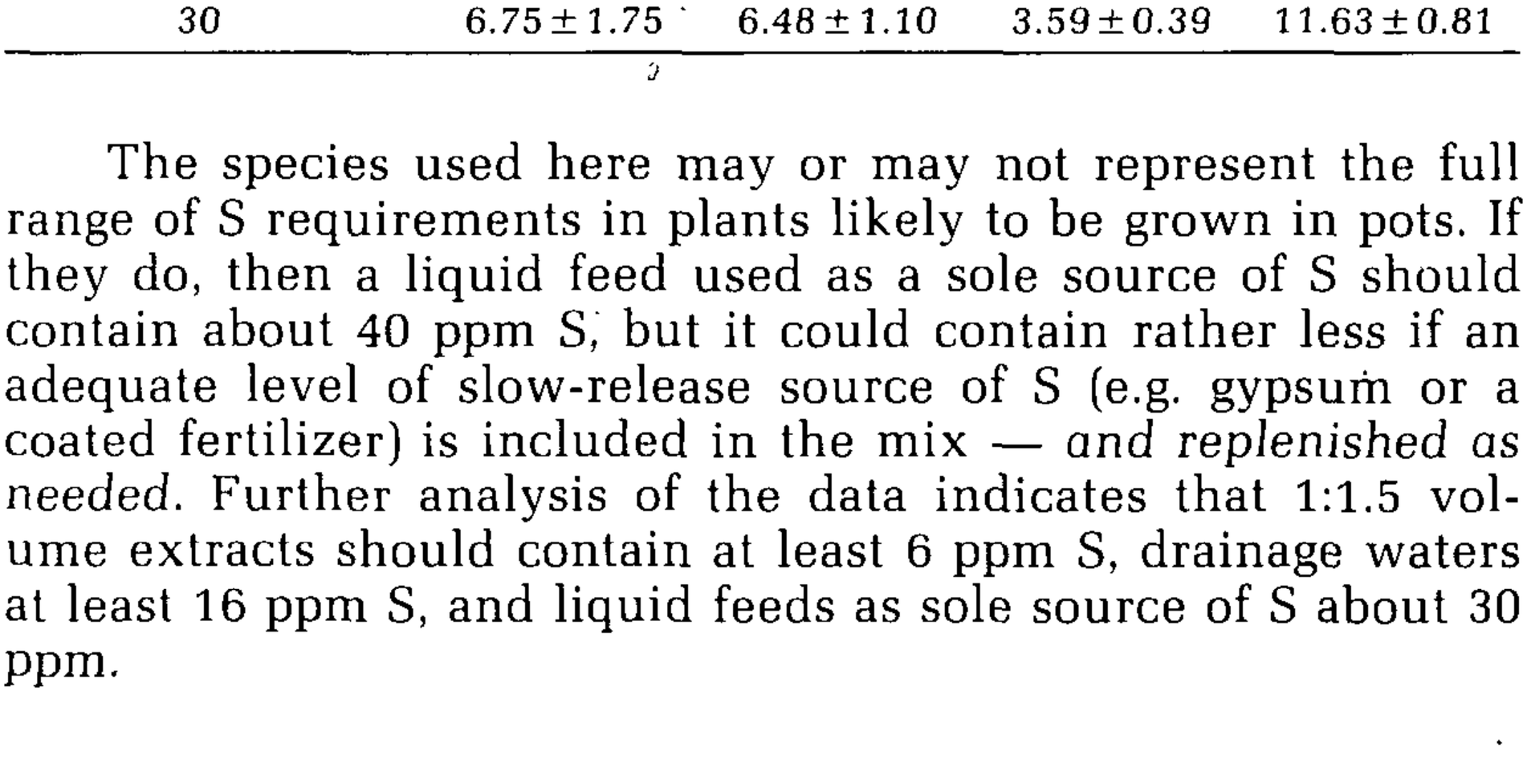

Figure 2. Relationships between sulfur in 1:1½ volume extracts of the growing media and sulfur in the liquid feeds used. The solid line gives the concentrations in extracts expected given that the mix contained water equivalent to 40 % of its volume when drainage had stopped.

Some simple arithmetic is helpful here. A common rate of use of gypsum is 0.75 g/L (from about 1.5 g/L superphosphate). If drainage water is saturated with respect to gypsum (2.41 g/L) and if 30 mL of water per L of mix drains from the pot at each watering, then the gypsum could all be lost in 11 days. A more realistic figure is 60 to 90 days, because of the slow rate of dissolution of gypsum.

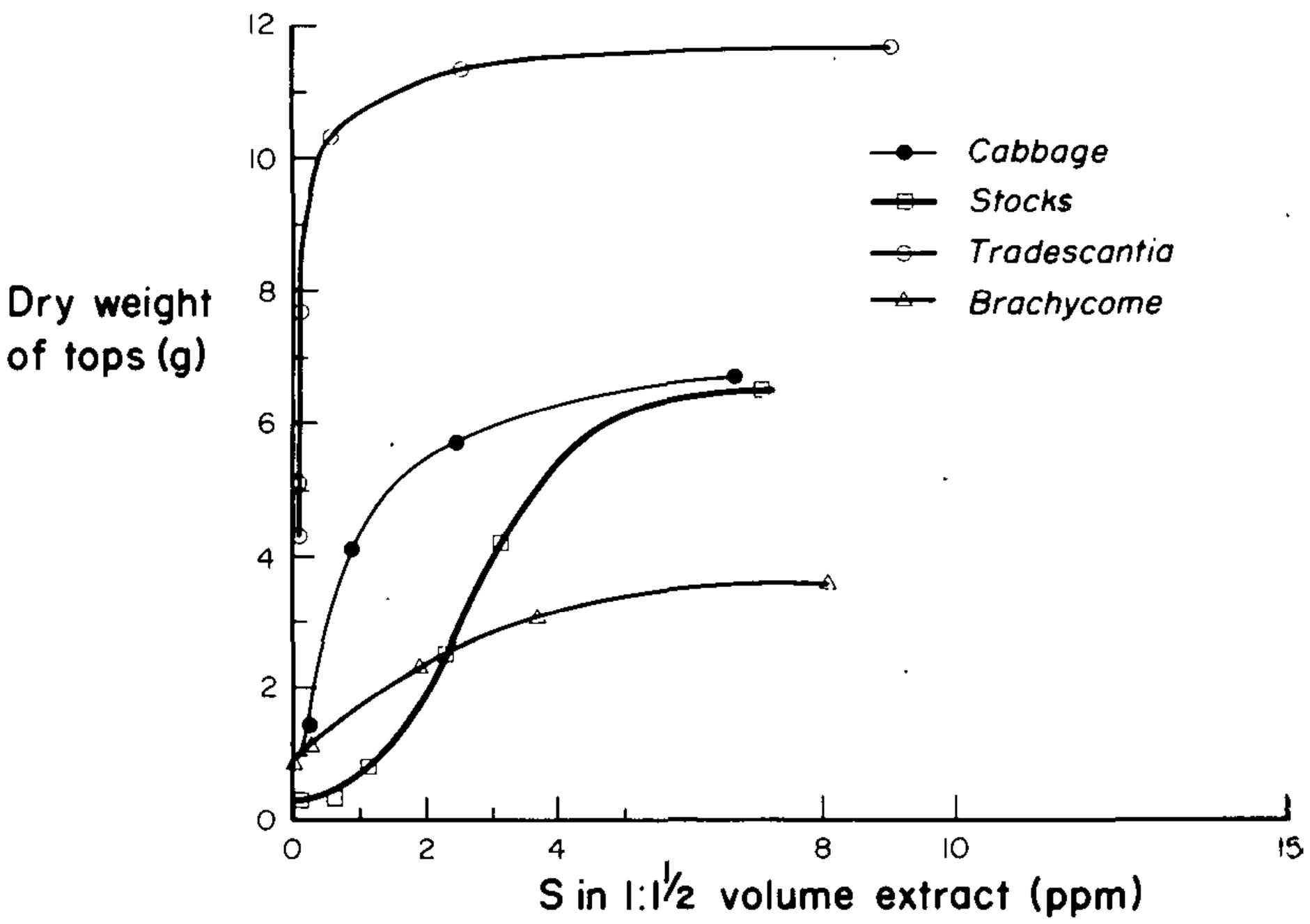

Figure 3. Relationships between dry weights of tops and the concentrations of sulfur in 1:1½ volume extracts of the growing media.

Clearly, if the only fertilizer used is a liquid feed containing substantially less than 35 ppm S, sulfur deficiency is possible within a "few" months. Just how long the "few" is will depend on local conditions. I am currently attempting to determine the range more precisely.

I now believe that the preference of many home gardeners for products such as Nitrosol® and Phostrogen® is due as much to their sulfur contents (122 and 22 ppm in the applied liquid, respectively) as to any other difference between them and competing products such as Thrive® and Aquasol® (~1 ppm S).

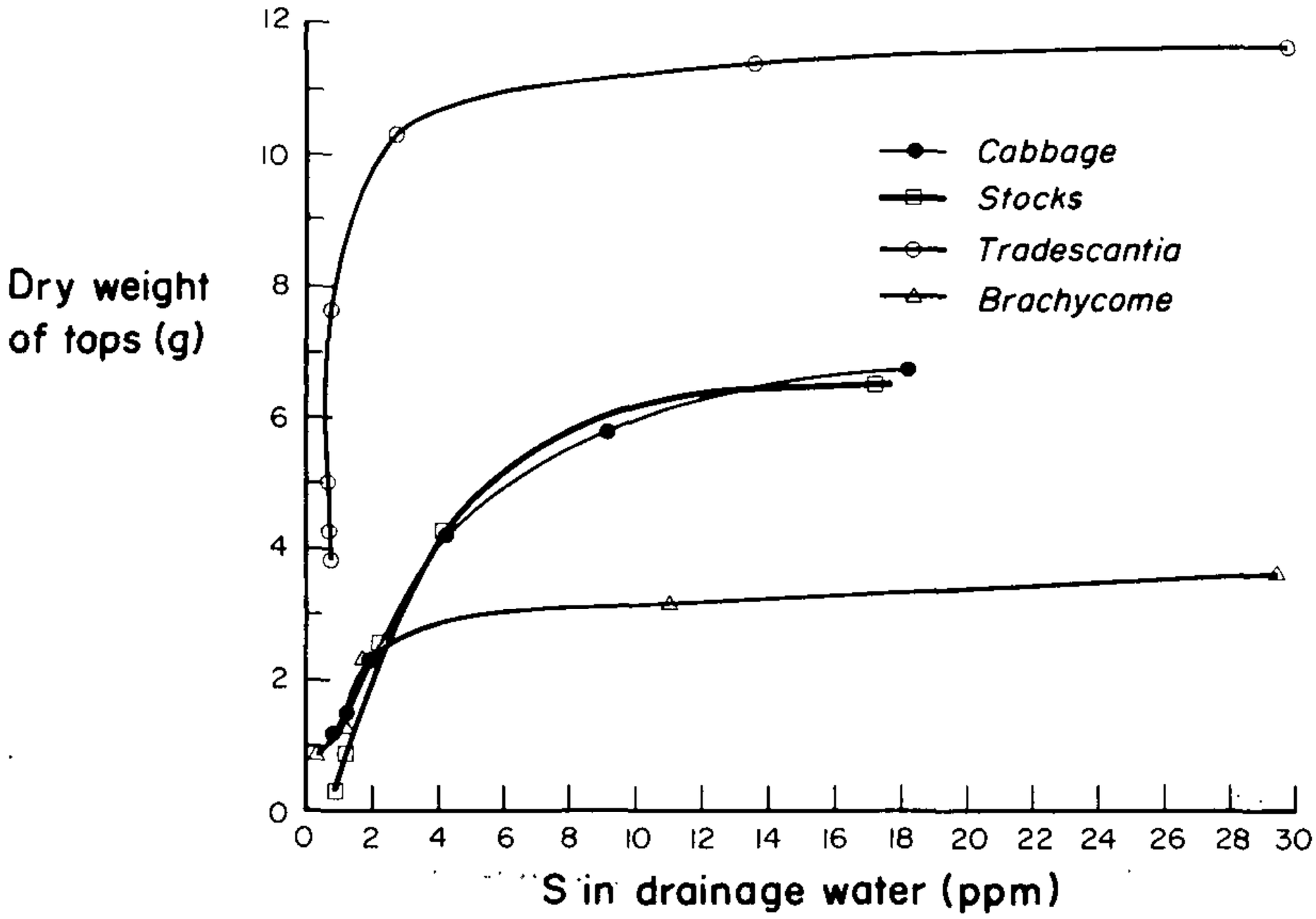

Figure 4. Relationships between dry weights of the tops and the concentrations of sulfur in pot drainage waters.

VERMICOMPOSTS

I come to the second part of my presentation. We all know that earthworms are good for soils. Organic gardeners have for some time extolled the virtues of earthworm castings (vermicompost). I once thought that vermicompost would be a useful component of potting mixes. I am now less enthusiastic, as you will see.

In late 1984 I acquired samples of 7 vermicomposts produced from materials as listed in Table 2. The sieved (<3 mm) vermicomposts were mixed at a rate of 30% by volume into a base potting mix consisting of ground *Pinus radiata* bark and quartz sand (4:1 by volume) to which had been added Aqua Soil Wetter® wetting agent and $MgSO_4.7H_2O$ at 0.375 g/L. The pH values of the mixtures were adjusted to ca. 5.6 as required with dilute sulfuric acid. Thirty-two equal lots (approx. 900 mL) of each mixture were weighed into plastic bags. Aliquots of solutions supplying N (1.35 g NH_4NO_3/bag), P (0.68 g $Ca(H_2PO_4)_2$), K(0.26 g KCl) and trace elements (0.03 g FeEDTA, 0.675 g GU-49, 0.02 g $MnCl_2.4H_2O$, 0.01 g $ZnCl_2$, 0.004 g $CuCl_2.2H_2O$, 0.002 g $Na_2B_4O_7.10H_2O$ and 0.00002 g $(NH_3)_6Mo_7O_{24}.4H_2O$) were added to the bags in all 16 possible combinations (O, N, P, K, NP, NK, PK, NPK, and these plus trace elements), so giving two bags of each combination. After thor-

ough mixing, the total contents of a bag was transferred to a 125 mm nursery pot. The pots were randomised on individual saucers on benches in a shaded, evaporatively cooled glasshouse. There were two series of control pots: one received a full complement of nutrients; the other received all major nutrients but no trace elements.

Sufficient distilled water was applied to each pot to give at least some drainage. For those mixes whose salinities were above an acceptable level, about half a pot volume of water was added and the leachate retained in a separate container. This leachate was returned to the pots in small aliquots over the first few weeks of the growing period. In this way the young plants were not deprived of any of the soluble nutrients in the vermicompost.

On January 25, 1985 one bare-rooted seedling of *Matthiola incana* (cv. Austral stocks) was planted into each pot. For the first week, watering was with distilled water but subsequently watering was with either distilled water or solutions containing 150 ppm N (as NH_4NO_3) and/or 100 ppm K (as K_2SO_4), as indicated by treatment. The only P and trace elements applied were those given before potting.

After 2 weeks it was clear that most plants in pots receiving no N were deficient in N. This deficiency intensified in all pots except V6 (which contained residual meatmeal). There seemed little point in retaining the saucers so they were removed on day 27. All subsequent watering was with enough of the appropriate solution to give a small amount of drainage.

The visual appearance of the plants was scored on a 0-10 scale on days 20 and 50. This scoring, examples of which are given in Figure 5, and the data for final dry weights of the tops, have been interpreted as given below. Future statistical analysis and chemical analysis of the tops will enable this interpretation to be refined.

Unless modified, the vermicomposts were inadequate for plant growth for the following seasons:

V1 high pH; deficiencies - N (severe), S (slight)
V2 high pH; deficiencies - N (severe), P (mild), trace elements (slight), S (slight)
V3 high pH; deficiencies - N (severe), P and K and trace elements (slight), S (slight)
V4 high pH; deficiencies - N (severe), K (mild); suspected toxicities - Zn (severe), Cu (?)
V5 deficiencies - N (severe), S (severe), trace elements
V6 high pH; deficiencies - P (slight), S (slight)
V8 deficiencies - N (medium), P and trace elements (possibly induced by high Zn and/or Cu), S (slight)

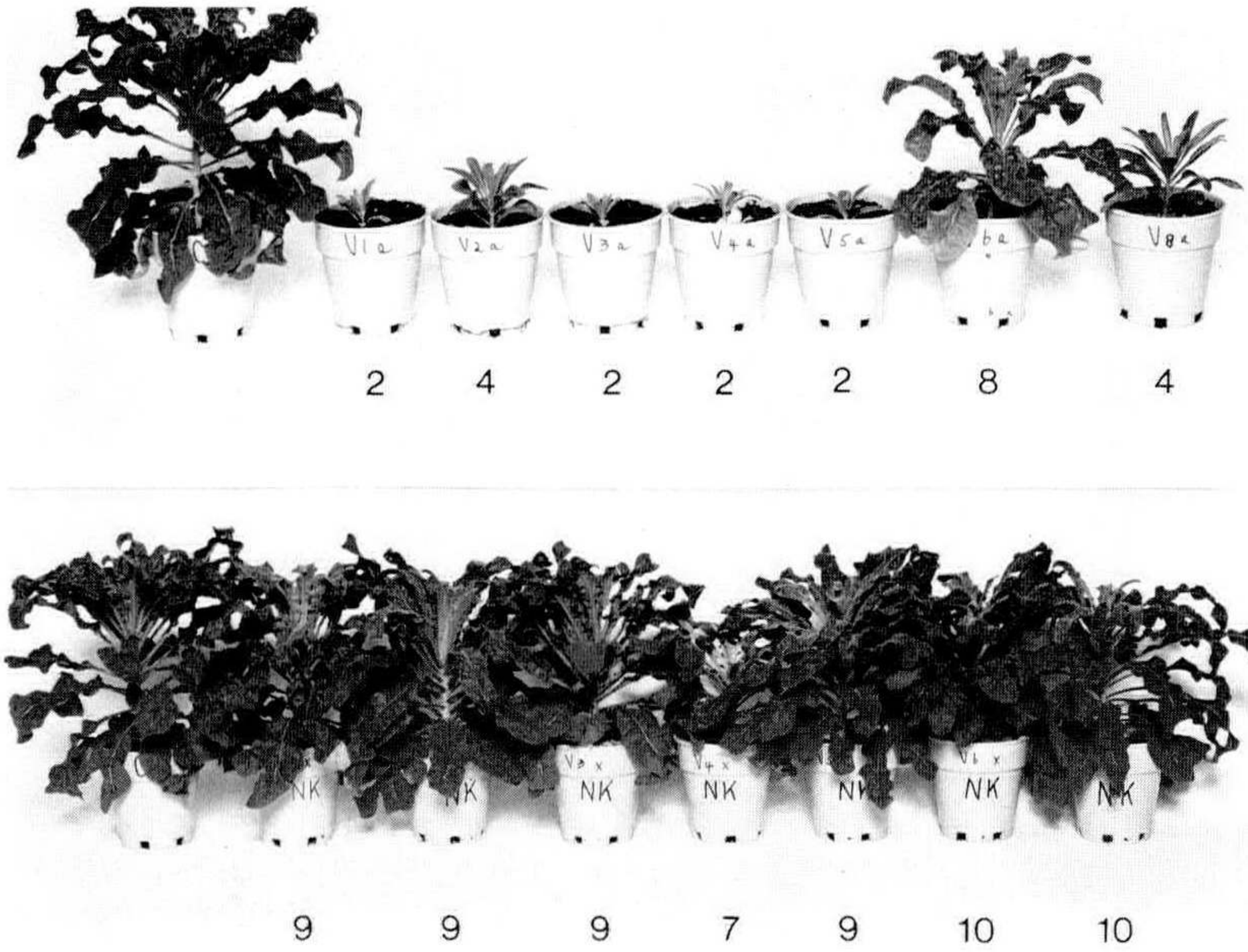

Figure 5. Control plant and plants grown in the vermicompost mixes which received (above) no added nutrients, and (below) all nutrients.

On the basis of these results I conclude that vermicomposts are extremely variable in composition. Assessing their quality will be difficult, and must be on a better basis than appearance. When used as a component of mixes based on pine bark or sawdust, supplemental N must be used from potting. In this experiment the use of sulfuric acid to acidify five mixes obscured S deficiency in them. A later check showed that plants became deficient in S in all pots within two months of potting. The most troublesome problem could be coping with trace element problems ranging from deficiency to severe toxicity. One would usually expect vermicomposts based on animal manures to have adequate levels of trace elements but the results for V8 show that this is not always so. The severe toxicity of V4 shows the need for care when producing vermicomposts from domestic (and municipal?) wastes.

Vermicomposts do impart a rich-humus appearance to a potting mix and will increase cation exchange and buffer capacities. These benefits have to be weighed against possible nutritional problems and decrease air-filled porosity as the level of addition goes over 30 percent by volume.

Acknowledgements. I thank Barbara Graham for dedicated technical help, Adrian Beech for most of the analyses, Ray

Table 2. Some properties of the potting mixes containing vermicomposts.

Vermicompost	Water extract (ppm)*						DTPA extract (ppm)+				B$^{\Delta}$ (ppm)	Air-filled porosity (Vol %)	Unamended pH of vermicompost	EC° (mS/cm)
	N	P	K	Ca	Mg	S	Fe	Zn	Cu	Mn				
V1 (sheep)	0	43	70	45	21	36	7.4	56	3.6	7.1	0.2	20.5	6.9	0.68
V2 (cow)	45	56	274	31	26	59	21.5	20	1.5	13.3	<0.1	13.6	6.7	1.55
V3 (poultry)	0	45	74	44	18	29	5.5	28	0.7	8.2	<0.1	18.9	6.7	0.60
V4 (domestic)	0	93	350	27	19	60	10.3	77	5.8	6.3	0.1	17.1	7.8	1.47
V5 (kitchen)	0	22	99	28	12	35	20.6	20	0.7	6.7	<0.1	18.2	5.9	0.69
V6 (domestic)	500	80	429	57	43	36	9.1	38	1.9	9.5	<0.1	20.7	6.6	2.49
V8 (pig)	50	101	126	60	45	52	10.7	63	25	7.1	<0.1	11.1	5.8	1.07
Control 1	450	70	190	109	140	40	21.1	3.8	1.8	21.1	0.1	21.8	-	2.62
Control 2	400	87	160	94	134	39	4.9	1.6	0.4	4.9	<0.1	21.8	-	2.46

* 1:1½ volume; ppm in the extract
\+ 10 g and 20 mL extractant [5]; ppm on dry weight basis
Δ In mannitol/$CaCl_2$ extract [3]
° 1:1½ volume (before acidification)

Correll for advice on experimental design, and Dan Pogson, Jim Williams, Alan McKay, Jim Harmon, John Sabine, Victorian Prisons Industries, Brian Ferrier and John Jenkins for gifts of vermicomposts, and Falgs Nurseries for bedding plant seedlings.

LITERATURE CITED

1. Arnold Bik, R. and Boertje, G.A. 1975. Fertilizing standards for potting composts based on the 1:1½ volume extraction method of soil testing. *Acta Hort.* 50: 153-6.
2. Barrow, N.J. 1967. Studies on extraction and on the availability to plants of adsorbed plus soluble sulfate. *Soil Sci. 104*: 242-9.
3. Cartwright, B., K.G. Tiller, B.A. Zarcinas, and L.R. Spouncer 1983. The chemical assessment of the boron status of soils. *Aust. Jour. Soil Res. 21*: 321-32.
4. Handreck, K.A. 1984. Quality of potting mixes in retail packs. *Austral. Hort. 82*: 9-24.
5. Lindsay, W.L. and W.A. Norvell 1978. Development of a DTPA soil test for zinc, iron, manganese and copper. *Jour. Amer. Soc. Soil Sci. 42*: 421-8.

THE USE OF TISSUE CULTURE IN THE SEARCH FOR PANAMA DISEASE RESISTANT CLONES OF BANANA

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The banana is one of the most important fruit crops in Queensland with a gross annual value of $45M in 1984. According to Simmonds (20) all current banana cultivars have been derived from two species. They are *Musa acuminata*, which is the source of the "A" genome, and *Musa balbisiana*, which is the source of the "B" genome. Commercial cultivars are usually seedless triploids and tetraploids comprising various combinations of these two genomes.

Panama disease, also known as fusarium wilt, is caused by *Fusarium oxysporum* Schlecht ex Fr. f. sp. cubense (E.F. Smith) Snyd. & Hans. This disease has been known for a long time in Queensland where it is the major limiting factor in the production of the 'Lady Finger' (AAB group) banana.