

## Water Solubility and Physical Losses and Sulfur and Phosphorus from S-Coated Triple Superphosphates

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### ABSTRACT

Coated fertilizer must retain the coating during transport and handling, but the nutrients in the coat must be released readily in the soil to meet plant demand. Three experimental fertilizer where S is adhered to TSP granules using AD1, AD3 or AD2 adhesive were compared with a commercial S coated TSP, Hifert (HF) Goldphos-10. Fertilizer S loss from the granule was measured in a rotating drum friabilator. The highest particle loss was recorded with HF, and there were no significant differences recorded between AD1, AD2 and AD3. Release of S from the coated fertilizers was measured by placing the fertilizers between 500 µm nylon mesh and leaching with distilled water at 20 mL min<sup>-1</sup> for up to 96 h. In all release was fastest from AD1 and AD3, and the amount of Ca and P released from the granule was also highest with these two products. Granules were scanned in the electron microscope, and electron microprobe both before and after leaching. Dispersion in distilled water was also recorded. The microprobe scan confirmed the leaching data with more S remaining in the granule with HF than AD1 or AD3. These data confirm earlier studies that the method of adhesion of S to TSP can markedly alter the agronomic performance of the fertilizer.

**Keywords:** sulfur, attrition, granule strength.

### INTRODUCTION

Some measurements which are commonly undertaken to determine physical properties of fertilizers include hygroscopicity, hardness and caking tendency (Bharti 1991). Studies on the factors influencing the rate of nutrient release from coated fertilizers and the evaluation of adhesive materials on nutrient release have mainly focused on nitrogen and phosphorus fertilizers (Hall & Baker 1967; Giordano & Mortvedt 1970).

Two physical characteristics need to be considered in choosing coated fertilizers in order to achieve the maximum efficiency of fertilizer application. The first is the strength of bonding of the coat against frictional forces. This is an important consideration during transportation and application. The second is the strength of the bonding under the conditions experienced in or on the soil. This relates directly to the agronomic effectiveness of the products. The rate of dispersion of the coated fertilizer under soil conditions directly affects the rate at which the fertilizer nutrients enter the soil

solution.

In this study, two experiments were undertaken to investigate the physical strength of coated fertilizers against frictional forces and simulated rain.

### MATERIALS AND METHODS

#### Experiment 1 – Mechanical Test

The fertilizers tested were as follows three TSP-S sources AD1, AD2, and AD3 and TSP-S Hifert Goldphos 10 (HF). They were produced as described by Dana *et al.* (1994).

A 30 cm diameter and 4 cm deep Perspec cylinder ('friabilator') was set up to rotate at 25 rpm on its central axis, in a vertical plane (Scoot 1986). During each rotation the material placed in the friabilator was lifted by a small plate attached to the edge of the cylinder, dropped from a height of approximately 15 cm, and then rolled for approximately three-quarters of the circumference until the plate was encountered again.

Prior to the friabilator test, three subsamples (0.002 g) of intact granules of each coated fertilizer were digested for total S and P using a nitric-perchloric digestion mixture in which potassium dichromate was included (Till *et al.*, 1984). The S and P content of the fertilizer extracts were determined by ICP.

Three samples (20 g) of each fertilizer were placed separately in the friabilator. Rotation was stopped after 1, 2, 4, 8, 16 and 32 min. At each of these times the material was sieved through a 20 mesh (841  $\mu$ m) screen. The fine material was removed and weighed, and the coarse material was returned for further testing. A subsample (0.001 g) of the line particle was taken and then digested for total S and P using the same procedure as previously. The results were subjected to analysis of variance as a split plot in time.

### Experiment 2 – Leaching Experiment

The fertilizers tested were the same as in Experiment 1. Samples (2g) of each fertilizer were placed in a 3,4 cm (internal diameter), and 7,5 cm (high) plastic vial between layers of 500 nylon mesh. Droplets of deionized water were pumped onto the fertilizer at a rate of 20 ml,  $\text{min}^{-1}$  through three 1-5 mm internal diameter tubes. The solution and line material ran to waste. The fertilizer remaining between the layers of mesh was collected, after 3, 6, 12, 21, 36, 48 and 96 h, dried at 30°C, weighed and analyzed for calcium and phosphorus content after digestion in a mixture of perchloric and nitric acid (Till *et al.*, 1984) and also for elemental S remaining in the granule after extraction with acetone (Shedley, 1982). The experiment was replicated three times. The same statistical procedure as used in the physical strength study was used to analyze the data.

Before and after 24 h of leaching, one granule was taken from each fertilizer. These granules were dried in an oven at 80°C for 4 h. The granule was mounted on a bronze stub (0-5 cm diameter) with Selley superglue and rubbed with a fine sandpaper to form a cross-section. The granule was then gold-coated and a photograph of the cross-section taken under an electron microscope.

A cross-section of each fertilizer was also scanned using the electron microprobe. The scanning for S was conducted on four locations equidistant across the flat cross section.

A separate test was conducted to study the dispersion of different coated fertilizers in distilled water at different times (0,48 and 96 h). In this study, one granule of each product : TSP4S with AD1, AD2, and AD3 and TSP-S Hifert (HF) was placed in a petri dishes (4 cm diameter) which was filled with distilled water. The petri dishes were left undisturbed and a photographic record was taken.

## RESULTS AND DISCUSSION

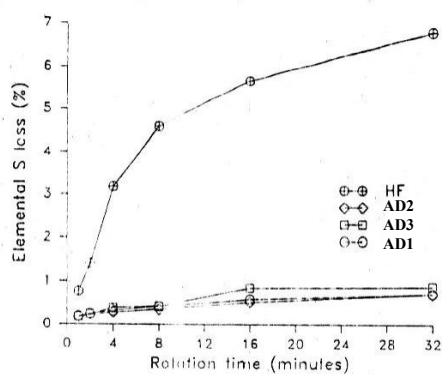
### Experiment 1

The S and P contents of the intact granules were not different among the coated fertilizers tested. The S content ranged between 10.6 to 10.9% and the P content ranged between 19.6 to 20.4% (HF).

There was a significant fertilizer source x time interaction recorded in the amount of elemental-S lost from the granules. The amount of loss increased with time in all treatments with the highest loss (7%) recorded from HF, with no significant differences recorded between the UNE1, UNE3 and UNE2 (Fig.2). The loss of elemental S by mechanical friction leads, not only to a lower S content of the fertilizer, but, danger of explosion.

In interpreting these findings, the history of the products needs to be considered, for instance, the length of storage conditions or handling method during transportation. Storage and bagging are important stages in the fertilizer manufacture before the fertilizer is ready to be used by consumers (Tisdale & Nelson, 1975). The HF material was obtained from Hi-Fert Pty Ltd and the storage length was unknown, whereas the AD1, AD3, and AD 2 products were produced in a bench plant and had not been subjected to transportation.

Fig.1. Effect of fertilizer source and rotation time

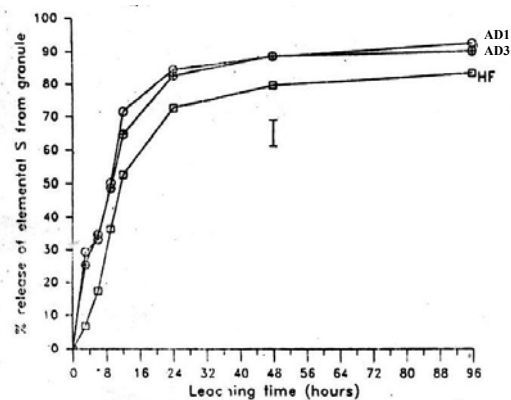


on elemental S loss (%) from the fertilizer granules during the rotation period. Vertical bar indicates the 5% l.s.d for the fertilizer source x rotation time interaction

### Experiment 2

Release of S from fertilizers has been investigated by Janzen & Bettany (1986), who found differing rates of release from the different S sources, and suggested that this was related to the initial particle size of the product and the dispersion of the particles in the soil. The effect of temperature on the release of nutrients from coated fertilizer had been reported by Oertli & Luut (1962). They found an approximate 100% increase in initial release rate of nutrients when the temperature was increased from 10 to 20°C. Brown *et al.* (1996) reported that a significant decrease in urea release was recorded with increasing coating thickness of resin from 9.0 to 13.2%.

### Elemental-S Release from Granules



There was a significant fertilizer source x leaching time interaction on the release of elemental S from the granules. In all products there was a rapid release of S from the coat in the first 24 h and a slower release thereafter. The release of elemental S from the AD1 and AD3 products did not differ significantly and was greater than the release from the HF product (Fig.2)

Fig. 2. Effect of fertilizer source and leaching time on percentage of elemental S lost through leaching. Vertical bar indicates the 5% l.s.d for the fertilizer source x leaching time interaction

### Phosphorus and Calcium Release from Granules

There was a significant fertilizer source x leaching time interaction in the release of calcium and phosphorus from the coated fertilizers. The amount of calcium and phosphorus loss increased with time, and the losses from the AD1 and AD3 products did not differ significantly and were greater than the loss from the HF products (Fig.3).

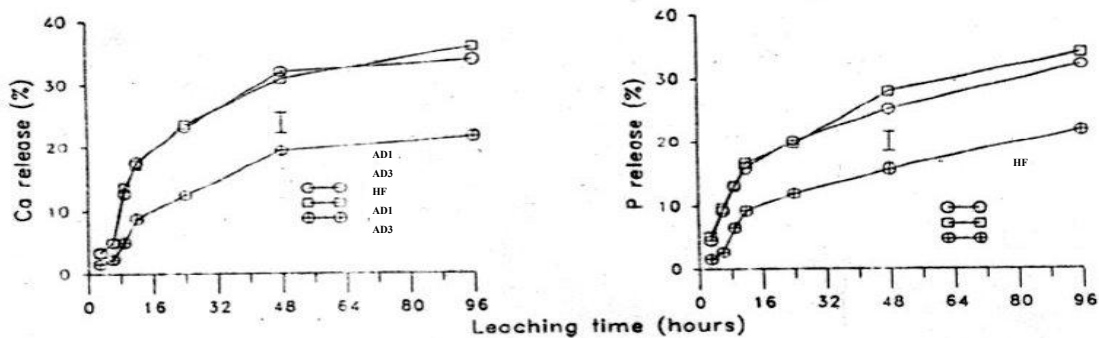
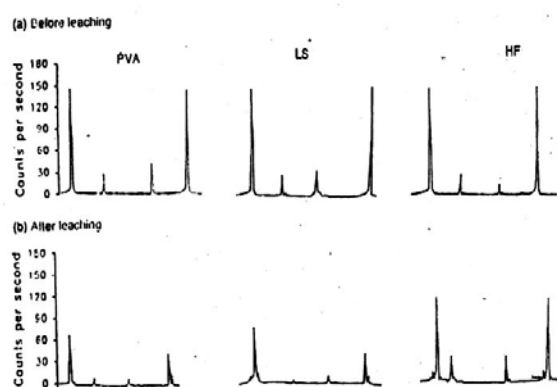


Fig. 3 Effect of fertilizer source and leaching time on loss of calcium and phosphorus through leaching. Vertical bar indicates the 5% l.s.d for the fertilizer source x leaching time interaction

fertilizers prior to and after 24 h of leaching agreed with the chemical analysis of the granules. Prior to the leaching, no differences were observed in the percentage of S among AD1, AD3 and HF. The percentage of S remaining in the granule from HF was higher than from AD1 and AD3 after 24 h of leaching. This indicates that a higher amount of S was lost from the AD1 and AD3 than from the HF granules (Fig.4).



## CONCLUSION

The result of these studies showed that the release rate of S from the HF fertilizer was lower than from the other sources. The greater release of S from the coat of TSP granules with AD3 or AD1 was associated with a greater rate of release of Ca and P. This difference in release rate of S was found to be responsible for delayed tillering in flooded and non-flooded rice and a lower grain yield in non-flooded rice (Dana *et al.*, 1994) and a lower pasture yield and S and P content in the tops of pasture in the first 17 weeks after application by Blair *et al.* (1994).

## REFERENCES

Bharti, M.E. 1991. Quality control measures for developing of 10:20:2 grade fertilizer, *Fertilizer Research* 28, 213-6.

Blair, G.J., M. Dana, & R. Lefroy. 1994. A glasshouse evaluation of sulfur fertilizer sources for crops

and pastures II. A comparison of sulfur coated triple superphosphates and gypsum *Australian Journal of Agricultural Research* 1517-23.

Brown M.J., R.E. Luebs, & P.F. Pratt. 1966. Effect of temperature and coating thickness on the release of urea from resin coated granules. *Agronomy Journal*. 58. 175-8.

Dana. M., R.D.B. Lefroy, & G.J. Blair. 1994. A glasshouse evaluation of sulfur fertilizer sources for crops and pastures I. Flooded and non flooded rice. *Australian Journal of Agricultural Research*. 1497 – 1515.

Giordano, P.M. & J.J. Mortvedt. 1970. Release of nitrogen from sulfur-coated urea in flooded soil. *Agronomy Journal*. 62, 612-14.

Hall, J.K. & D.E. Baker. 1967. An evaluation of asphalt coatings on phosphorus fertilizers. *Agronomy Journal*. 59, 503-5.

Janzen, H.H. & J.R. Bettany. 1986. Release of available sulfur from fertilizers. *Canadian Journal of Soil Science*. 66, 91-103.

Oertli, J.J. & O.R. Lunt. 1962. Controlled release of fertilizer minerals by incapsulating membrane, I. Factors influencing the rate of release. *Soil Science Society of America Proceeding* 26. 579-83.

Scott, J.M. 1986. Seed coating as an aid to pasture establishment. Ph.D. Thesis. University of New England.

Till, A.R., G.S. Mc Arthur, & R.L. Rocks. 1981. An automated procedure for the simultaneous determination of sulphur and phosphorus and radioactive in biological samples. *Proceedings of International Conference Sulphur-84, Calgary, Alberta, Canada, (SUDIC)*, Calgary, Canada.

Tisdale, S. L & W.R. Nelson. 1975. *Soil Fertility and Fertilizers*. Third Edition. Macmillan Publishing Co. New York.

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Ucapan Terima Kasih (*Acknowledgements*) diketik di

antara kesimpulan dan daftar Pustaka.

Tabel dibuat dengan bentuk terbuka dan diberi judul singkat tentang isi tabel. Keterangan isi tabel, bila diperlukan, dicantumkan sebagai catatan kaki, diberi nomer yang diikuti kurung tutup (nomer keterangan diketik sebagai superscript, misalnya <sup>1)</sup>, <sup>2)</sup>, dan seterusnya). Contoh :

Tabel 1. Effect of soil solarization on the population density of rhizospheric microbes.

Duration of Solarization (weeks)	Population density 1)		
	Bacteria	Actinomycetes	Fungi
Control	8.1 a	5.1 a	4.9 a
5	8.4 a	5.1 a	5.6 a
6	8.8 a	5.7 b	5.4 ab
7	8.6 a	5.9 b	5.4 ab

1) Means within the same columns followed by the same letters are not significantly different (Tukey's test,  $\alpha=0.05$ ).

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**Bab dalam Buku :**

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**Makalah dalam Jurnal :**

Christensen, B.T. 1986. Straw incorporation and soil organic matter in marco aggregates and particle size sparates. *J.Soil Sci.* 37.125-135.

**Makalah dalam Internet :**

AQIS [Australian Quarantine and Inspection Service]. 1996. Leagminers of chrysanthemum. <http://www.dpie.gov.au/home page/imadevice.implicit/leafmine.htm.5p>.

**Makalah dalam Buku/Prosiding :**

Klomp,H.&P.Gruys.1965. The analysis of factors affecting reproduction and mortality in a natural population of the pine looper, *Bupalus piniarius* L. *Proc. Int. Congr. Ent. 12 London, 1964* : 369-72

**Abstrak :**

Ratna, E.S., T. Santoso, & U. Kartosuwondo. 2001. Oviposisi, enkapsulasi, dan keberhasilan hidup parasitoid *Eriborus argentiopilosus* (Cameron) (Hymenoptera : Ichneumonidae) pada tiga jenis inang larva Lepidoptera. A - 1.01.h.59, Abstrak *Simposium Pengendalian Hayati Serangga, Sukamandi 14-15 Maret 2001*. Tema : *Pengendalian Hayati Serangga Mendukung Pertanian Berkelanjutan*. Perhimpunan Entomologi Indonesia, Cabang Bandung.

**Skripsi/Tesis/Disertasi:**

Supartha, I W. 1998. Bionomi *Liriomyza huidobrensis* (Blanchard) (Diptera : Agromyzidae) pada Tanaman Kentang. Disertai Doktor. Program Pascasarjana IPB. Bogor, 143 h.

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