SULFUR COATED FERTILISER MATERIALS AS SULFUR SOURCES FOR RICE UNDER FLOODED AND NON-FLOODED CONDITIONS

By

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PREFACE

I certify that the substance of this thesis has not already been submitted for any degree and is not being currently submitted for any other degree. I certify that, to the best of my knowledge, any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

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ABSTRACT

Sulfur (S) deficiency in crop production has been reported in many parts of the world and has resulted in a decline in both crop yield and quality. This has eventuated as a consequence of a number of factors including the increasing use of high analysis fertilisers such as urea, triple superphosphate (TSP), mono- and di-ammonium phosphate which contain little or no sulfur. As the need for S increases to counter the S deficiencies, many attempts have been made to use elemental S (S°) to supply crop demand. Since plants use only the SO_4^{2-}-S, S° needs to be oxidized before a plant can utilize the SO_4^{2-}-S.

In the recent past, the use of S° as a source of S for crops has increased significantly. Coating of fertiliser materials with S° has been introduced to deliberately supply S to plants and these employ finely divided S bound to granular products with various binders such as lignosulfonate, formaldehyde and so forth. This has resulted in the production of a number of S° coated fertilisers. This study was thus undertaken to investigate the effectiveness of a range of S coated TSP fertiliser materials in rice under flooded and non-flooded conditions.

The experiment was conducted in a glasshouse using a factorial combination of 6 sources of S^O coated fertiliser materials [Goldphos10 (GP10), UNE511, UNE1, TSP+S°f (fine), TSP+S°m (medium) and TSP+S°c (coarse)], and a Control, 2 water regimes (flooded and non-flooded) and 3 replications. Fertilisers were prepared using lignosulfonate as the binder in all but GP10 which is a commercial product The soil used in the study was a S-deficient Aquic Haplustalf. The treatments were arranged in a randomized complete block design (RCBD). Phosphorus and S from the different S^O coated fertiliser materials were applied at the rates of 46 kg P/ha and 10 kg S/ha, respectively. The use of ^{35}S labelled soil and the employment of the reverse dilution technique, enabled the estimation of the recovery of fertiliser S in the various rice components derived from the different S fertiliser sources. Tillers were counted at 20, 27, 41, 55 and 69 days after transplanting (DAT) and leaf samples were harvested at 27, 41, 55 and 69 DAT. At the 27,41 and 55 DAT harvests the last fully expanded leaf was sampled from 3 plants in each pot.

Tiller numbers increased rapidly under flooded conditions from 3.1 tillers/plant at 20 DAT to almost 4 tillers/plant at 27 DAT. Tiller numbers under non-flooded conditions increased slowly from 2.7 tillers/plant at 20 DAT to 4.6 tillers/plant at 55 DAT. Filled grain numbers were significantly higher under flooded (578 grains/pot) than under non-flooded conditions (372 grains/pot).

Tiller numbers in the GP10 S fertiliser source was significantly lower than the other sources but similar to that of the Control treatment at 20 DAT. At 41, 55 and 69 DAT, S sources did not influence tiller numbers. No significant differences in mean filled grain numbers were recorded between UNE1, TSP+S°f, TSP+S°m and TSP+S°c, and between UNE511, UNE1 and TSP+S°f S fertiliser sources.

Water regime had no influence on straw dry weight, whereas the filled grain dry weight was significantly higher under flooded conditions compared to that under non-flooded conditions.

Higher but similar mean straw dry weights were recorded in the S fertiliser sources TSP+S°f, UNE1, TSP+S°m, TSP+S°c and UNE511. Application of GP10 resulted in a lower mean straw dry weight, although it was similar to that of UNE511, UNE1, TSP+S°m and TSP+S°c. Filled grain dry weights were higher and similar in the TSP+S°m, TSP+S°c, TSP+S°f and UNE1 S fertiliser sources with the means of 10.4, 10.3, 10.1 and 9.9 g/pot respectively. GP10 had the lowest mean dry weight of filled grains which was similar to that of the Control treatment.

Results from S concentration, S content and the recovery of fertiliser S in the leaves, straw and grain, showed that consistently lower S concentrations in the leaves at each leaf harvest were observed in the Control, GP10, and UNE511 treatments after 20 DAT. The S content of leaves followed a similar trend as the S concentration in the leaves at each leaf harvest. The fertiliser S recovered in the leaves from the GP10 and UNE511 fertilisers was significantly lower at each leaf harvest compared to the other S sources (UNE1, TSP+S°f, TSP+S°m and TSP+S°c).

Sulfur concentrations in the straw and grain showed that the applications of UNE1, TSP+S°f, TSP+S°m and TSP+S°c fertilisers resulted in significantly higher but similar mean straw and grain S concentrations compared to that of the Control, GP10 and UNE511 treatments. A similar trend was observed in the case of the mean straw and grain S contents, and the mean total S content of the rice tops (sum of S contents in the straw and grain), where applications of UNE1, TSP+S°f, TSP+S°m and TSP+S°c fertilisers resulted in significantly higher but similar mean straw and grain S contents. Mean percentage recovery of fertiliser S in the straw and grain, and mean total S recovered in the rice tops were significantly lower in the GP10 and UNE511 fertiliser treatments. Flooding of the soils generally increased the straw S concentration, straw and grain S contents and the percentage fertiliser S recovery.

Dispersions of the different S fertiliser sources in distilled water observed at different times, indicate that at 24 hours, UNE1 disintegrated and dispersed rapidly followed by the TSP+S°f, TSP+S°m and TSP+S°c S fertiliser sources. At 120 hours (5 days), these fertilisers almost completely disintegrated and dispersed extensively. Both GP10 and UNE511 failed to disintegrate and disperse, even after 5 days. Furthermore, tests on the granule strength of the S fertiliser sources show that UNE1 had a higher granule strength compared to the other S sources.

The data on P concentration and P content of leaves, straw and grain, showed that generally, all S fertiliser sources had higher leaf P concentrations in the presence of flood water than in the absence of flood water. A similar trend was observed for P content of leaves. The results on P concentrations of straw and grain showed that the mean P concentration in the straw was significantly higher in the Control, GP10 and UNE511 treatments with the means of 0.26%, 0.19% and 0.14%, respectively. Mean P concentration in the grain was higher in the Control and GP10 treatments. Flooding of the soils significantly increased the mean P concentrations of straw and grain from 0.11% and 0.23% under non-flooded conditions to 0.19% and 0.27% with flooding, respectively. Mean P contents of grain and straw were higher in the GP10 treatment.

The results on N concentrations and N contents of straw and grain showed that the mean N concentration in the straw was higher and similar in the Control, GP10 and UNE511 treatments with the means of 0.81%, 0.76% and 0.76%, respectively. Moreover, flooding of the soils resulted in lower mean straw and grain N concentrations However, the mean N contents of straw and grain indicate that although N concentrations in the straw and grains were higher in the Control and GP10 treatments, their mean N contents were lower.

Based on these results, it was concluded that UNE1, TSP+S°f, TSP+S°m and TSP+S°c were effective S sources for rice under flooded and non-flooded conditions. The results also showed that the use of water-soluble adhesives such as calcium lignosulfonate to bind elemental S particles to TSP products contributed significantly to the effectiveness of the products. The production process was also found to have a strong influence on the effectiveness of a product. Moreover, it was concluded that in the current study granule strength was not a major factor contributing to the effectiveness of the products. Furthermore, the use of the different S° particle sizes did not have any influence in the current study. Therefore, some aspects that need to be investigated include the effects of the different temperature regimes on the water-soluble characteristics of the coat materials used in the study, the effect of the coating thickness on the effectiveness of the fertilisers and the suitable S° particle size range, which can not only release S but also supply it when it is required by the crop.

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