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EFFECT OF UREA AND AMMONIUM SULPHATE ON SULPHUR NUTRITION OF TEA

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Sulphur nutrition ot tea was studied in relation to soil and leaf sulphur status in a long term field trial fertilizer with either urea or sulphate of ammonia equivalent to 112, 224 and 336 kg N ha^{-1} $year^{-1}$. Despite the significant difference in total soil sulphur and ammonium acetate extractable sulphate sulphur in the soil (O—45 cm depth) between ammonium sulphate and urea treatments the sulphur status of the flush (two leaves + bud) and mature leaves was not affected by the source of nitrogen. This confirms that despite the exclusive use of the urea which does not add any sulphur to the soil when compared to ammonium sulphate (24% S), over the past six years, the sulphur reserves in the soils are adequate to meet the sulphur requirements of the tea crop. Further the soil sulphur survey revealed that in all the tea growing regions cultivated tea soils had very much higher sulphur levels (500-600 mg kg^{-1} SO_4 -S) in the O-60 cm depth) when compared with the neighbouring Jungle soil (80-100 mg kg^{-1} SO 4-S) at the comparable depths.

Sulphur removal with the harvested tea crop is small and only 10-15 kg S is removed even with a harvest of 3000 kg made tea ha^{-1} $year^{-1}$.

INTRODUCTION

The tea plant (*Camellia sinensis L.*) responds to high levels of fertilizer nitrogen (200-300 kg ha^{-1} year $^{-1}$). In the past 20 to 30 years , the chief source of nitrogenous fertilizer for tea in Sri Lanka has been ammonium sulphate and its continued use has resulted in the tea soils becoming acidic and certain plantations are recording soil pH values as low as 3.7 and 3.8. Currently urea is being increasingly used as an alternative source of nitrogen, as urea acidifies the soil to a lesser extent, releases less bases into the soil solution from cation exchange sites and is cheaper per unit of nitrogen (Wickremasinghe, Nalliah and Wijedasa, 1985a). N^{15} labelled fertilizer studies revealed that urea and ammonium sulphate were equally efficient sources of fertilizer nitrogen for mature tea (Wickremasinghe, Nalliah and Paramasivam, 1984) and were immobilized and mineralized to very similar extents in Sri Lankan tea soils (Wickremasinghe, Rodgers and Jenkinson, 1985b).

Sulphur is identified as one of the sixteen essential elements necessary for healthy plant growth. Sulphur is a constituent of the sulphur bearing amino acids cysteine and methionine and is essential for the synthesis of the vital plant pigment chlorophyll and the vitamin Thiamine. Thus, sulphur plays a vital role in photosynthesis and any limitation or insufficiency of this nutrient adversely affects the photosynthesis and carbohydrate metabolism of the plant.

Sulphur deficiency was one of the first mineral deficiencies to be reported and it is interesting to note that this was in the tea crop itself. Storey and Leach (1933) reported the disease " Tea Yellow " in Nyasaland tea plantation in East Africa and attributed this disease to physiological sulphur deficiency. Though sulphur deficiency is connected with the failure of the tea to produce chlorophyll and certain sulphur containing amino acids and proteins in sufficient amounts, its function is still obscure. Foliar analysis revealed that bushes suffering from sulphur deficiency had leaf sulphur values below 0.10 per cent. The deficiency symptoms were characterized by yellow marbling of the leaves resulting in " Net Veining " where the leaf blades took a striking yellow colour with the veins down to the finest branching standing out distinctly green. The sulphur content in the healthy leaves were around 0.2%.

The sulphur requirements of crops vary with different plant species. Grasses and cereals are reported to remove about 8-10 kg sulphur ha^{-1}, beans about 25-30 kg S ha^{-1} while the highest crop removal of sulphur of about 40-45 kg ha^{-1} was observed in the Brassica family (Russel, 1973).

Jordan *et. al*, 1959 reported that suplhur deficiency in crops is normally associated in regions where the soils are heavily leached and the rainfall returns less than 5 kg sulphur ha^{-1} annually.

The immediate source of soil sulphur for crops grown on well drained soils is the sulphate in soil solution and the sulphate absorbed on soil colloids. Soil organic matter (humus) serves as the principal reservoir of sulphur in soils and as humus becomes oxidized, sulphates are released. In acid soils (pH < 5.0) positive charges which develop on Iron and Aluminium hydroxide surfaces help to absorb sulphates and assist to minimize the leaching losses of sulphates.

In view of the above observations and the fact that urea does not contribute any sulphur to the soil, compared to ammonium sulphate lead us to study the effect of these two fertilizers on the sulphur status of the soil and the sulphur nutrition of the tea bush overall.

MATERIALS AND METHODS

Experimental plots for the study were selected from a long term field experiment at St. Coombs Estate, Talawakele comparing urea and sulphate of ammonia now in its 6th year receiving 112, 224 and 336 kg N ha^{-1} $year^{-1}$. All plots received the equivalent of 30 kg P_2O_5 and 90 kg K_2O ha^{-1} $year^{-1}$ and the treatments were replicated thrice.

Soil sampled from the experimental plots at random down to a depth of 45 cm at 15 cm increments (0-15, 15-30, 30-45 cm) were used to determine the total sulphur and ammonium acetate extractable sulphate sulphur in the soil from the differential fertilizer nitrogen treatments.

Total sulphur

Two ml of magnesium nitrate was added to 1g of soil in an evaporating basin and excess moisture evaporated at 70°C, and then kept in the muffle overnight at 300°C. The contents were digested with 5 ml of 31.2% HNO_3 on a water bath for 3½ h and transferred to a 50 ml volumetric flask, made to volume, and filtered; 40 ml aliquot of the extract was placed in 50 ml volumetric flask followed by the addition of 4 ml 50% acetic acid, 1 ml ortho-phosphoric acid and 5 ml Tween 80-$BaCl_2$ reagent and sulphur concentration in the sample determined by turbidimetry (Buttlers and Chenery, 1959).

Ammonium acetate extractable sulphur

10 g air dry soil was extracted with 25 ml of ammonium acetate for 30 minutes. Activated charcoal (0.25 g) was then added and sample shaken for a further period of 3 minutes. The soil suspension was filtered and 10 ml aliquot used to determine ammonium acetate extractable sulphate sulphur in the soil by turbidimetry (Buttlers and Chenery, 1959).

Plant sulphur

Leaf samples (flush and mature) from the respective experimental plots were sampled at random and the sulphur contents in the leaves determined using Tween 80/$BaCl_2$ instead of gum acacia and $BaCl_2$ crystals (Buttlers and Chenery, 1959).

RESULTS AND DISCUSSION

Sulphate of ammonia by virtue of its chemical composition has 24% S and 21% N compared to urea which has no S but 46% N. The continuous use of sulphate of ammonia in tea plantations over the past few decades has added more sulphur to the soil than nitrogen and as a result there is a build up of sulphur in tea soils. Further, compared to 3-4% nitrogen removed in the harvested crop only 0.3-0.4% sulphur is removed.

The effect of continuous use of urea and ammonium sulphate over the past six years on total sulphur content in the soil with the differential nitrogen treatments is given in Table 1.

TABLE 1—*Effect of fertilizer urea and ammonium sulphate on total sulphur content in the soil*

Nitrogen level (kg N ha^{-1} $year^{-1}$)	112		224		336	
	Total S mg kg^{-1} soil					
	SA	*Urea*	*SA*	*Urea*	*SA*	*Urea*
Soil depth						
0—15 cm	1191	870	1512	1125	1637	837
15—30 cm	1117	1146	1812	1262	1637	1162
30—45 cm	1475	1271	1892	1462	1667	1295
LSD						
0—15 cm = 446	(P = 0.01)					
15—30 cm = 444	(P = 0.01)					
30—45 cm = NS	(P = 0.05)					

At the lower level of N application (112 kg N ha^{-1} $year^{-1}$) the difference in total sulphur content between the urea and sulphate of ammonia treatments was not significant (Table 1). However, with increase in nitrogen (224 and 336 kg N ha^{-1} $year^{-1}$) sulphate of ammonia treatments showed a significant increase in the total sulphur content compared to urea and this was probably due to the attendant application of sulphur with sulphate of ammonia applications.

TABLE 2—*Effect of urea and ammonium sulphate on ammonium acetate extractable SO_4—S in the soil*

Nitrogen level kg N ha^{-1} $year^{-1}$	112		224		336		
	SO_4 —S in the soil mg kg^{-1}						
Soil depth (cm)	*SA*	*Urea*	*SA*	*Urea*	*SA*	*Urea*	*LSD*
0—15 ..	582	227	678	253	692	270	128(P = 0.01)
15—30 ..	569	452	720	420	687	450	105(P = 0.05)
30—45 ..	624	593	667	486	687	478	89(P = 0.01)

Table 2 shows the effect of increasing levels of urea and sulphate of ammonia on ammonium acetate extractable SO_4—S in the soil. Despite this significant difference in total soil sulphur and ammonium acetate extractable sulphate sulphur in the soil between the urea and sulphate of ammonia treatments (Tables 1 and 2), the sulphur status of the flush (two leaves+bud) and mature leaves was not affected by the source of nitrogen (Table 3) thus confirming that the sulphur reserves in the soils are adequate to meet the demands of the tea plant.

TABLE 3—*Effect of urea and ammonium sulphate on sulphur status of the mature leaf and flush*

N level kg. N ha^{-1} application^{-1}	*% S in mature leaf*		*% S in flush*	
	SA	*Urea*	*SA*	*Urea*
112 ..	0.31	0.31	0.41	0.35
224 ..	0.32	0.33	0.36	0.36
336 ..	0.34	0.34	0.39	0.39
LSD (P = 0.05)		NS		

It is evident from Table 3 that the sulphur removal with the harvesting of the tea crop is very small, only 10-15 kg being removed for every 3000 kg made tea ha^{-1} $year^{-1}$ which is negligible when compared with the sulphate sulphur in the soil (2000 kg SO_4—S ha^{-1}) despite the exclusive use of urea.

Further, leaf fall from the tea i.e. tea leaf litter and that from prunings, and foliar application of zinc sulphate contributes 8-10 kg S ha^{-1} $year^{-1}$.

Effect of long term tea cultivation on sulphur status of the tea soils and that of the neighbouring jungle soils from different tea growing regions of the country are given in Table 4. Ammonium acetate extractable sulphate sulphur in all the tea soils were very much higher than that of the neighbouring jungle soils in all the regions. The average sulphate sulphur levels in most of the tea soils ranged between 500-600 mg kg^{-1} (1000-1200 kg ha^{-1}) in the 0-60 cm depth and the corresponding values for the neighbouring jungle soils ranged between 80-100 mg kg^{-1}. The relatively high sulphur status of the tea soils is probably due to the application of high levels of sulphate of ammonia over the past few decades which added substantial quantities of SO_4-S to the soil along with each Nitrogen application (Wickramasinghe *et al.*, 1987).

In addition 8-12 kg of sulphur is returned to the soil annually with rain (Amarasiri and Lathiff, 1982) (Table 5).

These findings leads to the conclusion that there is a substantial reserve of sulphur in the tea soils and that continuous use of urea based fertilizer mixtures in the tea plantations is unlikely to bring about any sulphur deficiency and associated crop loss in the near future.

TABLE 4—*Sulphur status of the tea soils and the neighbouring jungle soils.*

Location	*Ammonium Acetate Extractable SO_4—S (mg kg^{-1})*		
	Sampling Depth cm)	*Jungle Soil*	*Tea Soil*
St. Coombs ..	0—15	22·0	195·8
	15—30	50·6	316·2
	30—45	91·6	404·0
	45—60	124·4	452·0
Passara ..	0—15	1·0	60·4
	15—30	1·2	136·8
	30—45	1·4	97·0
	45—60	2·8	111·2
Hantane ..	0—15	30·6	34·4
	15—30	26·8	113·2
	30—45	31·0	154·2
	45—60	28·6	281·0
Kottawa ..	0—15	48·0	88·2
	15—30	57·0	132·8
	30—45	41·4	176·0
	45—60	116·2	187·8
Deniyaya ..	0—15	18·6	72·8
	15—30	12·0	102·3
	30—45	7·2	159·7
	45—60	6·4	233·4

TABLE 5— *Sulphur brought down by rainfall at different locations in Sri Lanka (kg ha^{-1} an^{-1})*

Location	*Jan.*	*Feb.*	*March*	*April*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Total S* (*kg ha^{-1} an^{-1}*)
Ampara ..	0·6	1·3	1·4	1·3	0·0	N.R.	0·7	0·1	2.2	1·1	1·3	0·8	10·8
Bandarawela ..	0·2	0·5	0·9	0·7	0·4	0·2	1·4	0·4	1·6	1·3	0·9	0·4	8·9
Batalagoda ..	0·3	0·1	2·0	1·4	0·8	0·9	0·6	0·2	1·1	2·1	6·4	1·4	17·3
Bombuwela ..	0·5	0·4	2·9	3·5	3·8	1·9	0·9	1·8	1·5	2·2	1·1	3·4	23·9
Gannoruwa ..	N.R.	N.R.	1·0	1·4	1·0	2·0	1·4	1·2	1·3	1·5	1·7	0·8	13·3
Karadian Aru ..	0·5	0·7	0·5	0·6	0·4	0·2	6·0	0·2	1·8	1·2	1·4	1·1	14·6
Maha Illuppallama ..	0·0	N.R.	0·4	1·6	0·5	0·1	0·8	0·2	1·2	0·9	0·7	0·6	7·0
Murunkan ..	0·2	N.R.	N.R.	0·4	0·7	0·2	0·3	N.R.	0·4	0·5	1·1	1·1	4·9
Paranthan ..	0·2	0·6	0·3	0·4	1·2	N.R.	2·0	N.R.	2.0	1·9	2·3	0·4	11·3
Sita Eliya ..	N.R.	2·2	0·9	0·5	0·8	1·2	1·7	0·9	2·1	1·2	0·9	0·3	12·7

N.R = No rain

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