

A COMPARATIVE STUDY OF THE EFFICIENCY OF UTILIZATION OF UREA AND AMMONIUM SULPHATE BY MATURE TEA PLANTS USING N-15 LABELLED FERTILIZERS

K. N. Wickremasinghe, P. Nalliah and S. Paramasivam

(Tea Research Institute of Sri Lanka, Talawakele, Sri Lanka)

The efficiency of utilization of fertilizer urea and ammonium sulphate by mature tea plants was studied under simulated field conditions using N-15 labelled fertilizer urea and ammonium sulphate.

The efficiency of utilization of the two fertilizers was compared by evaluating the yield independent criteria namely atom per cent N-15 excess, per cent N derived from fertilizer, and per cent N derived from soil in the flush, 3rd leaf and mature leaf. The atom per cent N-15 excess and per cent N derived from fertilizer in the flush and 3rd leaf were directly related to the availability of fertilizer nitrogen in the soil, while the mature leaf continued to steadily draw and store fertilizer N and served as a sink in both urea and ammonium sulphate treatments. The effect of urea and ammonium sulphate fertilizers on crop growth and new shoot production was very similar and evident after about 6 weeks from fertilizer application. The experimental results clearly indicate that both urea and ammonium sulphate were equally efficient sources of fertilizer nitrogen for mature tea.

INTRODUCTION

The tea industry earns for Sri Lanka about 40% of its foreign exchange and is vital to the economy of the country. Although tea was introduced to Sri Lanka in the 1860's manuring of tea plantations on a regular and organized basis developed only in the early 1930's when it was increasingly felt that the use of chemical fertilizers was the surest and quickest way of augmenting the nutrient supply of the soil for higher crop production. It was soon realized that the tea crop responds to very high levels of nitrogen, such as 200 to 300 kg N per hectare per annum (Fernando *et al.*, 1969).

In tea, the vegetative portion of the crop harvested for tea manufacture i.e. two leaves and the bud, contains about 3 to 4 per cent N and this is harvested every 7 to 10 days. Fertilizer recommendations are based on the yield potential of the tea and for an average production of 200 million kilograms of made tea, 20 million kilograms of N is given with 240-300 kilograms N being currently applied for the high yielding mature tea. Until the early 1970's most of this N was given exclusively as ammonium sulphate and its continuous use in such large quantities was suspected to be the cause for the decline in soil pH. Chenery (1966) suggested the use of other sources of N like Calcium ammonium nitrate and Urea.

The major difference between urea and ammonium sulphate is that urea is an organic nitrogen fertilizer while ammonium sulphate is an inorganic nitrogen fertilizer and that the presence of enzyme urease in the soil is necessary for the hydrolysis of urea. Wickremasinghe *et al.* (1981) reported that the ambient levels of urease present in tea soils are adequate to hydrolyse the equivalent of 100 kg urea N ha⁻¹ in less than four days. After hydrolysis in both the urea and ammonium sulphate treatments nitrogen is in the ammonium form.

The Tea Research Institute initiated a large number of field experiments in 1965 to compare the use of sulphate of ammonia, urea and calcium ammonium nitrate in the different tea growing areas (Bhavanandan and Manipura, 1969). These investigations showed that even when 100 per cent of the N requirement was applied in the form of urea, in most of the trials the yields were similar to that obtained with sulphate of ammonia; in 27 out of 31 experiments urea and ammonium sulphate gave similar yields. In all the experiments calcium ammonium nitrate gave lower yields (Tillekeratne, 1970; Watson and Wettasinghe, 1972; Sandanam *et al.*, 1980). Based on field experimentation and on fundamental research findings the Tea Research Institute in 1979 recommended that at least 50 per cent of the N requirement of the tea plant be given as urea.

With the global energy crisis the cost of urea and ammonium sulphate fertilizers have increased by about 300 per cent and today the price of a kg of N from urea costs Rs. 6.05 while that from ammonium sulphate costs Rs. 20.23. Therefore, purely from an economic point of view the gain by the complete switch over from ammonium sulphate to urea is about 150 million rupees. However, financial gains alone is not the ultimate test for the acceptance of a fertilizer. One of the important criteria for the preference of a particular fertilizer would be the efficiency of its utilization by the plant. The primary objective of the work reported here was, therefore, to study the transformation of the two types of fertilizers, urea and ammonium sulphate in the soil in relation to immobilization, mineralization, nitrification, the dissolution of soil K, Ca and Mg and their respective efficiencies of utilization by the tea plant, and also the long term effect of sulphur in tea nutrition.

The experimental results presented here are in relation to the efficiency of utilization (plant uptake) of these two fertilizers by mature tea plants. Their effects on nitrification and the release of potassium, calcium and magnesium will be discussed in a subsequent paper. Fried *et al.* (1975) reported that it is only through the use of labelled nitrogen that the efficiency of utilization of nitrogen could be determined accurately.

The technique used before the advent of the tracer method of calculating the difference in total nitrogen uptake between control and nitrogen treated crop over estimates the utilization of fertilizer nitrogen. This is due to the enhanced mineralization of native organic soil nitrogen with the application of fertilizer (priming effect) and the stimulation of root growth facilitating greater uptake of nitrogen from soil (Aleksic *et al.*, 1968). It must be stressed here that no assumptions have to be made with respect to the behaviour of fertilizers in soil, whether part of the fertilizer becomes involved in chemical reactions or biological processes of ion exchange and the only assumption to be made is that ^{14}N and ^{15}N behave physically and chemically identical in the soil.

MATERIALS AND METHODS

The efficiency of utilization of fertilizer urea and ammonium sulphate by mature tea plants were studied under simulated field conditions using 7-year-old tea plants in $1.2 \times 0.6 \times 1.2$ metre ($l \times w \times h$) cement pots. The pots were filled with soil according to the field profile and tea plants were established in them. This study commenced in 1975. Prior to the application of fertilizer, the soil was brought to field capacity by saturating it with water and allowing the excess water to drain off from the bottom of the pot.

The plants were fertilized with 9 atom per cent ^{15}N excess urea and ammonium sulphate and 7 grams N per pot (equivalent to 100 kg N ha⁻¹ application⁻¹) were added to the soil in duplicate. The pots were watered daily equivalent to 2 cm rain day⁻¹ for a period of one week initially, and watering reduced to 1 cm rain day⁻¹ thereafter for 98 days. The excess water was allowed to drain off from the bottom of the pot and this prevented the soil getting water logged.

The method of sampling adopted was to harvest the following plant parts: flush (two leaves and bud), third leaf and mature leaf (Fig. 1) from the tea bushes at approximately four-week intervals from the time of application of fertilizer and the atom per cent N - 15 excess, per cent N derived from fertilizer (NdfF) and percent N derived from soil (NdfS) in the different plant parts was estimated. From these results the nitrogen derived from fertilizer urea and ammonium sulphate by mature tea plants were calculated and the efficiency of utilization of these two fertilizers were compared.

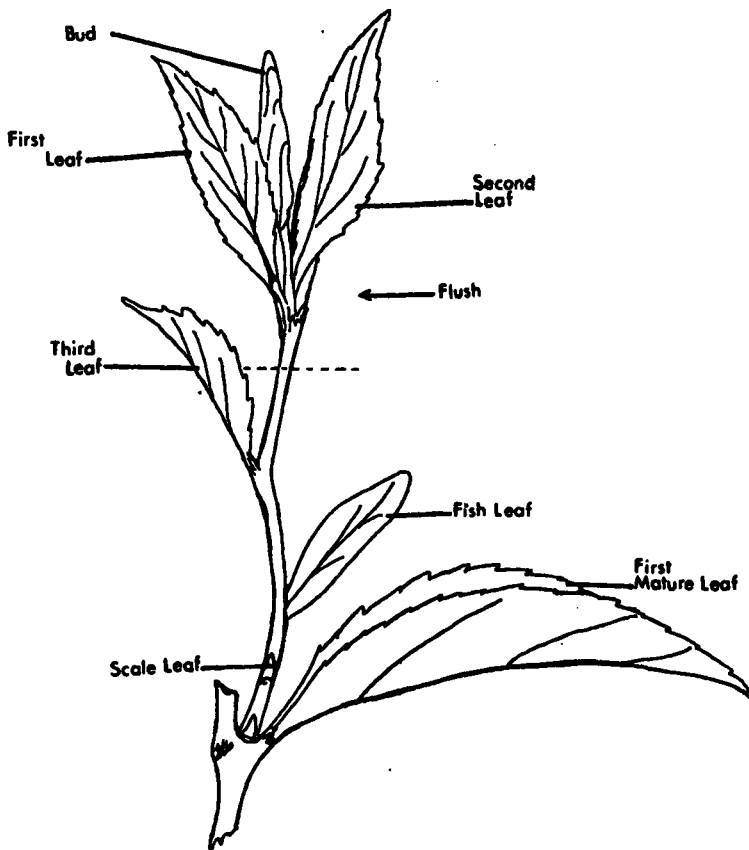


Fig. 1.—Diagrammatic representation of tea shoot showing the different sampling components.

RESULTS AND DISCUSSION

In the present study which compared the efficiency of utilization of urea and ammonium sulphate by mature tea plants the total assessment of N-15 incorporation in the whole plant (leaf, stem and root) was not possible due to the relatively large size of the plants. Therefore the yield independent criteria such as N-15 atom per cent excess, nitrogen derived from fertilizer (NdfF) and nitrogen derived from soil (NdfS) in the different plant parts namely flush, third leaf and mature leaf were calculated directly from the isotope dilution determinations (I.A.E.A. Tracer Manual—Technical Report).

The first harvest from the tea bushes were taken 28 days after application of fertilizer and the atom per cent ^{15}N excess, per cent NdfF and per cent NdfS in the flush, third leaf and mature leaf for the urea and ammonium sulphate treatments are given in Table 1. It is evident that, independent of the type of nitrogen fertilizer, the flush and third leaf, which are fast growing organs in the shoot (Fig. 1) take up comparatively more fertilizer nitrogen than the mature leaf (Table 1) which has been found to serve as a reservoir or sink for most mobile plant nutrients such as potassium and magnesium (Sivasubramaniam *et al.*, 1976).

TABLE 1 — *Efficiency of utilization of N derived from fertilizer urea and ammonium sulphate by mature tea*

Treatment	Harvest	Days after fertilizer application	Atom per cent ^{15}N excess			Per cent N derived from fertilizer (NdfF)			Per cent N derived from soil (NdfS)		
			Flush	3rd leaf	Mature leaf	Flush	3rd leaf	Mature leaf	Flush	3rd leaf	Mature leaf
Urea	1st	28	4.5	3.5	2.5	51.2	40.2	29.0	48.8	59.8	70.9
	2nd	49	3.9	3.6	2.2	45.9	41.4	25.0	54.1	58.6	74.9
	3rd	76	2.9	3.3	2.5	32.9	37.7	29.4	67.0	62.3	70.6
	4th	98	2.7	2.7	2.9	30.9	31.4	33.6	69.1	68.6	66.3
Ammonium sulphate	1st	28	4.7	4.1	2.2	53.7	46.7	25.4	46.3	53.3	74.5
	2nd	49	3.9	3.4	2.3	45.0	39.5	26.7	54.9	60.4	73.2
	3rd	76	2.9	3.2	2.4	33.3	36.5	27.8	66.6	63.4	72.2
	4th	98	2.7	2.8	3.1	30.7	32.5	35.5	69.3	67.5	64.5

Even in the second harvest, 49 days after application of fertilizer the same trend was maintained. However, the nitrogen derived from fertilizer was little less than that of the first harvest (45.9 and 45.0 per cent as opposed to 51.2 and 53.7 per cent for flush in urea and ammonium sulphate treated bushes respectively (Table 1).

The effect of fertilizer on growth and new shoot production was clearly seen after 7 weeks of fertilizer application and the crop yield increased substantially, indicating that the best effect of applied fertilizer is reflected in crop production after about 7 weeks (Tables 1 and 2).

TABLE 2 — *Effect of fertilizer urea and ammonium sulphate on crop yield in mature tea*

Treatment	Plant part	Dry weight (g)			
		Days after fertilizer application			
		28	49	76	98
Urea	Flush	6.8	17.6	8.4	20.8
	3rd leaf	4.7	11.0	6.0	14.2
	Mature leaf	7.8	15.4	7.9	16.8
Ammonium sulphate	Flush	5.5	14.3	6.1	18.3
	3rd leaf	3.6	12.5	4.4	11.6
	Mature leaf	5.5	13.5	5.9	16.4

In the third harvest 76 days after fertilizer application NdfF decreased markedly in the flush and third leaf in both urea and ammonium sulphate treatments (Table 1 and Fig. 2) but increased slightly in the mature leaf. The same trend was repeated again in the fourth harvest 98 days after fertilizer application and the corresponding values for flush and mature leaf were 30.9 and 33.6 for urea and 30.7 and 35.5 for ammonium sulphate treatments respectively (Table 1). On the whole it is clearly seen that the flush and third leaf continues to draw less and less nitrogen from the applied fertilizer with time while the mature leaf continues to absorb progressively more and more nitrogen thus confirming its function as a sink for nutrients (Table 1).

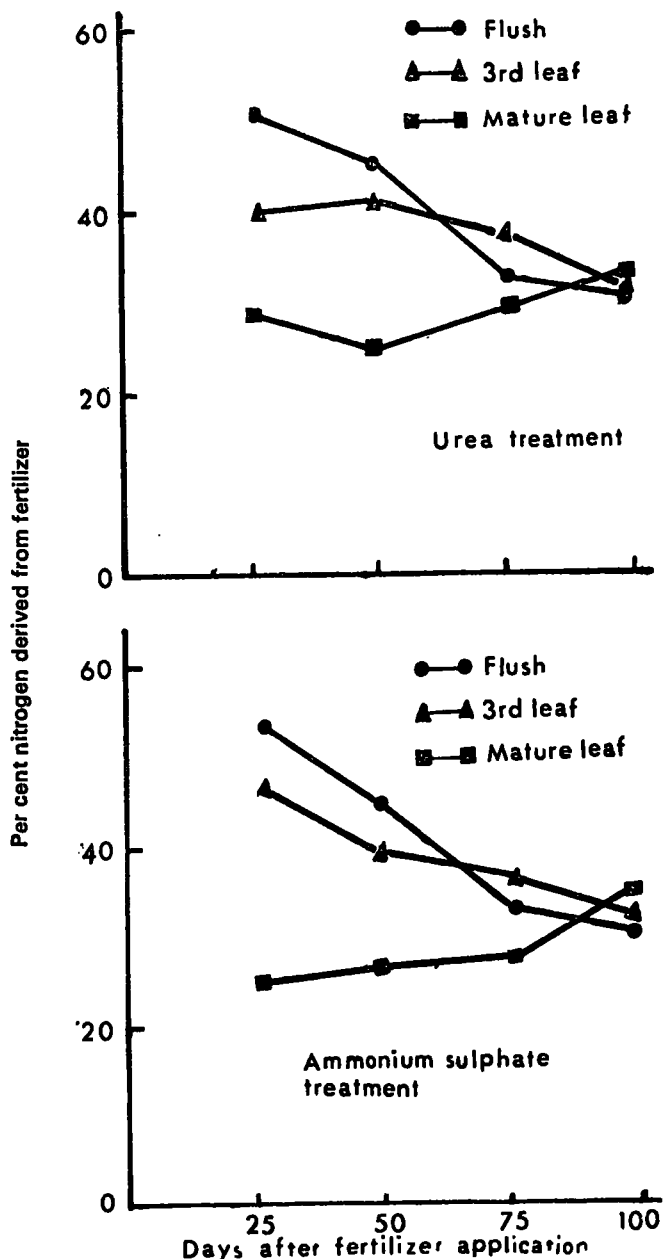


Fig. 2. — Uptake of fertilizer urea and ammonium sulphate by mature tea.

It is interesting to note that in spite of the relatively small third harvest after 76 days of fertilizer application a peak harvest was again obtained at the end of 98 days (Table 2) and the contribution of NdfF for flush was only 30 per cent for both fertilizers in contrast to 45 per cent for the second harvest, while the respective contribution by the native soil nitrogen (nitrogen derived from soil) were 69 and 54 per cent (Table 1) thus confirming the importance of native soil nitrogen in supporting crop growth and production of flush. This clearly demonstrates that the maintenance of soil fertility is extremely important in tea production and is as vital as application of fertilizers to sustain higher crop production. The above experimental findings based on atom per cent ^{15}N excess, per cent nitrogen derived from fertilizer (% NdfF), per cent nitrogen derived from soil (% NdfS) clearly show that mature tea plants can utilise both urea and ammonium sulphate fertilizers equally efficiently and urea could be used to supply the fertilizer nitrogen requirements of mature tea.

ACKNOWLEDGEMENTS

We wish to thank the International Atomic Energy Agency and Sri Lanka Atomic Energy Authority for Technical Assistance offered in connection with the ^{15}N programme. A special thanks to Mr D. P. Kuruppu of the Atomic Energy Authority for helping us in ^{15}N sample analysis.

REFERENCES

- ALEKSIC, Z., BROESHART, H. and MIDDELBOE, V. (1968). The effect of nitrogen fertilization on the release of soil nitrogen. *Plant and Soil*, **29** (3), 474-477.
- BHAVANANDAN, V. P. and MANIPURA, W. B. (1969). Fertilizer responses of tea in the up-country districts. *Tea Q.* **40**, 135-144.
- CHENERY, E. M. (1966). Introducing calcium ammonium nitrate. *Tea Q.* **37**, 51-55.
- FERNANDO, L. H., BHAVANANDAN, V. P., WETTASINGHE, D. T. and MANIPURA, W. B. (1969). Fertilizer recommendations for tea in Ceylon. *Tea Q.* **40**, 129-134.
- FRIED, M., SOPER, R. J. and BROESHART, H. (1975). ^{15}N labelled single treatment fertility experiments. *Agronomy Journal* **67** (3), 393-396.
- International Atomic Energy Agency, Vienna (1976). Tracer Manual on Crops and Soils. Technical Reports Series No. 171, 119-127.
- SANDANAM, S., SIVASUBRAMANIAM, S. and RAJASINGHAM, C. C. (1980). Response of seedling tea to forms and levels of nitrogenous fertilizers, levels of potassium and liming in the up-country tea growing districts of Sri Lanka. *Tea Q.* **49**, 20-29.
- SIVASUBRAMANIAM, S. and JAYMAN, T. C. Z. (1976). The use of fertilizers for tea in Sri Lanka. 2. Foliar and soil analysis with particular reference to potassium. *Tea Q.* **46**, 4-11.
- TILLEKERATNE, L. M. de W. (1970). Interim report on fertilizer responses of seedling tea in extension experiments in Uva. *Tea Q.* **41**, 71-73.
- WATSON, M. and WETTASINGHE, D. T. (1972). Some effects of treatments designed to lower soil acidity on the growth of the tea plant. *J. Nat. Agric. Soc. Ceylon* **9-10**, 32-42.
- WICKREMASINGHE, K. N., SIVASUBRAMANIAM, S. and NALLIAH, P. (1982). Urea hydrolysis in some tea soils. *Plant and Soil* **62**, 473-477.