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THE USE OF FERTILIZER FOR TEA IN SRI LANKA

I — INTRODUCTION AND HISTORICAL REVIEW

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Tea was first planted in Sri Lanka on a commercial scale in 1867 after the Coffee Rust Disease, *Hemileia vastatrix*, ravaged the country's coffee plantations. Coffee lands and virgin forest areas were cleared and planted in tea. In 1896 there was some evidence that increased crops could be obtained by the application of manure and there was no widespread fear this would harm either the health of the tea plant or the quality or manufactured product. Oil seed cake and bone meal were used, and applications were irregular, being not more frequent than biannual (Eden 1934). Following this finding, manure application became a more widespread practice, but it did not appear to be properly organized. Inorganic fertilizers were introduced only at the beginning of this century but were not popular because it was believed that organic fertilizers contained nitrogen in a form which was more steadily available, and that they were useful for preserving the quality of tea. Upto 1917 there was a steady increase in the use of imported inorganic fertilizers until the war began, when once again, local supplies of fertilizer which were mainly organic, became popular. Green manuring was advocated by Wright (1904) and Bamber (1912) and this practice wa. . .ued until the 1930s. During this period, loppings from shade trees, inter-plant. .eguminous bush crops and some ground covers were widely used. Unlike in some other countries, clean weeding was also done (Eden 1934).

Fertilizer mixtures containing N,P and K were used in Sri Lanka before 1930s (Eden 1934). The composition of some of these mixtures are given below :

Pruning mixture

	lb			
Fish Guano	220			
Blood meal	70	Equivalent	N	— 31.0
Nitrate of potash	80	in lb/acre	P_2O_5	— 59.4
Rock phosphate	80		K_2O	— 26.4
Concentrated superphosphate	50			
	500			

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General mixture

	lb			
Groundnut cake	200			
Fish Guano	200			
Blood meal	100	Equivalent	N	— 60.5
Sulphate of ammonia	100	in lb/acre	P_2O_5	— 34.0
Muriate of potash	50		K_2O	— 25.0
Superphosphate	100			
	750			

Nitrogenous fertilizers were used in various forms with phosphate and potash. The use of large quantities of phosphate and potash in the pruning mixture was of great interest and the timing of fertilizer applications after pruning was carefully considered. The pros and cons of burning or burying prunings were evaluated (Petch 1909). In these early years inorganic manures were applied to supply modest quantities of nitrogen varying between 20 and 40 lb N. Little or no potash (as muriate) appears to have been applied. Application of liberal quantities of superphosphate of the order of 100 lb P_2O_5 are on record. It was believed that phosphate was important for the recovery of the tea bush after pruning and that it also promoted the quality of made tea. This was why large quantities were applied.

The importance of potash for tea was realized quite early in Sri Lanka (Petch 1928). Although potassium deficiency symptoms on tea were described 'as marginal scorch' in 1928, Petch was of the opinion that no such symptoms were visible on tea under Ceylon conditions. Although he had commented that potassium was essential for wood growth, he rejected potash fertilizer application based on soil analysis. He concluded that Ceylon tea soils are quite well supplied with potassium.

Dr T. Eden became the Agricultural Chemist of the Tea Research Institute of Ceylon in 1927 and was the pioneer worker in devising reliable statistically-designed field experiments. He studied manuring policies in various countries and resorted to field experiments to obtain reliable information on what should be the correct fertilizer practices for Ceylon tea. Eden (1929) was mainly interested in investigating the yield response of tea to varying levels of nitrogen in conjunction with varying levels of potash. In 1931, he laid out the now-famous 3^3 classical factorial fertilizer experiment at St Coombs. This was the first factorial fertilizer experiment on any tree crop anywhere in the world. His contribution to statistically-designed fertilizer experimentation on tea at the Tea Research Institute of Ceylon earned for him a Doctor's Degree in Science from the University of Manchester in 1935. In 1949, he became the Director of the Tea Research Institute of East Africa.

In the first cycle of Eden's classical experiment (1931-1934) he tested three types of nitrogenous fertilizer blood meal, cyanamide and sulphate of ammonia, each at three levels (0,20,40 lb N per acre per annum), in all possible combinations with three levels of potash (0,20,40 lb K_2O per acre per annum). At the end of the cycle

he concluded that there was no difference in crop as a result of using organic and inorganic fertilizers. There was a response to increased levels of nitrogen but there was no response to potash in the first cycle. He omitted the types-of-nitrogen treatment from the second cycle onwards and made it a 3^3 NPK factorial design.

From the early 1930s the application of fertilizer to tea was based on scientific findings. A series of experiments were carried out to evaluate various agricultural operations that were in common use. Eden (1938) has discussed the residual effects and timing of fertilizer applications in respect to pruning and length of pruning cycle. He found that the application of fertilizer three to six months before pruning was more desirable than application at the time of pruning, and he stated that 'increased crop and increased wood go hand in hand'. Summarizing the results of his experiment over 18 years, Eden (1949) made the following observations :

1. Nitrogen could be used economically at rates up to 80 lb per acre. The response was proportional to the dose of nitrogen and nitrogen efficiency was found to increase as the pruning cycle proceeds, provided that the last dose is applied sufficiently long before pruning for the fertilizer to exert its full effect.

2. Phosphate appeared to have an useful limit which was certainly not greater than an average of 30 lb P_2O_5 per acre.

3. It took 10 to 12 years for seedling tea not receiving any potash at all to show deficiency symptoms and crop decline. He attributed this to 'the mineral a prominent feature of the rocks from which our soils have been weathered, which is itself rich in potash'. He also reported that the quantity of potash removed by way of pruning and cropping was 3.47 lb for every 100 lb of made tea. He concluded that for an 80 lb dose of nitrogen the optimum level of potash was around 40 lb.

Full details of this long-term NPK experiment will soon be published in a future article in this series.

During the war years artificial inorganic fertilizers were in short supply and as a result drastic cuts were made in the use of NPK fertilizers, especially potash. Eden (1940) was confident that the low levels of potash applied because of the wartime shortage would not affect yield or wood formation of tea plants in Ceylon. Mixtures such as T 240, T 300, T 420 and the old basal mixture T 500, containing very low potash, were recommended (Norris 1946). The composition of T 500 is given here to illustrate the levels of phosphate and potash in respect to nitrogen.

T 500 Basic Mixture—Norris (1946)

	lb			lb
Groundnut cake	430		N —	30.1
Saphos phosphate	60	giving	P_2O_5 —	17.7
Muriate of potash	10		K_2O	6.0

This mixture was applied till early 1950s and as a result some estates were starved of potash.

Portsmouth (1953) clearly described the typical diagnostic symptoms of potassium deficiency in tea from observations on the zero potash plots in Eden's NPK experiment and published colour photographs of the symptoms. He attributed the following consequences to tea as a result of potassium deficiency :

1—Many vacancies due to deaths of badly-deficient bushes following pruning,

2—Continued shedding of lower leaves,

3—Thin twiggy wood,

4—Almost complete absence of any new flush,

5—Pronounced marginal scorch.

Subsequent work has confirmed these findings. It is, therefore, quite clear that diagnosis of potassium deficiency in tea in Ceylon was known for a considerable period of time.

Regular NPK fertilizer supplies was restored after the war, to tea in Ceylon. The use of balanced NPK mixtures to replace the amounts of those nutrients removed by the crop was advocated. It was argued that 1000 lb made tea removed 65 lb N, 15 lb P_2O_5 and 40 lb K_2O and that most of the phosphate applied to the soil was fixed. On this basis, Lamb (1952) stressed the importance of using a balanced NPK mixture TRI 500 on tea estates. The following composition was suggested.

	TRI 500 mixture			
	lb			
Ammonium sulphate	320		N	— 65.9
Saphos phosphate	105	equivalent to	P_2O_5	— 30.9
Muriate of potash	75		K_2O	— 37.5
	500			

It was recommended that the above mixture should be applied to provide 8 lb nitrogen per 100 lb of made tea, which provided 20% more nitrogen than that removed from the soil. This mixture was used by estates for several years and they used either the 8 lb nitrogen ratio for maintenance or a 10 lb expansion ratio. Even higher ratios were used depending on special circumstances.

The TRI 500 mixture supplied adequate phosphate and potash. Lamb and Tolhurst (1954) realised that heavy potash applications could lead to magnesium deficiency and discussed the complexity of tea nutrition in detail. Later Tolhurst (1958) recommended the use of magnesium fertilizer in Ceylon and at the same time insisted that the potash level recommended in the TRI 500 mixture be continued without any reduction. Tolhurst (1954) described magnesium deficiency symptoms on tea and suggested foliar spraying of magnesium sulphate to remedy it. Symptoms of magnesium deficiency in tea were illustrated in colour as far back as 1959 (Mulder & de Silva 1959).

At the end of the 1950s the information obtained from field experiments and estates in all tea growing areas in Ceylon warranted a change in the fertilizer levels. The T 500 mixture provided double the quantity of P_2O_5 likely to be removed in crop and pruning wood. It was found that partial fixation in the soil did not limit the supply of phosphate to the tea plant. Long-term field experiments offered evidence that high levels of phosphate may be detrimental to tea (Pearce 1959).

On the basis of fertilizer experiments in the low-country of Ceylon, Joachim (1961) pointed out the importance of the nitrogen : potassium ratio and also observed that the use of potash at levels higher than the standard quantities, was not advantageous. It was also noticed that the T 500 mixture did not supply sufficient potash for both high and low-yielding tea when used on the ratio basis.

Tolhurst (1961a) introduced the T 700 series which gave 30 lb P_2O_5 and 60 lb K_2O for every 100 lb N applied. This mixture was used in the high country of Ceylon. For other areas a mixture containing higher proportions of potash were suggested. The modified mixtures were T 725 and T 750 having 25 and 50 percent more potash, respectively. These were also recommended on an 8, 10 or 12 lb nitrogen ratio. For young tea, the T 200 mixture containing higher levels of phosphate and potash in relation to nitrogen was recommended (Tolhurst 1961b).

At the end of 1960, sufficient data had been gathered on the importance of micronutrients for tea. Tolhurst observed boron (1961a) and zinc (1962) deficiency on tea in Ceylon and recommended soil applications of borax and foliar spraying of zinc sulphate respectively to remedy these deficiencies. The application of dolomite after pruning was continued and this also provided sufficient magnesium for the tea plant.

Gunn and Kanapathipillai (1962) pointed out that according to the concept of ratio manuring, a ten pound ratio meant that responsiveness (or return) of the estate was ten and that this was never so, as actual responses were much lower. They suggested a new system called the yield-trend method or regression method, where the yield data and nitrogen doses over a period of twelve years were to be statistically examined and the nitrogen responsiveness of the estates determined. This was soon followed by a more comprehensive scheme (Joachim *et al.* 1963) where the yield trend of the field over the preceding three cycles were examined and the nitrogen level decided on the yield category, and yield trend. The initial level was to be maintained for one cycle and then altered according to the response obtained.

Based on trends in experiments and also on economic considerations, Tolhurst (1965) suggested that phosphate could be reduced to approximately 20 lb P_2O_5/acre/annum or even omitted for one or two years. In the case of potash, it was suggested that it be limited to about 40 lb for low-yielding tea, and maintained between 60 and 90 lb K_2O for high yielding tea. Fernando *et al.* (1969a) found that for high-yielding clonal tea, phosphate and potash need not be increased in the same proportion as nitrogen. They also found that on the replacement basis, high-yielding tea would be supplied with nitrogen, far in excess of what is required and also that the nitrogen applied is more effective in the second year than in the first year of the cycle. Fernando *et al.* (1969b) made fertilizer recommendations based on actual yield responses obtained in several field experiments in all tea-growing districts in Ceylon and not on

a replacement basis. They have taken into consideration the type of tea, whether seedling or clonal, and the yield trends, which could vary from one field to another on an estate. The level of phosphate was limited to 20 and 30 lb P_2O_5 lb per acre per annum for seedling and clonal tea respectively. The potash level could vary from 40 to 120 lb K_2O per acre per annum depending on the district and the type of tea. The T 700 series mixtures were no longer recommended for tea yielding over 2000 lb per acre per annum and potash applications were limited to 120 lb per acre per annum beyond which there was evidence of a decline in yield.

The main source of nitrogenous fertilizer for tea in Sri Lanka is sulphate of ammonia. In recent years urea has been used on a limited scale by estates.

It is quite clear that the use of fertilizer for tea in Sri Lanka had been based on the results of field experimentation over the last four decades. This has been supplemented by foliar and soil analytical data which have substantiated findings from field experiments. Such analyses have been carried out on seedling and clonal tea in different districts and also on material from field experiments. These results will be fully presented in future articles in this series.

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