INTRODUCING CALCIUM AMMONIUM NITRATE (CAN)

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As long ago as 1954 it was hinted (Tolhurst 1955) that large applications of sulphate of ammonia to Ceylon tea could not go on for ever without ultimately causing trouble by over-acidifying the soil. The trouble in this respect does not lie so much in acidity *per se* because Storey & Leach (1933) grew tea seedlings in water culture solutions quite successfully when the reaction was as low as pH 3.0 or 1/1000 normal sulphuric acid. The effect would be very different if a soil of such a high acidity were used, since otherwise harmless, insoluble compounds of iron, manganese and aluminium would then be rendered excessively available by the increased acidity. With all other crops the most harmful of these three elements is aluminium which interferes directly with the uptake of phosphate and the plants die from phosphate starvation. Uptake of more than about 100 parts per million of all three elements does little harm; in fact such amounts of iron and manganese are absolutely essential to plant growth—mostly in promoting the formation of chlorophyll and helping in enzyme systems. But in acid soils with reactions below pH 5.0 most plants can absorb manganese to levels much above 100 ppm and progressively suffer for it until at about 1000 ppm they are virtually dead. However, the tea bush is exceptional in that it has the ability to take up manganese with no apparent harm to massive levels of 3.0% (30,000 ppm) of its leaf dry weight, and of aluminium to 2%. Although this propensity of the tea bush may be to some extent an advantage, there is evidence that it is not entirely desirable because Joachim (1961), has reported a slight trend for yields of low-country Ceylon tea to decrease with high uptake of manganese. Before enlarging on this subject it should be mentioned that no plant has yet been proved an iron accumulator; if relatively large amounts of iron in any form are fed to a plant, it just dies.

Acidification of a soil not only brings toxic elements into solution, it also renders soluble large quantities of essential nutrients like potassium, magnesium and calcium which are washed into the deep subsoil. The leaching of these bases in light soils may be so severe as to induce deficiency symptoms as well as crop losses.

Sulphate of ammonia, soil reaction and nutrient losses

A figure that should be borne in mind is that the acidity produced in a soil by 100 lb of sulphate of ammonia requires 110 lb of calcium carbonate to be neutralized. If this is not added then neutralization takes place at the expense of the basic plant nutrients calcium, potassium and magnesium already present in the soil and that large amounts of these will ultimately be lost in the deep subsoil and spring or stream water.

The acidification of soils by sulphate of ammonia was first demonstrated in the classical experiments at Rothamsted. There 25% of the available potassium in a very heavy soil was lost by applying annually only 40 lb N for 80 years. Similar losses were reported by Smith (1962) for tea soils in East Africa after only 10 years of sulphate of ammonia dressings.

Other studies have been made all over the world with the same result—acidity increases and basic nutrient content decreases. One of the best examples is that quoted by McVicar *et al* (1963) in which 800 lb of sulphate of ammonia applied over three years to a clay loam soil reduced the pH value from 7.0 to 4.1 in the top six inches and halved the content of available basic nutrients but little change was detected below eighteen inches.

Progressive Ceylon tea planters are now thinking in terms of 250 to 300 lb N for seedling tea and even 500 lb N per annum for mature TRI 2020 series clonal tea. The losses of calcium and potash from these applications must be enormous in soils as free draining as those on most tea estates. It may have been a good thing after all that these huge doses of nitrogen given to tea were applied as mixtures with potash. Losses of potash if the nitrogen had been applied alone might have been so serious that crop yields would have suffered.

High acidity of Ceylon tea soils

Very large areas of Ceylon tea fields are now so acid from sulphate of ammonia applications that their reaction is well below 4.5. Many cases are on the TRI files of soils with pH values under 4.0—the lowest being 3.6. Fortunately Ceylon soils are not as highly manganiferous as those of East Africa, but Uva soils are the richest in manganese and the highest uptake occurs there. In the writer's experience in Uganda, tea failed altogether when the pH fell below 3.3.

Warning signs are already beginning to show in much of the high yielding clonal tea that is receiving over 300 lb N per acre per annum. These are mottled leaves, usually just below the plucking table in which the veins stand out as a green fishnet on a yellowish background which may be more or less spotted with brown dead tissue. This was first described by Tolhurst (1955) as "Low Country Chlorosis". If these leaves are burnt they invariably produce a dark brown ash containing the well known manganese dioxide of school-boy chemistry days. The deleterious effect of excess manganese on the tea bush probably lies in its preventing the uptake of sufficient iron for the bush to produce the maximum amount of flush. Unfortunately no quantitative data will be available to verify this until the new series of field experiments have run for a few years and leaves from plots have been analysed.

The remedy

The cure for the above is extremely simple—just apply some lime or dolomite to raise the pH to about 5.0 and everything should be all right. As yet no long-term formal experiments on liming tea soils have been made in Ceylon. Some have just been laid out but it should be emphasized that this is only moderate liming to bring back the soil reaction to between pH 4.5 and 5.0, and not to pH 6–7 as in Europe because this will not only kill the tea but cause losses of potash as well. The ideal is to try to bring the pH value up to between 4.5 and 5.0 and maintain it there regardless of high levels of nitrogenous fertilizers applied.

The case for calcium ammonium nitrate

American, European and Japanese agriculturists have been mindful of the problem of over-acidity in soil produced by sulphate of ammonia for at least 40 years. They limed their soils and changed over to a mixture of ammonium nitrate and limestone called Nitro-Chalk in England and CAN elsewhere. CAN is a mixture of ammonium nitrate and ground limestone giving 20.5 to 23.0% N in the final product. CAN does not acidify the soil—neither does it make it more alkaline. Once the soil reaction has been raised to about 4.5 then CAN will maintain it at a level conducive to maximum yields. Applications of CAN should also minimize losses of potash by leaching and so effect considerable economies in the use of this expensive fertilizer.

CAN and yield of tea

In South India an experiment has been carried out by UPASI (Raman 1965) for five years with CAN and so far it has not been significantly different from sulphate of ammonia. It should be noted that the reaction of these soils was pH 5.3. In Kenya on highly manganiferous virgin soils on the Timbilil Estate of the TRIEA which have a total nitrogen content of over 1% and reaction of pH 4.9 to 5.5 no advantage from any nitrogenous fertilizer including CAN has been obtained on 6-year-old seedling tea. But in 35-year-old tea on a neighbouring group, CAN has successfully replaced sulphate of ammonia over a large acreage but no formal experimental evidence is as yet available to assess the effect.

In Ceylon the TRI has been applying CAN alone to two fields at St Coombs for the last 6 months and the yields from these fields are comparable with those of which had been given TRI mixtures. On Aislaby Estate, Bandarawela, CAN has been tried out on a few fields and the yield trend was upwards. Response occurred only a few days after application which is extremely advantageous in that the flow of leaf into the factory can be better controlled by judicious timing of the fertilizer applications.

Application of CAN

CAN is supplied in small granules of 1/8" to 1/20" diameter which can be very easily broadcasted and an acre can be covered in half the time that it takes to distribute a mixed fertilizer. The normal practice of dragging over or through the plucking table a bag* containing fertilizer when bushes are high must be *avoided*, unless the bushes are absolutely dry. Water from leaves, moist with dew or rain is absorbed so readily by the bag and CAN, forming strong solutions which if allowed to come into contact with tea leaves will cause scorching in hot sunlight. This, however, can be entirely avoided if the jute is replaced by heavy-gauge polythene. No such trouble occurs when low tea is fertilized because the bag is carried above the bushes. In dry weather when *all* dew has evaporated CAN can be safely scattered over the bushes. Most of the granules fall to the ground but a few lodge on the lower maintenance leaves. These do no damage, for within a few hours the granule softens and overnight the soluble part of it (ammonium nitrate) dissolves in the dew and drops off leaving a white smudge of lime behind, which is washed off in the first shower. Severe scorching occurs if CAN is scattered over *wet* leaves. By over-bush scattering considerable economies in labour are obtained.

If a bag is damaged, slight caking occurs at the hole because the material is hygroscopic, but the cakings are soft and can easily broken by hand. Setting in hard lumps does not occur at all, as it sometimes does with sulphate of ammonia and mixtures. Since CAN is packed in jute bags, lined with thick polythene sheeting these can now be kept quite satisfactorily in the humid climate of Ceylon. A certain amount of dampness occurs on the outside where dust seeps through the seams of the bag, but the contents inside are usually quite dry. Before the advent of polythene, humidity in Ceylon made this fertilizer so wet that it could not be handled and only one shipment appears to have been imported.

A warning

CAN is recommended because of its desirable properties of not acidifying the soil, of conserving basic nutrients, ease of application and rapidity of response. There is, as yet, no evidence that it will be better than sulphate of ammonia in increasing yields although this may be likely in clonal tea fields which are given dressings up

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* A cut-down hessian fertilizer bag

to 500 lb N every year. Theoretically there should be some advantage in applying half the nitrogen in the form that most plants absorb readily—*ie* nitrate. This nitrate is extremely soluble and can move freely within the soil profile during storms. It is advisable therefore to avoid applications during the height of the monsoon. The other half is the less readily available form of the ammonium ion which is adsorbed on to the soil colloids and is slowly returned to the plants by the bacterial process of nitrification. The TRI has shown that yield increases up to 10% occur in the third 6 months of a two-year cycle when frequency of doses is increased from 7 to 11 per cycle and a total of 225 lb N is applied (Fernando 1965). It would appear that CAN is eminently suitable for advantage to be taken of this "little and often" technique especially at rates higher than 200 lb N per acre.

Provisional suggestions for the use of CAN

Apply to a few good mature fields up to 540 lb N in 2 cwt doses of CAN every month to every six months, according to the state of the tea and what clone or jat it is and compare with similar doses of sulphate of ammonia given to similar fields. The unit of application should be a one cwt bag so as to avoid weighing prior to broadcasting. Amounts of sulphate of ammonia will be the same if the CAN contains 20.5% N but if a 23% N grade is used then increase the sulphate of ammonia by 12%. One dressing of nitrogen per year applied during the monsoon, should be in the form of sulphate of ammonia so as to supply the sulphur requirements of the crop. Alternatively one whole year of the cycle might be given sulphate of ammonia instead of CAN.

It is suggested that the following should be used as a tentative guide for the amounts of nitrogen to apply. No fixed ratio is adhered to because the objective is to get the maximum crop in the shortest possible time. Superintendents must roughly judge the yield potential of each field on the basis of the previous highest annual yield plus 25%. Budget considerations will certainly be the over-riding factor in the question of how many fields are to be involved in this forward-looking policy. But it should be borne in mind that the return for the investment in nitrogen should be at least 6-fold and may even be 20-fold during the quality season.

Yield Category (lb/acre)	Applications of 2 cwt doses per year	Total weight CAN (cwt)	Total weight* N(lb)
5000 plus	12	24	540
4000—5000	10	20	450
3500—4000	9	18	405
3000—3500	8	16	360
2500—3000	7	14	315
2000—2500	6	12	270
1500—2000	5	10	225
1200—1500	4	8	180
1000—1200	3	6	135
500—1000	2	4	90

* Assuming a nitrogen content of CAN is 20.5%; if it is 23% do *not* change the dressings because the additional N will give proportionally more return but make sure more sulphate of ammonia is given to the other field of the pair if paired field experiments are conducted.

On up-country estates do not apply any fertilizer 2-3 months before pruning and until 4 months after pruning. On mid-and low-country estates the times are 2 months and 2½ months after pruning. The basal dressing (see preceding article by Mr Tolhurst) must be applied every year but only experience will tell how many applications of CAN should be missed out in the year of pruning. None should be missed out for fields in the lowest category.

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