S.L.J. Tea Sci. 67(1/2), 6-12, 2002, Printed in Sri Lanka

Ammonia Volatilization Following Dolomite and Urea Applications in a Tea Soil

S. Ananthacumaraswamy and L. S. K. Hettiarachchi
(Tea Research Institute of Sri Lanka, Talawakelle, Sri Lanka)

Ammonia volatilization from nitrogen fertilizer is an important mechanism of N loss that may reduce N fertilizer efficiency. An incubation study, to investigate the best time period, when the dolomite and N-fertilizer should be applied to a tea soil was examined. Increasing rates of 0, 500, 1000, 3000 and 4000 kg ha^{-1} $cycle^{-1}$ of dolomite was applied to a soil (Red Yellow Podzolic soil) sampled from Talawakelle region and a urea containing fertilizer was applied immediately, at 1st, 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, and 10th weeks after dolomite application. The ammonia loss was measured at weekly intervals. The loss of nitrogen in the form of ammonia after application of urea ranged from 1-7% of the applied N. Maximum losses occurred after 8 weeks of dolomite application. Dolomite application increased the soil pH from 5.5 to 6.7 in 6 weeks.

INTRODUCTION

Nitrogen is the most important fertilizer nutrient for tea. The economically important portion of the tea bush, consisting of terminal shoots and the vegetative portion of crop harvested for tea manufacture (two leaves and a bud), contain as much as 3-5 % of N. Thus, 30-50 kg N per 1000 kg made tea is removed per year. To sustain fertility and maintain high yields, at present 240-360 kg N ha^{-1} $year^{-1}$ is applied along with phosphorus as Eppawela rock phosphate and potassium as muriate of potash. Fertilizer application to tea is carried out on annual basis with 4-5 split applications per year. Nitrogen is applied to the crop in the form of urea and/or ammonium sulphate. Until the early 1970's, most of nitrogen was given exclusively in the form of ammonium sulphate. However, at present, TRI recommends urea as the sole source of nitrogen for mature tea because it acidifies the soil to a lesser extent than ammonium sulphate besides its low cost. There are many ways by which the applied N can be lost from the soil; leaching, denitrification, plant uptake, and ammonia volatilization. Fixation of ammonium by clay and microbial immobilization would temporarily reduce N availability to plants.

The fate of urea applied to acidic tea soils has been studied extensively by several workers (Bhavananthan 1970a, Sivasubramaniam 1980 and Wickremasinghe *et.al.*, 1981 and 1982). It releases less bases into the soil solution from cation exchange sites (Wickremasinghe *et. al.*, 1985). When Urea is applied to the soil, it gets hydrolysed initially to the unstable ammonium carbamate, which then gets immediately converted to ammonium carbonate. This hydrolysis is catalyzed mainly by urease enzyme. Bhavananthan (1970b) showed that there is a temporary pH rise in soil due to production of ammonium carbonate. The decomposition of ammonium carbonate *i.e.* $(NH_4)_2CO_3$ occurs due to heat. As a result the ammonia evolved would escape if soil is dry. Further, since the reaction is reversible, if the soil is alkaline, NH_3 would escape from the soil, rather than reacting with soil water. In addition, if the soil pH is already high (as transitory), it would enhance evolution of NH_3. The loss of ammonia results in loss of nitrogen, and reduces fertilizer efficiency (Bhavananthan, 1970a).

Tea prefers acidic soil of pH between 4.5 to 5.5. However, since of late the pH of tea fields in Sri Lanka has markedly declined to levels closer to 4.0. To overcome this decline, dolomite is used and the quantity to be applied is based on soil pH. Generally, the whole quantity is applied before or immediately after pruning (Anon, 2000). Therefore, when dolomite and urea based fertilizer are applied at closer intervals, there is a tendency that some of the nitrogen from urea may get lost as ammonia. This is due to the alkaline nature of dolomite. Further if urea stays on the soil surface in close contact with dolomite, without percolating down the soil profile, then the conversion of ammonium carbonate would have influence on the ammonia volatilization. Several chemical processes have been proposed to reduce the potential for NH_3 volatilization from N fertilizer. They are acidification, salt addition, urease inhibition. Calcium and Mg salts also have been, added to urea to form insoluble carbonates (Gezgin and Bayrakll, 1995)

Due to volatilization losses, urea can become an inefficient source of N for tea. However, the time period between urea and dolomite applications may be an important factor. Therefore, an incubation study was carried out to investigate magnitude of ammonia losses after application of dolomite and thereby to determine the optimum time period for first application of urea based fertilizer, following dolomite application.

MATERIALS AND METHODS

The soil used in this study was collected from St.Coombs estate (1382 m amsl), Talawakelle, Sri Lanka where tea has been cultivated for over 25 years. The top 0-15 cm soil was collected using a mammoty after removal of mulch on the soil surface and it was passed through a 4 mm sieve. The soil falls into the category of to Ultisol according to US soil taxonomy (De Alwis *et.al.*, 1980, Panabokke, 1967). Some important properties of the soil are presented in Table 1.

Table 1: Some important properties of the soil used

pH Soil:Water 1:2.5	Organic Carbon %	Total-N %	Av-P µg/g	Exch-K µg/g	Exch-Mg µg/g	CEC Cmol kg^{-1}
5.7	4.0	0.30	27.0	104	58.0	15.9

150 g of sieved soil was placed in a clear glass bottle of 11.0 cm height and 7.0 cm diameter and the surface was evenly levelled. Dolomite (18% MgO, 50 % passed through 100 mesh and 90% passed through 30 mesh) was applied on top at the rates representing 0, 500, 1000, 3000 and 4000 kg ha^{-1} $cycle^{-1}$, i.e. 0, 0.193, 0.385, 1.16 and 1.54 g $bottle^{-1}$, respectively. The corresponding amounts of dolomite to be applied to each bottle, was calculated based on the area of soil at the surface. At 0, 1, 2, 3, 4, 5, 6, 7, 8 and 10 weeks, fertilizer mixture U709 consisting of urea, Eppawela rock phosphate and muriate of potash was evenly distributed over the surface at the rate of 90 kg N ha^{-1} $application^{-1}$ which represented 6.75 g of N per bottle. Each treatment was replicated thrice, randomized and the soils were incubated at 20°C. Moisture level of the treated soils was maintained at 60% field capacity throughout the experiment.

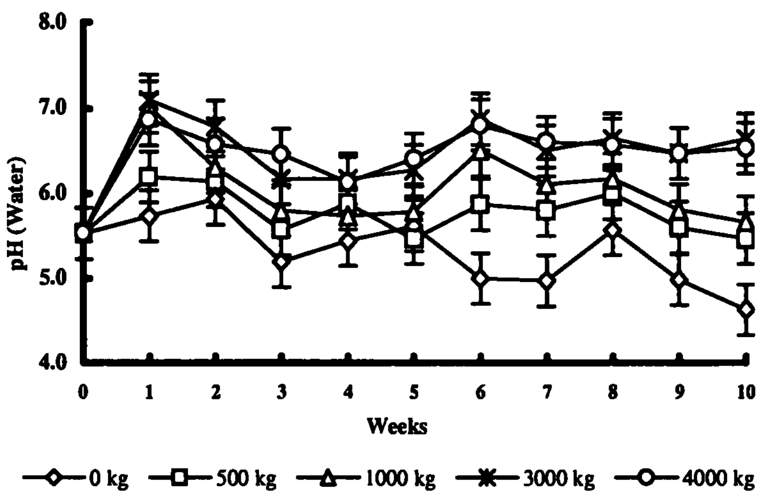
The method described by Fenn and Kissel (1973) was used to estimate the volatilization of ammonia. A plastic cup of 10 ml containing 5 ml of 0.5N H_2SO_4 solution and 2 drops of methyl red indicator was placed inside the bottle and the bottles were sealed air tight, with parafilm and wax. After two weeks of urea application, the acid solution inside the cup was transferred to a conical flask and titrated against 0.01N NaOH solution until the colour changed from pink to yellow. The amount of NH_3 released from the applied urea fertilizer was calculated.

The pH of soils, were measured at each sampling, using water and 0.01M calcium chloride (soil: solution 1:2.5). Total N was determined by Kjeldahl method, available P was extracted by borax solution (Beater, 1949) and P was determined by Vanadomolybdate blue method, 1N ammonium chloride exchangeable K (Jayman and Sivasubramaniam, 1970) by Flame photometer, 1N ammonium chloride exchangeable Mg (Jayman and Sivasubramaniam, 1970) by Atomic Absorption Spectrophotometer. Organic carbon was determined by Walkly Black method, and CEC by leaching with ammonium chloride, sodium sulphate and ammonia distillation with sodium hydroxide (Jayman and Sivasubramaniam, 1970). The data was analysed statistically using SAS package appropriate for the experiment.

RESULTS AND DISCUSSION

Effect of dolomite application on soil pH

The initial pH of the soil in water was 5.7. The soil pH increased with increase in dolomite application (Fig. 1). The increases in pH at higher levels of dolomite i.e. 3000 and 4000 kg ha $^{-1}$ yr^{-1} were higher than the control or lower level of dolomite (500 and 1000 kg) initially. The highest pH was obtained at 6 weeks after dolomite application in all the treatments except in control. No further increase in soil pH was observed up to 10 weeks. In control treatments the soil pH has reduced gradually from 5.7 to 4.7 at the end. Any N fertilizer when nitrified in the soil by nitrifying bacteria, releases hydrogen ions to the soil solution. This process may have affected the decrease of pH in the control treatment. The average soil pH after 10 weeks of incubation for 0, 500, 1000, 3000, and 4000 kg dolomite rates, were 5.30, 5.79, 6.09, 6.55 and 6.54 respectively and was highly significant between the treatments (LSD=0.096).



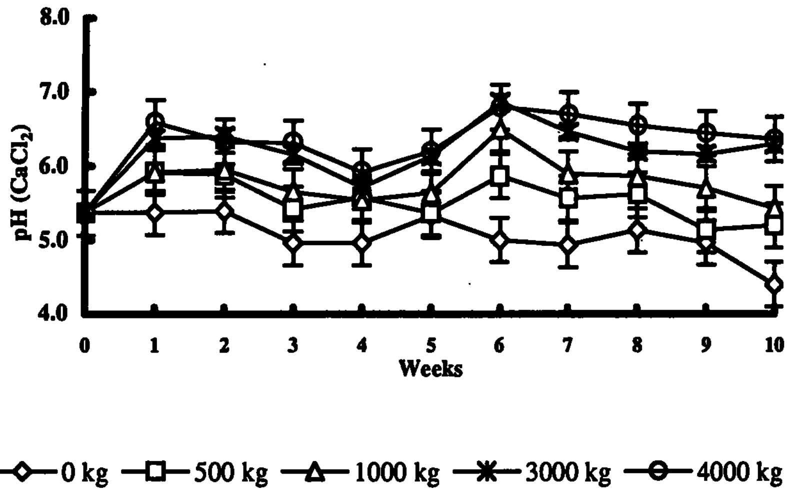


Fig.1: *Effect of dolomite on soil pH*

Effect of dolomite application on ammonia loss

At all urea fertilizer application steps, there were ammonia volatilization ranging from 1.0% to 7.0% from applied nitrogen (Fig. 2).

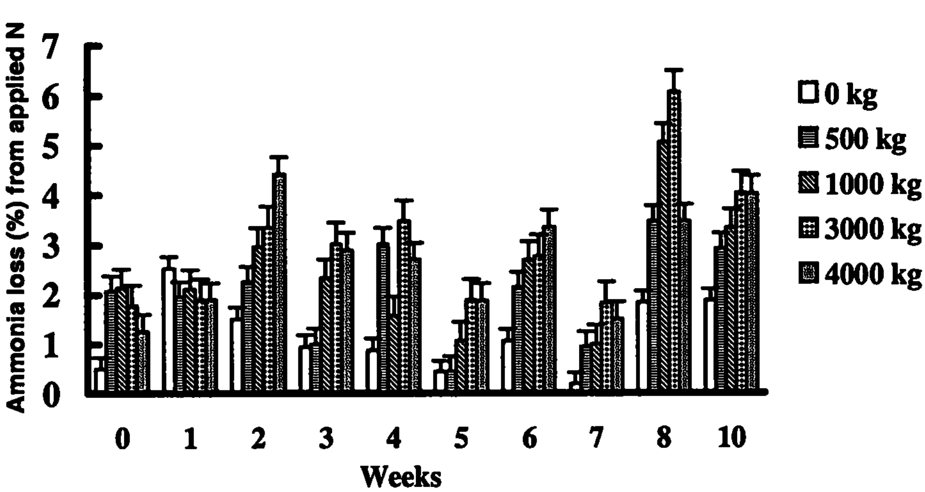


Fig. 2: *Effect of Dolomite on ammonia volatilization*

Further, at higher rate of dolomite application the higher losses occurred. The application of urea fertilizer after 8 weeks of dolomite application showed the highest ammonia volatilization, which amounts to about 3 times greater than the other application steps (Fig. 2). In contrast, ammonia losses as high as 30% has been observed from urea under field condition (Fernando and Bhavananthan, 1971). However, in their study, the amount of urea used was extremely high (urea:soil = 1:10), compared with field applied rates. They reported that mixing urea, saphosphate and muriate of potash had no significant effect on the losses of ammonia from urea. In addition, with the loss of soil moisture, the nitrogen loss also increased. However, from 22-30 % soil moisture level, there was hardly any difference in the nitrogen loss. Baruah and Day (1983) have reported a peak volatilization observed on 14 days at all the pH levels (pH 4.6-5.9) in tea soil under field conditions. This may be due to temperature variation and other factors such as urease activity, wind speed and rainfall in the field conditions.

CONCLUSION

Dolomite application increased soil pH from the initial level of 5.5 to 6.7 ($CaCl_2$) and 7.1 (H_2O) in 6 weeks time. The initial increase of pH, may be due to NH_4^+ formation after hydrolysis of urea and un-reacted alkaline dolomite particles which are present in the soil. However, the same effect may not occur in the field, as the conditions such as, rainfall and temperature in the field are different from controlled conditions.

The nitrogen loss as ammonia was highest after 8 weeks of dolomite application under laboratory condition. Therefore, it is beneficial to apply any urea based fertilizer 6-8 weeks after dolomite application to minimize ammonia volatilization. Further studies are required, under the field conditions to confirm and validate these findings.

REFERENCES

Anon 2000 Fertiliser recommendations for immature tea, Circular No. SP 2, Serial No. 00/2 Tea Research Institute of Sri Lanka, Talawakelle, Sri Lanka.

Baruah D and Day S K 1983 A laboratory incubation study on nitrogen releasing pattern of acid soils under the influence of pH and varying levels and forms of nitrogenous fertilizers. Two and a Bud. 30 (1/2), 81-85.

Beater B E 1949 Rapid method for obtaining readily soluble Phosphate and phosphate fixation in soil. Plant and Soil. 1, 215-220.

Bhavananthan V P 1970a Studies on the use of urea as a fertilizer for tea in Ceylon 1 – Introduction and preliminary observations Tea Q. 41, 87-91.

Bhavananthan V P 1970b Studies on the use of urea as a fertilizer for tea in Ceylon 2 – Urease activity in tea soils Tea Q. 41, 94 -98.

De Alwis K A, Jayasooriya S G and Perera M B A 1980 Soils of St. Coombs Estate 1 – Environmental and morphological characteristics. Tea Q. 49, (1), 5-24.

Fernando V and Bhavananthan V P 1971 Volatilization losses of ammonia from urea applied to the soil. Tea Q. 42, 48-56.

Fenn L B and Kissel D E 1973 Ammonia volatilization from surface application of ammonium compound on calcareous soils. 1. General theory. Soil Sci. Soc. Amer. Proc. 37, 855-859.

Gezgin S and Bayrakll F 1995 Ammonia volatilization from ammonium sulphate. J. Plant Nutr. 18 (11), 2483-2494.

Jayman T C Z and Sivasubramaniam S 1970 Manual of methods - Agricultural Chemistry Division, Tea Research Institute, Talawakelle.

Panabokke C R 1967 The soils of Ceylon and use of fertilizer for the advancement. p 71-76.

Sivasubramaniam S 1980 The use of fertilizers for tea in Sri Lanka. Tea Q. 49, 137-142.

Wickremasinghe K N, Sivasubramaniam S and Nalliah P 1981 Urea hydrolysis in some tea soils. Plant and Soil, 473-477.

Wickremasinghe K N and Talibudeen O 1982 Denitrification in a very acid and tropical soil. J. Soil. Sci. 32, 119-131.

Wickremasinghe K N, Nalliah P and Wijedasa M A 1985 Effect of urea and ammonium sulphate on the nitrification and the release of potassium, magnesium and calcium in acid tea soils. SL. J. Tea Sci. 54 (1), 11-17.

Wickremasinghe K N, Rogers G A and Jenkinson D S 1985 Transformations of nitrogen fertilizers in soil. Soil Biol. Biochem. 17(5), 625-630.