1

Feasibility of using soil pH-Buffering for Dolomite Recommendation

L.R.M.C. Liyanage,
W.M.S. Wijayathunge
A.N. Jayakody and G.P. Gunaratne
Soils and Plant Nutrition Division
Tea Research Institute of Sri Lanka

Tea Research Institute of Sri Lanka

2

Content

- Introduction
- Background
- Scientific Approach
- Outcomes and Interpretation
- Conclusions
- What to do next ?

Introduction

- Tea grows in wet & intermediate zones : 213,000 ha
- Key parameter for good growth : acidic soil pH
- Optimum Soil pH range : 4.5 - 5.5
- Soils : RYP (Ultisols), RBL (Ultisols), IBL (Inceptisols)
- Soil Series recognized : 19 Soil Series (Soil Taxonomy)
- Behavior of pH may be different in different soils changing productivity

Background : What make soils acidic ?

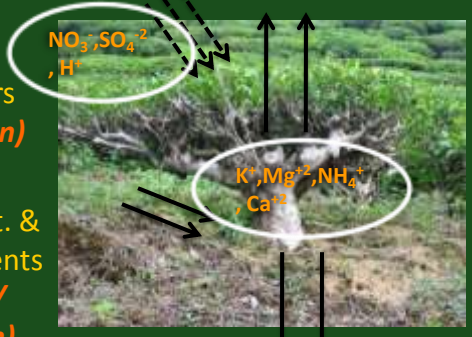
- Rainfall
- Leaching of positive alkaline ions *(Cations)*
- Uptake of alkaline nutrient cations by plants
- Addition of acidic fertilizer & amendments ; N
- Inherent / intrinsic soil characters

Addition and formation of H^+ and Al^{+++} cations accompanied by De-alkalisation

What make soils acidic ? ……..

Rainfall ***(Addition)***

Uptake ***(De-alkalisation)***



N fertilizers ***(Formation)***

Acidic Fert. & Amendments ***(Addition/ Formation)***

Leaching ***(De-alkalisation)***

Multiple factors cause soil acidity

***Reactions* of Al^{+++} (Formation)**

$$Al^{+++} + H_2O \longrightarrow H^+ + (AlOH)^{2+}$$

How to decrease soil acidity/ increase pH ?

- Addition of H^+ neutralizing materials
- Liming materials
  - Limestone, Calcite, Burnt lime , Slaked lime

    Dolomitic limestone / Dolomite (for tea)
  - Industrial Lime (By-products)
  - Wood ash, Egg shells , Oyster shells etc.

Ideal is targeted liming for a desired pH; not for just an increase

What were we doing at TRI ?

Initial liming recommendations were based not on pH but on Mg nutrition

- 1954 – 560 lbs/ac/yr (628 kg/ha/yr)
- 1959 – decided on average cycle yields

Cycle Average of Yield (lbs/ac/yr)	Dolomite to be applied (lbs/ac/yr)
Up to 750	70
750 – 1200	100
> 1200	130

What were we doing at TRI ? .....

- 1979 – for rehabilitation grasses : 1250kg/ha
- 1983 – 125kg/ha/yr for mature tea (F9)
- 1989 – (F12)

Yield Slab (kg/ha/yr)	Dolomite Requirement (kg/ha/yr)
1000 and below	100
1000 – 1500	150
1500 – 2000	200
2000 – 2500	250
2500 – 3000	300
3000 – 3500	350
3500 – 4000	400
4000 – 4500	450

What were we doing at TRI ? .....

- 1986 – For rehabilitation grasses depending on elevation
  - * Low country – 2000 kg/ha
  - * Mid country – 3000 kg/ha
  - * Up country – 4000 kg/ha
- 2000 – based on prevailing pH (Fertilizer Think Tank)

Soil pH	Dolomite (kg/ha/cycle)
Below 3.9	2500
3.9 – 4.2	2000
4.2 – 4.5	1500
Above 4.5	1000

Was it correct ?

- Gadd,1928; Eden,1928; Ananthacoomaraswamy, 1991 observed different behaviors in soils
- However , not given much attention for long
- Single pH point measurement used from 2000
- pH-buffering suggested by Jayakody @ SPND Research Review –2008
- Re-confirmed in Review Report - 2011

However, Investigations started in 2009

How would you like to eat when you are hungry ?

From an equally prepared pack for all ?

Get served from a *Buffet* based on hungriness ?

Soils may also like tailor-made liming

Justification

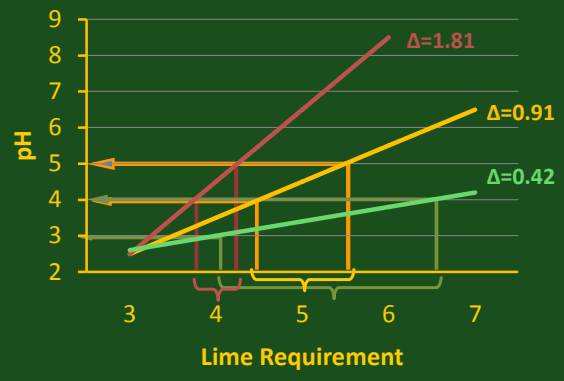
- Single pH-point based Liming appears imperfectly chosen due to diverse pH-buffer abilities of soils
- An improvement has become mandatory based on views of the tea growers/ stakeholders as well

What is pH-buffering ?

- Buffering :Resistance to changes :
- pH-buffer Systems in soils
  - Carbonate buffer system (alkaline pH range)
  - Phosphate buffer system (whole pH range)
  - Exchange buffer system (whole pH range)
  - Aluminum buffer system (extremely acidic range)

Large variations of above in different soils and hence different abilities to buffer pH

What is pH-buffering ?.....



Hence, pH buffering should be given due attention when liming

What do we need ?

1. Inclusion of all relevant Soil Series (1st step)
2. Development of a procedure to establish Buffer Curves (2nd step)
3. Verification of the procedure (3rd step)
4. Testing for its applicability (4th step)

What are the basic expectations ?

1. Development of a Technique for Lime Recommendation which has to be
   - Simple & easy for routine practices
   - Less time consuming and of low cost
   - Easily adoptable under Sri Lankan conditions

2. Substitution of the current procedure of action

Scientific Approach

- Soil samples from 30 sites to represent 19 Series
- Soils without liming for > 10 years
- Depth of soil sampling 15cm
- Initial pH measured
- $Ca(OH)_2$ as liming solution
- Treated with 0 ml, 1 ml and 2 ml $Ca(OH)_2$
- Pre-test to select the best equilibrating time

Scientific Approach.....

Equilibrating Time

- pH measured in suspensions at 0 , 20 , 40 min. & 1 hour, 1 hour and 20 min, 2, 4, 6, 24 & 48 hours

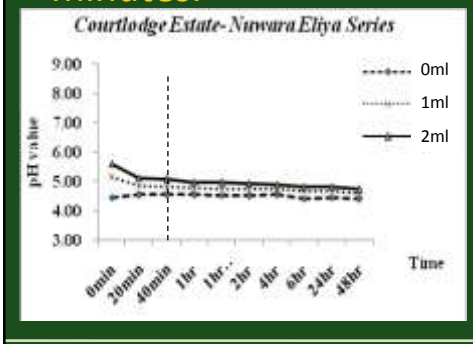
pH-buffering curves

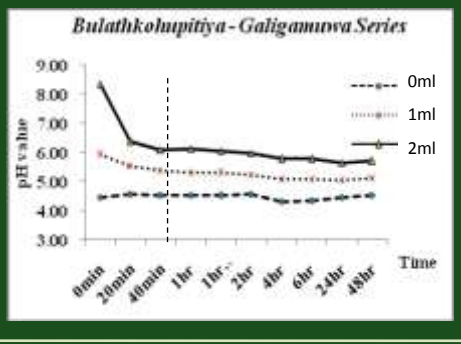
- pH measured at 0, 1 and 2 ml $Ca(OH)_2$ levels
- Buffer curves plotted for sampling sites separately
- Soil Series grouped based on the slopes of curves

Outcomes and Interpretation

Equilibrating Time

- All suspensions reached equilibration within 45 minutes.





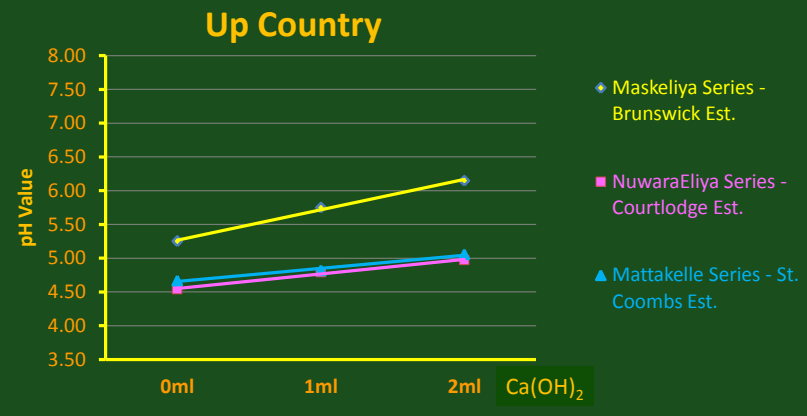
Outcomes and Interpretation.....

Equilibrating Time.....

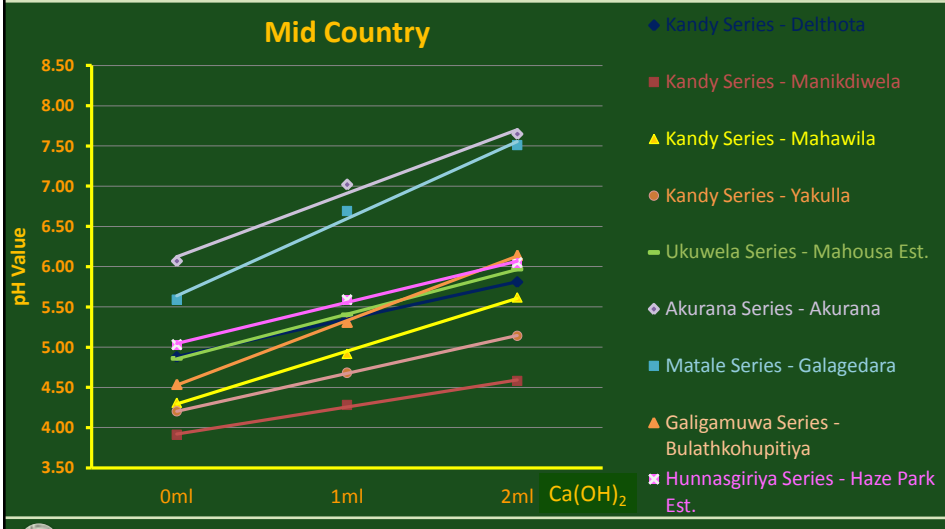
- Short enough for routine measurements
- Indicated the sufficiency of three measuring points for Buffer Curves
- Showed a linearity for the pH-range vital for tea

Outcomes and Interpretation.....

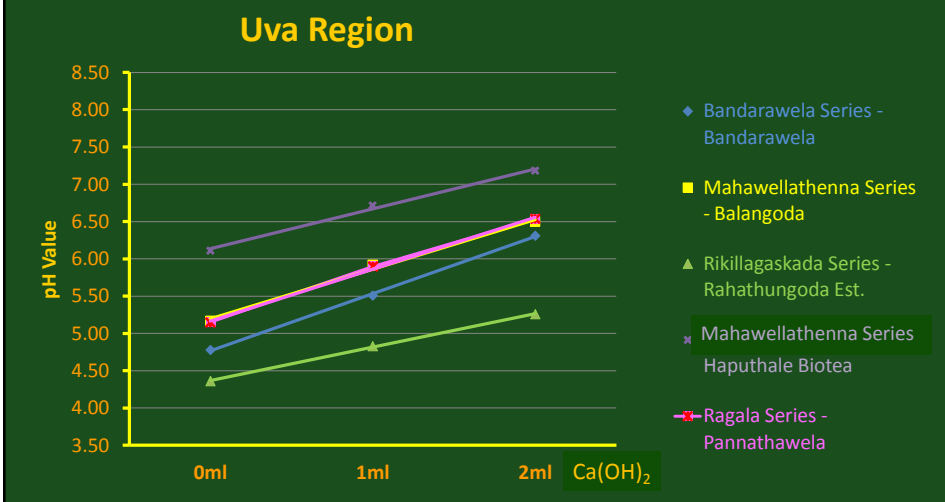
pH -buffering curves



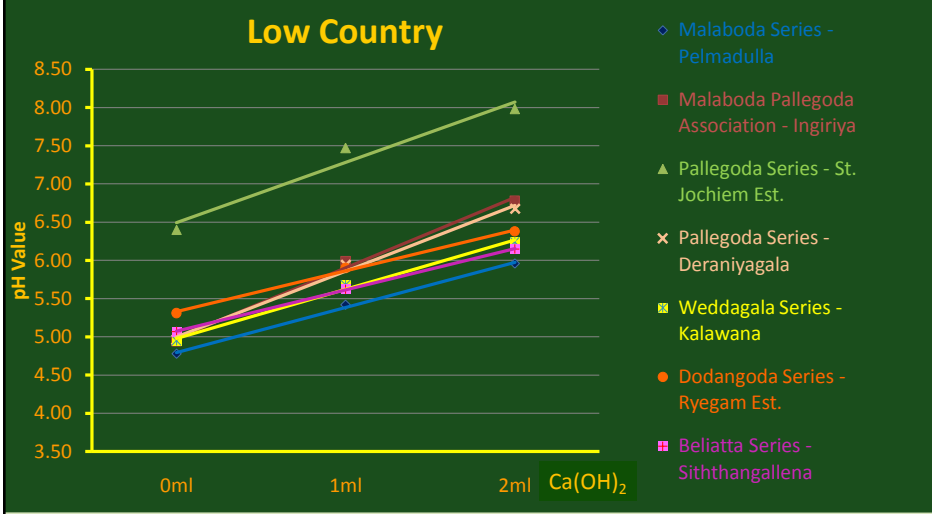
Outcomes and Interpretation.....



Outcomes and Interpretation.....

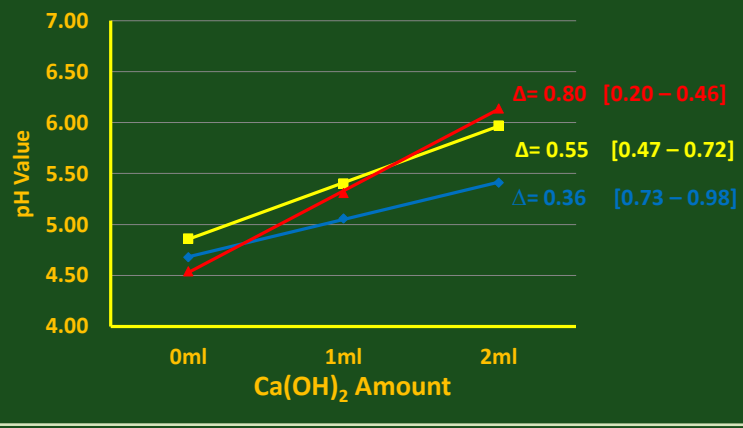


Outcomes and Interpretation.....



Outcomes and Interpretation.....

- Statistical bundling of closer Buffer Curves



Outcomes and Interpretation.....

- No world-wide accepted standard

Class 1 (Δ<0.46) Soil Series	Class 2 (Δ =0.47 - 0.72) Soil Series	Class 3 (Δ >0.73) Soil Series
Mattakelle	Hunnasgiriya	Bandarawela
NuwaraEliya	Malaboda. Maskeliya	Akurana
Kandy,	Mahawellathenna	Pallegoda
Ukuwela	Dodangoda, Beliatta	Galigamuwa
	Weddagala, Ragala	Matale
	Rikillagaskada	

As agronomic management matters : site specific checking is more suitable than above classes

Outcomes and Interpretation .....

- Buffering behavior of each and every Soil Series was different
- Indicated the need of different amounts of Dolomite to raise pH to desired levels
- Use of Similar amounts of Dolomite may cause over -liming in Pallegoda Series and lower-liming in Mattakelle Series as practiced at present

Outcomes and Interpretation .....

- To raise soil pH by one unit; different soils require different amounts of Dolomite

Soil Series	$Ca(OH)_2$ (ml)	Dolomite Equi: (mg)	Dolomite (kg/ha)	CEC (meq/100g)	OC%
Mattakelle	5.13	10.38	**1038**	21.01	3.86
Rikillagaskada	2.22	4.49	**449**	16.31	3.47
Pallegoda	1.16	2.35	**235**	10.97	1.19

- Organic Matter content and CEC have positive correlation to pH buffering

Conclusions

- Need of revising Dolomite Recommendation for Tea at hand
- Buffer Curves offer an improved procedure to arrive at Dolomite Requirements; be used generalized for different Buffer Categories or **Site Specifically**

What to do next ?

- Use the findings to derive Formulae to arrive at Dolomite Recommendations by giving attention to
  - Efficiency and purity of Dolomite
  - Duration of effective neutralization
  - Climatic factors; rain and temperature
  - Acidity development by Plant Uptake, leaching of alkaline cations and N-fertilizers

The next Stage; some in progress

Acknowledgement

- CEOs of Plantation Companies
- Managers and Asst. Managers of supported Estates
- Tea small Holders
- TSHDA Officials

THANK YOU,

Expecting your fullest cooperation at all levels

Tea Research Institute of Sri Lanka

33

Quality of Dolomite

Results of Dolomite samples analyzed for year 2011

Accepted with set guidelines	37 – 25%
MgO% Accepted	143 – 95%
100 mesh Accepted	102 – 68%
30 mesh Accepted	64 – 43%

35

Single point pH based liming

Main Drawbacks

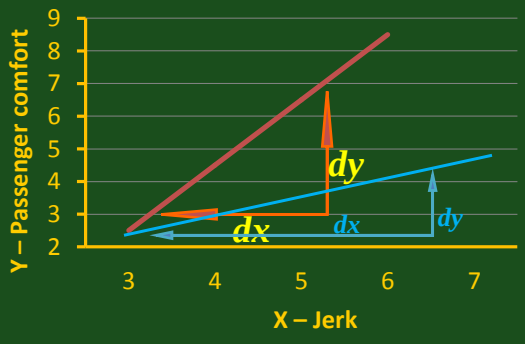
1) No idea whether the pH raised to a desired level
2) Duration of action of Dolomite unknown
3) Calcium Carbonate Equivalent of Dolomite not adequately highlighted/considered

Soil classification down to Soil Series level was not available

A day-to-day experience on Buffering

- Taking over the external jerks up to a limit
- Passenger feels comfortable
- Non functioning of buffers: damages to Train & passengers
- Buffers have to be efficient

Buffer Capacity of a system (BC)



$$\Delta = \frac{dy}{dx}$$

$$\Delta = \frac{(7-3)}{(5.3-3.1)} = 1.81$$

Buffer systems in soils

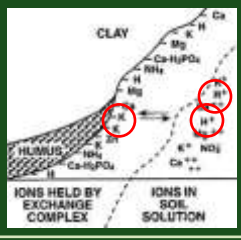
Carbonate buffering system

$CO_3^{--} + H^+ \longrightarrow HCO_3^-$; $HCO_3^- + H^+ \longrightarrow CO_2 + H_2O$

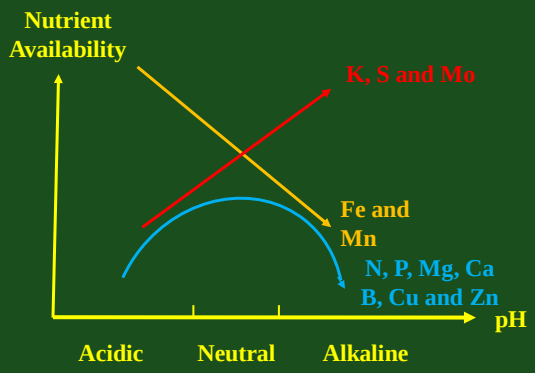
Phosphate buffering system

$PO_4^{---} + H^+ \longrightarrow HPO_4^{--}$; $HPO_4^{--} + H^+ \longrightarrow H_2PO_4^-$

Exchange complex system



Nutrient Availability Trends with pH



Acidity by N fertilizers

Fertilizer (1kg of N)	≡ H^+ ions (g)	≡ CaO Removal (kg)
SA (4.8kg)	108	3
SA (N) + (SO_4^{--})	36+72	1+2
Urea (2.2kg)	36	1
Ammo. -Nitrate	36	1