# Assessment of Standard Rapid Lime Requirement Methods on Acid Soils of Trinidad

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# Introduction

- *Soil Acidity and acidification*
  - Many agricultural soils in Trinidad are acid to extremely acid
    - Linked to geology/lithology, climatology and management: Trinidad has high rainfall and long history of ammonium sulphate use in sugarcane
    - Small number of farmers lime soils and very few do LR tests
  - Implications for plant growth
    - nutrient availability and fertility, aluminium toxicity, microbial activity
  - Implications for the environmental (breakdown and adsorption of toxins, etc)
  - Implications for economic returns by farmers

- *pH measurement*
  - pH = -log [$H^+$] = active acidity
    - It is probably the most important test to make on a soil
  - Total acidity = active + exchangeable + reserve
    - Two acid soils may have the same pH but not the same amount of acidity

# Introduction

- ***Managing or Reversing soil acidity***
  - Addition of LIME
  - Management depends on obtaining a good (accurate) LR determination


- ***Methods of Lime Requirement (LR)***
  - Field studies
  - Soil–Lime Incubations
  - Laboratory Methods (rapid)
    - Soil-Base titrations
    - Soil-Buffer equilibrations - 100's samples per day

# Objectives

- Evaluate and compare the LR calculated from the various standard laboratory methods on a range of acid Trinidad soils

- Make comparisons of LR values from laboratory methods with short- and longer- term incubation methods for determining LR

- Determine changes in concentration of extractable Al, Fe, Mn and Zn over time in response to different rates of lime applied to a range of acid soils

# Methodology

- LR assessments:
  - Soils : surface layer of 12 acid soils of Trinidad
  - Laboratory LR methods (all tests were done in triplicate):
    - 2 soil-base titration methods (unbuffered) using $Ca(OH)_2$
      - Full titration curve (FTC) method (Hardy and Lewis, 1929)
      - 3-addition method (Min Liu et al, 2004)
    - Buffered methods
      - SMP (Shoemaker et al, 1961)
      - A&E (Adams and Evans, 1962
  - Incubation LR methods:
    - 4-day incubation with 3 liming rates (1/2 LR, 1LR, 2LR based on 3-addition values)
    - Longer-term incubation

- Changes in Al, Fe, Mn and Zn
  - Long-Term Incubation Method
  - Completely randomized design with 12 soils, 3 liming rates (1/2 LR, 1LR, 2LR), 2 reps and 3 sampling times
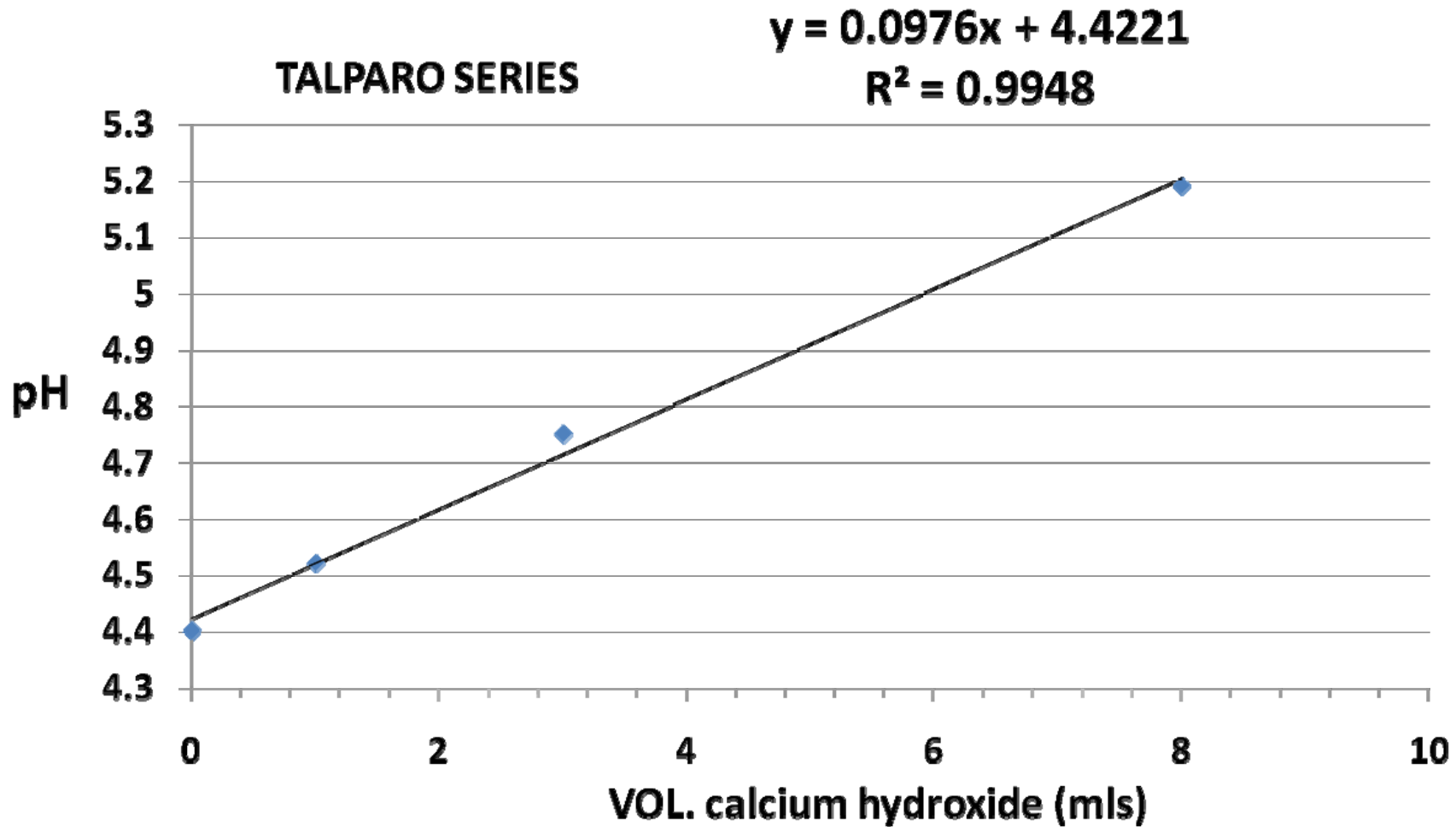
# Relevant Soil Characteristics

| SOILS | | | |
|---|---|---|---|
| Series | Texture | *Activity | pH ($H_2O$) |
| Talparo | Clay | M – H | 4.55 |
| Bejucal | Clay | M – H | 4.30 |
| Piarco | Sandy Loam | L | 4.66 |
| Frederick | Clay | M – H | 3.28 |
| River Estate | Sandy Clay Loam | L – M | 4.53 |
| Cunupia | Clay Loam | M | 4.62 |
| Maracas | Sandy Loam | L | 4.37 |
| Aripo | Sand | L | 4.71 |
| Arena | Sand | L | 3.62 |
| Nariva | Clay | H | 4.53 |
| Las Lomas | Sandy Loam | L – M | 4.06 |
| Sangre Grande | Silty Clay | M | 4.27 |

* H= high; M= moderate; L=low

# RESULTS
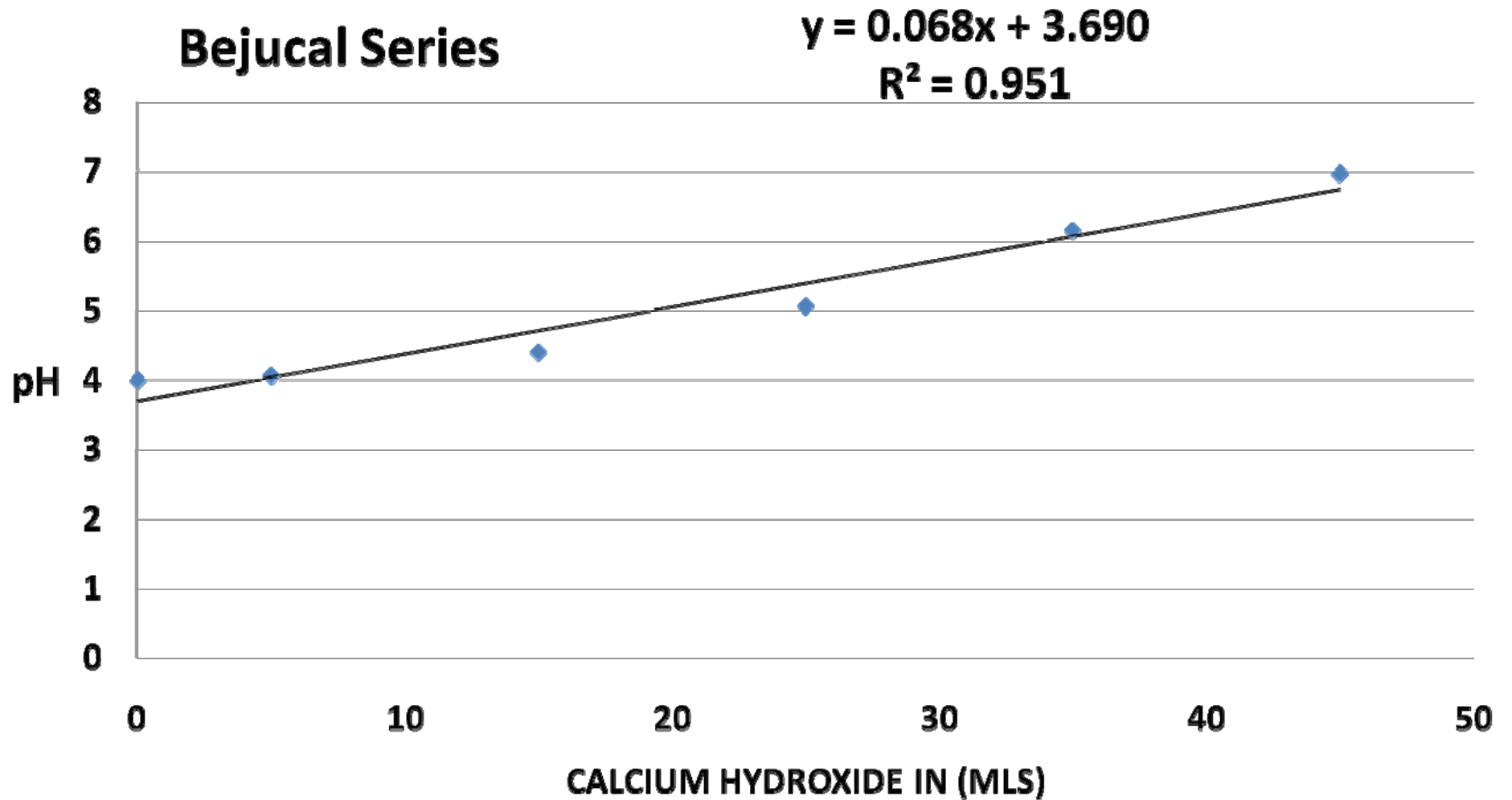## *Lime Requirement Determinations*
### *3-addition method*

# RESULTS
## *Lime Requirement Determinations*
## **FTC method**



**Bejucal Series**

$y = 0.068x + 3.690$
$R^2 = 0.951$

pH (y-axis, 0–8)

CALCIUM HYDROXIDE IN (MLS) (x-axis, 0–50)

# RESULTS
## Lime Requirement Determinations
## Rapid Methods

| Soil Series | Un-buffered Rapid Methods | | | |
| | 3-addition | | FTC | |
| | LR (Mg Ag Lime/ha) | Regression $R^2$ | LR (Mg Ag Lime/ha) | Regression $R^2$ |
|---|---|---|---|---|
| Talparo | 10.3 | 99 | 5.74 | 88 |
| Bejucal | 9.50 | 99 | 15.1 | 95 |
| Piarco | 3.94 | 99 | 3.84 | 99 |
| Frederick | 24.2 | 99 | 26.9 | 93 |
| River Estate | 6.44 | 99 | 5.74 | 98 |
| Cunupia | 10.4 | 98 | 6.76 | 100 |
| Maracas | 7.68 | 100 | 3.84 | 96 |
| Aripo | 1.00 | 99 | 2.50 | 95 |
| Arena | 2.08 | 92 | 2.70 | 100 |
| Nariva | 5.52 | 100 | 9.62 | 98 |
| Las Lomas | 4.74 | 99 | 9.62 | 100 |
| Sangre Grande | 8.22 | 100 | 9.62 | 99 |

**RESULTS**
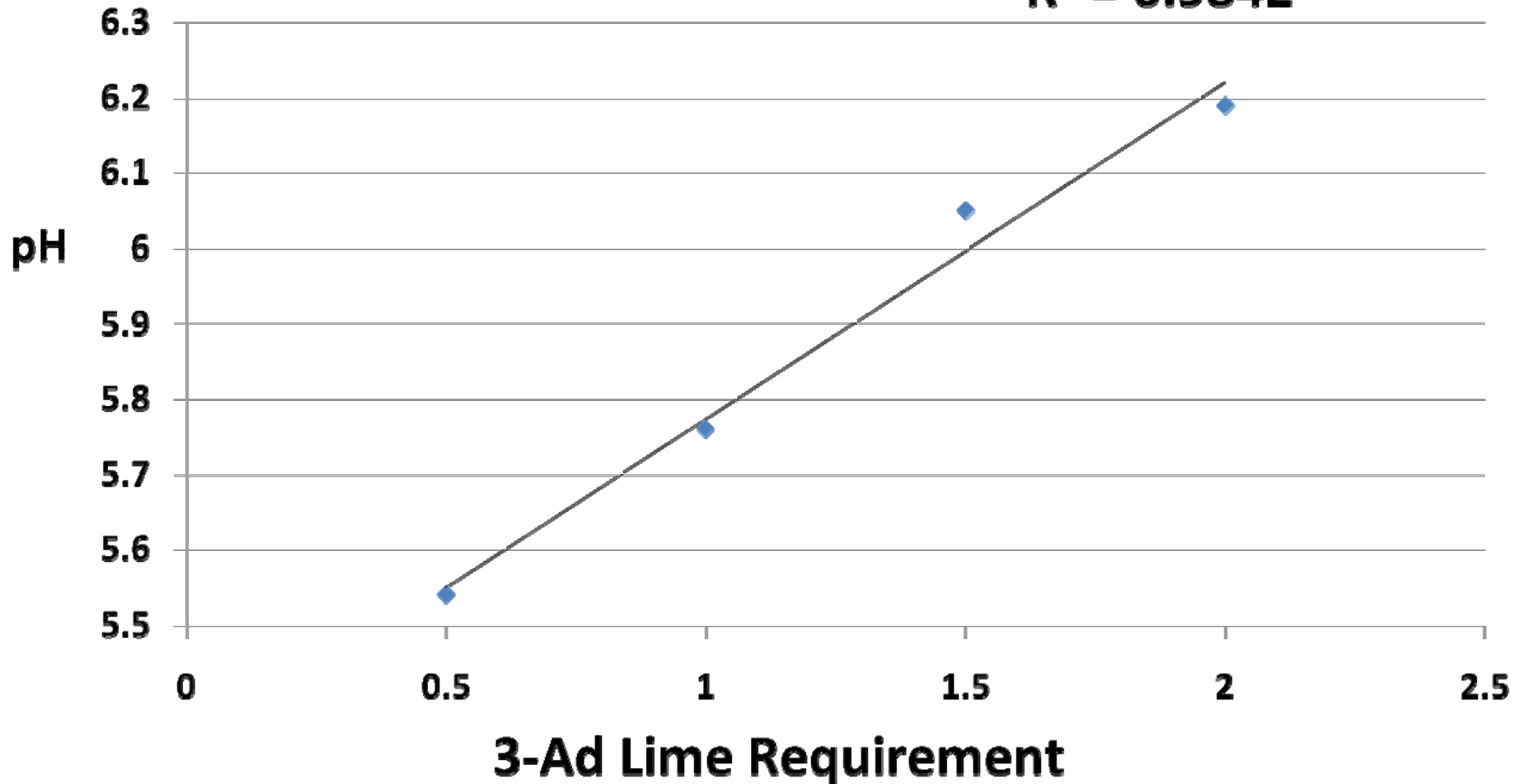*Lime Requirement Determinations*
*4-Day Incubation*

Bejucal Series
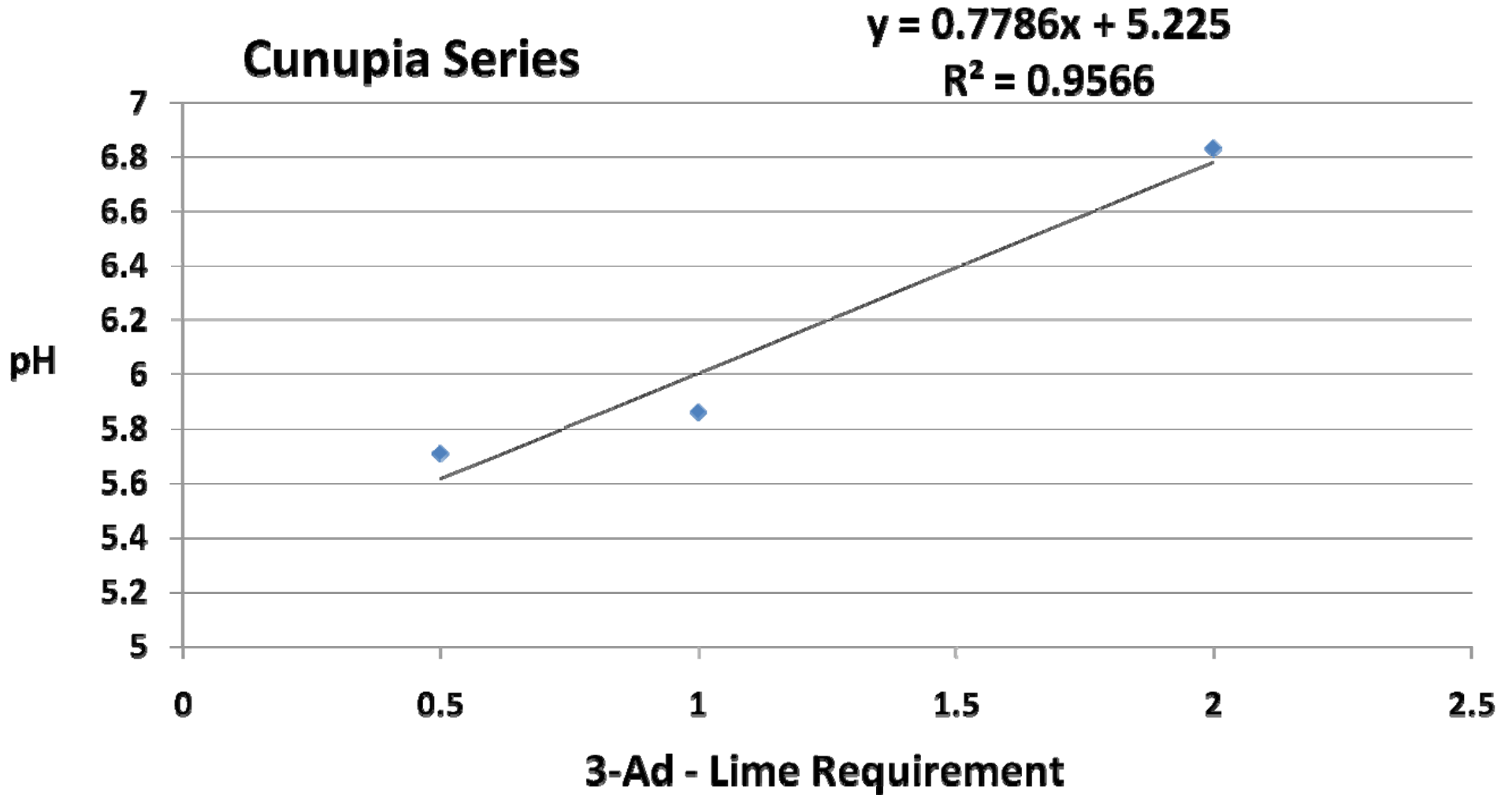
$y = 0.448x + 5.325$
$R^2 = 0.9842$

pH

3-Ad Lime Requirement

# RESULTS
## *Lime Requirement Determinations*
## Long-Term Incubation (108 days)

Cunupia Series

$y = 0.7786x + 5.225$
$R^2 = 0.9566$

pH (y-axis)

3-Ad - Lime Requirement (x-axis)

# RESULTS
## pH, Al and other heavy metal changes in LT Incubation

| Lime Rates (x 3AD LR) | pH | Concentration in soils (mg/kg) | | | |
|---|---|---|---|---|---|
| | | Al | Fe | Mn | Zn |
| 0 | 4.29 | 194 | 315 | - | 42 |
| ½ LR | 5.34 | 59 | 383 | 70 | 4.05 |
| LR | 5.72 | 48 | 285 | 63 | 3.55 |
| 1 ½ LR | 6.30 | 38 | 243 | 66 | 2.88 |
| p-value | < 0.01 | < 0.01 | < 0.01 | NS | <0.01 |

# RESULTS
## pH, Al and other heavy metal changes in LT Incubation

| Period (days) | pH | Concentration in soils (mg/kg) | | | |
|---|---|---|---|---|---|
| | | Al | Fe | Mn | Zn |
| 0 | 4.29 | 194 | 315 | - | - |
| 9 | 5.98 | 53 | 272 | 90 | 2.55 |
| 18 | 6.12 | 36 | 314 | 35 | 4.41 |
| 67 | 5.68 | 56 | 326 | 73 | 3.52 |
| | 5.36 *(108 d)* | | | | |
| p-value | < 0.01 | < 0.01 | NS | <0.01 | <0.01 |

# RESULTS
## *Lime Requirement Determinations*
## Incubation Methods

| Soil Series | Incubation Methods | | | |
| --- | --- | --- | --- | --- |
| | 4 day | | Longer-Term | |
| | LR (Mg Ag Lime/ha) | Regression R$^2$ | LR (Mg Ag Lime/ha) | Regression R$^2$ |
| Talparo | 13.9 | 97 | 20.4 | 97 |
| Bejucal | 24.4 | 98 | 33.5 | 98 |
| Piarco | 3.30 | 95 | 4.14 | 98 |
| Frederick | 54.2 | 89 | 76.5 | 97 |
| River Estate | 6.44 | 98 | 15.2 | 100 |
| Cunupia | 12.4 | 99 | 17.1 | 96 |
| Maracas | 7.76 | 97 | 9.9 | 100 |
| Aripo | 1.45 | 100 | 1.86 | 91 |
| Arena | 4.41 | 93 | 2.41 | 94 |
| Nariva | 11.0 | 98 | 26.4 | 93 |
| Las Lomas | 13.7 | 92 | 42.6 | 80 |
| Sangre Gran | 20.6 | 90 | 23.3 | 99 |

# RESULTS
## *Lime Requirement Determinations*
### <span style="color:red">*Rapid Buffer Methods*</span>

- ## SMP method
  - – 3 soils had soil-buffer pH values out of range
- ## AE method
  - – 6 soils were too acid (< 4.5)
  - – 1 soil had soil-buffer pH too low

# RESULTS
## Lime Requirement Determinations
## *All Methods*

| SOILS | | pH (H$_2$O) | Lime Requirements to pH 6.5 (Mg Ag lime /ha) | | | | | | |
| Series | *Texture/ Activity | | FTC | 3-Add | SMP | AE | Exc. Al | 4-day Inc | LT Inc |
|---|---|---|---|---|---|---|---|---|---|
| Talparo | C, M-H | 4.55 | 5.74 | 10.3 | 23.9 | 12.0 | 3.09 | 13.9 | 20.4 |
| Bejucal | C, M-H | 4.30 | 15.1 | 9.50 | 37.8 | NA | 6.09 | 24.4 | 33.5 |
| Piarco | SL, L | 4.66 | 3.84 | 3.94 | 4.7 | 4.20 | 1.27 | 3.30 | 4.14 |
| Frederick | C, M-H | 3.28 | 26.9 | 24.2 | NA | NA | 15.0 | 54.2 | 76.5 |
| River Estate | SCL, L-M | 4.53 | 5.74 | 6.44 | 10.5 | 6.8 | 1.84 | 6.44 | 15.2 |
| Cunupia | CL, M | 4.62 | 6.76 | 10.4 | 21.9 | 11.6 | 2.53 | 12.4 | 17.1 |
| Maracas | SL, L | 4.37 | 3.84 | 7.68 | 4.7 | NA | 2.60 | 7.76 | 9.9 |
| Aripo | S, L | 4.71 | 2.50 | 1.00 | NA | 1.20 | 1.18 | 1.45 | 1.86 |
| Arena | S, L | 3.62 | 2.70 | 2.08 | 4.7 | NA | 1.09 | 4.41 | 2.41 |
| Nariva | C, H | 4.53 | 9.62 | 5.52 | 31.8 | NA | 3.40 | 11.0 | 26.4 |
| Las Lomas | SL, L-M | 4.06 | 9.62 | 4.74 | 28.0 | NA | 6.00 | 13.7 | 42.6 |
| Sangre Grande | SiC, M | 4.27 | 9.62 | 8.22 | NA | NA | 7.56 | 20.6 | 23.3 |

* C=clay; SL= sandy loam; S= sand; SiC= Silty clay; CL= clay loam

  H= high; M= moderate; L=low

# Results

## Paired t-test of means of all LR methods vs LTI method

| LR method | p-value | Mean |
|---|---|---|
| FTC | 0.006 | 8.50 |
| 3-Add | 0.009 | 7.84 |
| SMP | 0.858 | 18.7 |
| Exc Al | 0.004 | 4.30 |
| 4-day | 0.011 | 14.5 |
| Long-term Incubation | | 19.1 |

# Conclusions

- Of all the standard rapid laboratory-based lime requirement tests available, the SMP buffer method gave the most accurate values for acid Trinidad soils especially those with moderate activity and above

- However, either the AE buffer method or the 2 un-buffered methods (FTC and 3-Add) are recommended for low activity, sandy soils

# MUCHAS GRACIAS