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RESEARCH ARTICLE

# Phosphorus Status of Major Coconut Growing Soils of Sri Lanka on the performance of *Pueraria phaseoloides*

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## ABSTRACT :

Phosphorus status of major coconut growing soils in the Intermediate Zone of Sri Lanka on the growth parameters and root nodulation of *Pueraria phascoloides* was studied in plant house and field experiments. In the plant house experiment, *Pueraria phaseoloides* was planted in Non Calcic Brown, Red Yellow Podzolic, Sandy Regosols, Yellow Latosols and Alluvial soils treated with phosphorus at the rate of 1g of Triple Super Phosphate (TSP) per pot ($T_1$) along with a control ($T_0$-no TSP) treatment. In the field experiment, *Pueraria phascoloides* was grown on above soils with application of Eppawela Rock Phosphate (ERP) at the rate of 912 kg ha$^{-1}$ ($T_1$) along with a control ($T_0$) treatment. The relationships between the relative increase of each crop parameter (X) due to phosphate treatment, which is defined by $[T_1 (X) - T_0(X)] / T_0 (X)$ and the initial available soil phosphorus determined by the 2.5 % Acetic acid and Olsen's bicarbonate were studied. The critical level for available soil phosphorus was determined by fitting the data in above relationships to the Cate and Nelson model. The results of the pot experiment showed that *Pueraria phaseoloides* significantly responded to P fertilizer application on soils containing available phosphorus less than 5 mg kg$^{-1}$ in both extraction methods. In the field experiment, the limiting value of soil phosphorus was 10 mg/kg$^{-1}$ as determined by 2.5 % acetic acid and 9 mg kg$^{-1}$ as determined by Olsen's method. Results revealed that the inherent phosphorus levels of most of the coconut growing soils in the Intermediate zone were below the limiting values and phosphate fertilizer application to *Pueraria phascoloides* is essential to enhance its growth and root nodulation.

**Key words :** coconut growing soils, critical level, growth parameters, *Pueraria phaseoloides,* relative increase, root nodulation, soil phosphorus

## INTRODUCTION :

*Pueraria phaseoloides* is an important leguminous cover crop grown in coconut lands to control soil erosion, suppress weed growth, increase soil moisture, recycle nutrients, increase soil nutrient availability, organic matter and improve soil fertility by fixing atmospheric nitrogen. Well grown *Pueraria phaseoloides* creepers would provide an effective soil cover and high nodulation of roots that would enhance nitrogen fixation. Nitrogen accumulation in aboveground biomass of *Pueraria phaseoloides* is 8 to 14 times higher than in intercropped fruit trees (Lehmann *et al.*, 2000). Nutrient re-cycling may be significantly enhanced by the cover crop, leading to less nutrient leaching and higher nutrient contents, such as K, in the topsoil. The amount of biological N fixation is an important factor for the N cycling. As a result, total soil N contents may often increase and enhance N availability is enhanced. The nutrient re-cycling depends on biomass production, nutrient content and decomposition rate. Lehmann *et al.*, 1999b reported that proportion of N accumulation in the above ground biomass of *Pueraria phaseoloides* was 83 % due to its high N content in a mixed fruit tree cropping system. He further stated that proportion of biomass production (55 %) and N – turnover (66 %) of *Pueraria phaseoloides* is also very high in comparison to fruit trees. Due to the high N contents and the low C/N ratio, litter decay is usually very rapid.

The soils in the coconut growing areas of Sri Lanka are generally deficient in the active as well as available forms of P (Loganathan *et al.*, 1982; Wijebandara and Somasiri, 1994). In some experiments carried out in Sri Lanka, particularly with soils containing lateritic gravels (Ultisols), coconut palms showed positive response to P fertilizer application (Balakrisnamurti, 1972; Nethsinghe, 1963; Salgado, 1957). But in other countries such as Philippines (Magat, 1979; Prudent and Mendoza, 1976), Tanzania (Thomas and Nandra, 1973), Jamaica (Smith, 1969) and Malaysia (Kanapathy, 1976) no response was obtained for P fertilizer application to coconut palms indicating the sufficiency of available P. However, phosphorus deficiency symptoms are not commonly observed in coconut plantations of Sri Lanka irrespective of soil and climate factors.

In certain coconut growing areas of Sri Lanka, *Pueraria phaseoloides* cannot be successfully grown as a cover crop. Establishment and maintenance of *Pueraria phaseoloides* on sandy soils in dry areas is difficult due to moisture stress in the top soil. Although *Pueraria phaseoloides* can be grown well as a cover crop in coconut lands in the wet areas, yet, it has been found that the root nodulation in those plants is poor. However, *Pueraria phaseoloides* cultivation as a cover crop in coconut lands of Sri Lanka is carried out without phosphate fertilizer application although it is known that phosphate deficiency in soils could adversely affect the growth of *Pueraria phaseoloides* and root nodulation. The lack of P affects both nodule formation and functioning and may become a limiting factor in some tropical soils (Appaduarai, 1968). Under tropical conditions application of 100 kg of Super Phosphate resulted in the fixation of 7[illegible] additional pounds of nitrogen (Vincent, 1965). Different rock phosphate sources increased dry matter yield, nodulation and P uptake of *Pueraria phaseoloides* compared with controls (Crespo and Curbelo, 1990, George and Sudhakumari 1997, Varghese and Ama, 1991). The objective of the present study was to study the effect of soil P status of different coconut growing soils of Sri Lanka on growth characteristics and root nodulation of *Pueraria phaseoloides*.

## MATERIALS AND METHODS :

A green house pot experiment was carried out using eight soil series comprising three from the coastal plain, two from an alluvial flood plain and three from the mantled plain collected from different locations of IL1 (semi-wet Intermediate Low country region) IL3 (sem

**Table 1:** Land form, great soil group and soil series of soils used for the pot experiment

| Land Form | Great Soil Group | Soil series |
|---|---|---|
| Mantled Plain | Non Calcic Brown (NCB) | Tambarawa (TAM) |
| Mantled Plain | Red Yellow Podzolic (RYP) | Andigama (AND) |
| Mantled Plain | Red Yellow Podzolic (RYP) | Kurunegala (KUR) |
| Coastal Plain | Sandy Regosols | Weliketiya (WEL) |
| Coastal Plain | Latosols and Regosols on old red and yellow sands | Madampe (MDP) |
| Coastal Plain | Latosols and Regosols on old red and yellow sands | Rathupasa (RAT) |
| Alluvial Plain | Alluvial soils | Welipelessa (WEP) |
| Alluvial Plain | Alluvial soils | Palugaswewa (PAL) |

(Source- Somasiri *et al.*, 1994)

- dry Intermediate Low country region) agro-ecological regions of Sri Lanka. The land form and great soil group of each soil series is given in (Table 1).

Soil samples were taken from both A and B master horizons of each soil series for the pot experiment. Soils were passed through 6 mm sieve at their field moist state soon after sampling and sub samples were taken from each soil for chemical analysis for available P and other chemical properties. Each soil sample was filled into four polypropylene pots (1.5 L) and each was treated with Triple Super Phosphate (TSP, 46 % $P_2O_5$) at the rate of 1 g per pot ($T_1$) along with a control (no phosphate) ($T_0$), in duplicate. Each soil was treated with a basal dose of N at the rate of 0.16 g Ammonium Sulphate ($[(NH_4)_2SO_4]$, 20.6 % N), K at the rate of 0.2 g Muriate of Potash (MOP, 60 % $K_2O$) and Mg at the rate of 0.1 g Magnesium Sulphate ($MgSO_4$, 27 % MgO) per pot. After treatment application, pots were arranged in a complete randomized design inside a green house and four pre-germinated *Pueraria phaseoloides* seedlings were planted in each pot. The pots were watered daily to maintain soil moisture content at the 60 % of the field capacity. Counting of *Pueraria phaseoloides* leaves, commenced one month after planting and continued at two week intervals for three months. The pots were dismantled, four months after planting and fresh weight, dry weights of vegetative parts and number of live nodules in the roots were recorded.

A field experiment was carried out in five soil series found in Bandirippuwa estate, Lunuwila that is located in North-Western province of Sri Lanka. The land form and great soil group of each soil series is given in (Table 2). Beds of dimension 1.5 m x 1.5 m were prepared with the top soil (A horizon) and the sub soil (after removal of A horizon) of each soil series separately. Soil samples were taken from each bed for chemical analysis. The beds were treated with ERP (30 % $P_2O_5$) at the rate of

**Table 2:** Land form, great soil group and soil series of soils used for the field experiment

| Land form | Great Soil Group | Soil Series |
|---|---|---|
| Mantled plain | Red Yellow Podzolic (RYP) | Boralu (BOR) |
| Mantled plain | Red Yellow Podzolic (RYP) | Pallama (PLM) |
| Coastal plain | Latosols and Regosols on old red and yellow sands | Madampe (MDP) |
| Coastal plain | Regosols | Sudu (SUD) |
| Alluvial plain | Alluvial soils | Lunuwila (LUN) |

(Source- Somasiri *et al.*, 1994)

912 kg $ha^{-1}$ ($TF_1$) alone with a control (without phosphate) ($TF_0$). All the beds were treated with a basal dose of N at the rate of 95 kg $ha^{-1}$ of $(NH_4)_2SO_4$ (20.6 % N) , K at the rate of 119 kg $ha^{-1}$ of MOP (60 % $K_2O$) and Mg at the rate of 60 kg $ha^{-1}$ $MgSO_4$ (27 % MgO). Treatments were arranged in a completely randomized block design with three replicates and planted with equal number of pre germinated *Pueraria phaseoloides* seedlings in each bed.

Three months after planting vegetative parts of *Pueraria phaseoloides* in a sample area of 0.5 $m^2$ were harvested and fresh and dry weights of harvested materials were recorded. Initial soils were analysed for pH at 1:5 soil: water ratio (Michael, 1965), Organic matter by Walkley and Black method (Jackson, 1967), total N by Kijedhal method (Black, 1965), texture by pipette metod (Day, 1965), phosphorus by 2.5 % Acetic acid method (Anon, 1985) and Olsen's bicarbonate method (Olsen *et al.*, 1954).

## RESULTS AND DISCUSSION :

As seen from Tables 3 and 4, bi-carbonate extractable P fraction of the soils used for the pot experiment and the field experiment ranged from 2.48 to 29.5 mg $kg^{-1}$ and 4.19 to 22.4 mg k respectively. The 2.5 % Acetic acid extractab P fraction of the soils of the pot experime ranged from 2.38 to 28.3 mg $kg^{-1}$ while that the field experiment ranged from 3.80 to 10 mg $kg^{-1}$. The Acetic acid extractable P conte in pot experiment were found to be low (2.3 3.04 mg $kg^{-1}$) in soils having clay fraction mo than 17.5 % (Andigama series and Kuruneg series) compared to the other soils whi contained more than 74.8 % sand, less than 19 % clay and silt (Table 3). It indicated that t acid soluble P fractions, mainly apatites, we low in those soils that contained higher cl fraction compared to those that contained hig sand fraction. However, Olsen's bicarbonate values, which depend on basic calcium bou P compounds, did not show the same tre Generally, apatites are not readily dissolv in alkaline extractants such as $NaHCO_3$ a therefore the latter extracts a different P fracti According to the classification of Trough (194 50 % of soils used for the pot experiment we acidic (pH 4.5 to 5.5) while the rest of the so were slightly acidic (pH 5.5 to 5.9) and the so used for the field experiment were acidic (Tab 3 and 4). However, a significant relationsh

**Table 3:** Important chemical and physical properties of soils used for the post experiment

| Soil series | PH – (1:5 $H_2O$) | Total N (mg $kg^{-1}$) | O.M % | Texture | | | 2.5 % HAc- P (mg $kg^{-1}$) | Olsen's – P (mg $kg^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| | | | | Sand ( %) | Silt (%) | Clay (%) | | |
| TAM-A | 5.35 | 292 | 0.47 | 89.0 | 3.65 | 4.10 | 4.77 | 4.01 |
| TAM-B | 5.44 | 292 | 0.34 | 87.0 | 4.08 | 3.95 | 3.34 | 3.18 |
| AND-A | 5.90 | 1058 | 1.27 | 60.3 | 8.40 | 26.6 | 2.60 | 2.99 |
| AND-B | 5.79 | 693 | 0.98 | 60.0 | 8.43 | 27.8 | 2.38 | 2.48 |
| KUR-A | 5.03 | 547 | 1.40 | 74.1 | 5.85 | 17.5 | 3.04 | 4.90 |
| KUR-B | 4.99 | 547 | 0.81 | 71.2 | 5.28 | 18.6 | 2.70 | 3.21 |
| WEL-A | 5.18 | 292 | 0.22 | 94.5 | 1.85 | 3.38 | 6.40 | 6.62 |
| WEL-B | 5.12 | 182 | 0.11 | 89.2 | 3.90 | 2.03 | 4.07 | 3.95 |
| MAD-A | 5.73 | 328 | 0.45 | 90.0 | 3.63 | 2.10 | 3.85 | 3.50 |
| MAD-B | 5.19 | 182 | 0.22 | 87.4 | 4.95 | 3.40 | 4.56 | 3.18 |
| RAT-A | 5.67 | 292 | 0.34 | 92.5 | 4.08 | 2.75 | 10.0 | 7.38 |
| RAT-B | 5.67 | 265 | 0.24 | 93.7 | 3.78 | 2.15 | 6.86 | 6.24 |
| WEP-A | 5.33 | 379 | 0.34 | 87.5 | 4.15 | 3.98 | 5.19 | 5.38 |
| WEP-B | 5.76 | 455 | 0.29 | 87.9 | 6.58 | 1.85 | 4.57 | 2.73 |
| PAL-A | 5.55 | 303 | 0.25 | 88.4 | 3.80 | 3.98 | 28.3 | 14.9 |
| PAL-B | 5.78 | 379 | 0.28 | 74.8 | 11.25 | 7.90 | 26.2 | 29.5 |

A - A horizon B - B horizon

…tween soil pH values and bi-carbonate …tractable P or Acetic acid extractable P values …as not found for these soils.

As seen from Tables 3 and 4, most of the …ils used for the experiment were low in both …tal nitrogen (< 500 mg $kg^{-1}$) and organic …atter content (< 1 %). Therefore, it is essential … improve organic matter content and increase …ailable nitrogen and phosphorus quantities to …hance the agricultural productivity of these …ils. It could be achieved by incorporating *…eraria phaseoloides* into the soil. However, …art from vegetative growth, nodulation in …ots is an important factor for effective nitrogen …xation of *Pueraria phaseoloides.*

In the pot experiment, the values of total …y matter weight, the number of leaves and the number of root nodules of *Pueraria phaseoloides* showed a significant increase in response to P fertilizer application to soils. To report the response of any crop parameter (X) to P fertilizer application, the term Relative Increase (RI) defined as $T_1$ (X) - $T_0$ (X) / $T_0$ (X), where $T_1$ (X) is the crop parameter of $T_1$ or $TF_1$ and $T_0$ (X) is that of $T_0$ or $TF_0$, has been used in this paper. RI > 0 indicates a positive response in parameter (X) of *Pueraria phaseoloides* to TSP application and RI >1 indicates a higher positive response.

**Table 4 :** Important chemical and physical properties of soil in field experiment

| Soil series | PH - ($H_2O$) | Total N ($mg\ kg^{-1}$) | O.M (%) | Texture | | | 2.5% HAc- P ($mg\ kg^{-1}$) | Olsen's - P ($mg\ kg^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| | | | | Sand (%) | Silt (%) | Clay (%) | | |
| BOR-A | 4.86 | 890 | 1.76 | 77.8 | 17.0 | 3.45 | 101.0 | 22.4 |
| BOR-B | 4.34 | 525 | 1.12 | 78.2 | 10.9 | 4.58 | 5.75 | 8.23 |
| PLM-A | 5.19 | 470 | 0.97 | 85.5 | 7.08 | 3.40 | 82.4 | 4.19 |
| PLM-B | 4.83 | 336 | 0.63 | 87.1 | 8.50 | 3.28 | 13.2 | 9.76 |
| MDP-A | 5.32 | 265 | 0.47 | 94.5 | 2.78 | 3.10 | 7.82 | 7.47 |
| MDP-B | 5.23 | 220 | 0.33 | 88.4 | 30.3 | 3.90 | 3.80 | 4.53 |
| SUD-A | 5.09 | 377 | 0.90 | 97.7 | 1.58 | 3.45 | 6.94 | 6.81 |
| SUD-B | 5.01 | 345 | 0.68 | 93.5 | 2.53 | 3.03 | 5.12 | 8.47 |
| LUN-A | 5.32 | 291 | 0.53 | 94.6 | 0.90 | 2.68 | 7.42 | 13.2 |
| LUN-B | 5.27 | 235 | 0.36 | 97.6 | 1.55 | 2.80 | 8.10 | 14.7 |

A - A horizon, B - B horizon

**Table 5:** Relative Increase (RI) of dry matter weight of vegetative parts, number of nodules and number of leaves of *Pueraria phaseoloides* used for the pot experiment

| Soil series | RI of Dry matter weight of vegetative parts | RI of Number of nodules | RI of Number of leaves |
|---|---|---|---|
| TAM-A | 1.33 | 2.81 | 0.61 |
| TAM-B | 3.99 | 3.56 | 0.86 |
| AND-A | 10.5 | 14.3 | 1.02 |
| AND-B | 31.3 | 46 | 1.81 |
| KUR-A | 1.65 | 5.88 | 0.71 |
| KUR-B | 12.3 | 34 | 0.75 |
| WEL-A | 0.85 | 0.44 | 0.44 |
| WEL-B | 3.33 | 9 | 0.73 |
| MAD-A | 4.25 | 7.05 | 1.45 |
| MAD-B | 5.16 | 8.38 | 0.98 |
| RAT-A | 0.25 | 0.71 | 0.34 |
| RAT-B | 0.67 | 3.76 | 0.21 |
| WEP-A | 9.72 | 6.11 | 1.08 |
| WEP-B | 17.9 | 25.7 | 1.85 |
| PAL-A | 0.20 | 0.63 | 0.28 |
| PAL-B | 0.37 | 0.65 | 0.31 |

A - A horizon, B - B horizon

The RI values of dry matter, number of nodules and the number of leaves were less than one for PAL-A, PAL-B, RAT-A and WEL-A soils but greater than one for the other soils (Table 5). This is a consequence of the latter soils being were more deficient in available phosphorus than the former, and therefore *Pueraria phaseoloides* highly responded to TSP application on the latter soils. The foregoing results also showed that vegetative growth as well as root nodulation of *Pueraria phaseoloides* increased by many fold as a result of phosphorus fertilizer application. The relationships between RI values and soil P values determined by the chemical methods showed that it is possible to obtain a limiting value of available soil P for vegetative growth as well as for nodulation of *Pueraria phaseoloides* which would be useful in planning P fertilizer application.

The relationship between RI of above mentioned crop parameters in the pot experiment and inherent available soil P determined by each of the two chemical extraction methods showed a curvilinear relationships as shown in Figure 1 : ( 1a, 1b, 1c, 1d, 1e and 1f).

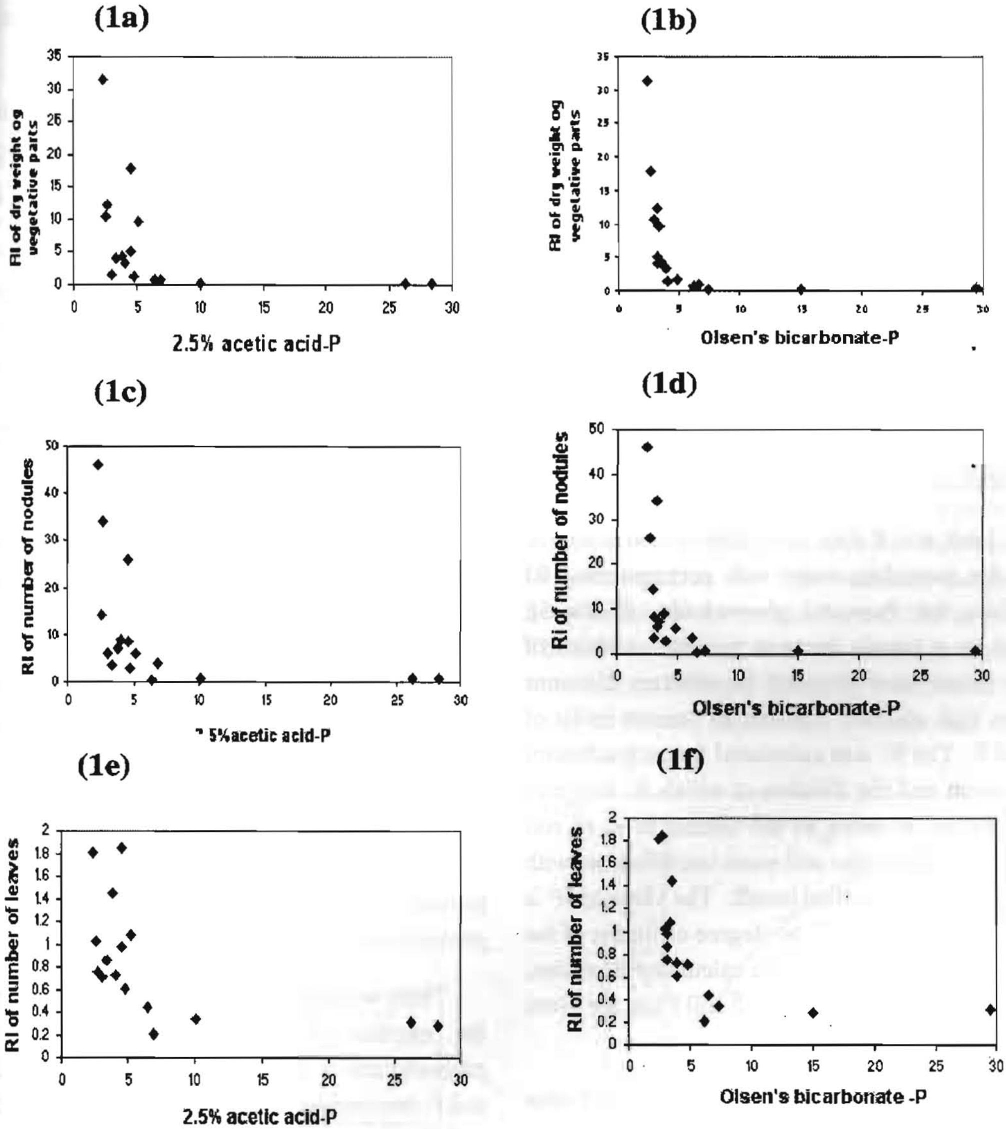



*Figure 1 :* Relationship between Relative Increase (RI) of different parameters and soil P by 2.5 % Acetic acid method and Olsen's bicarbonate method

**Table 6 :** Highest $R^2$ values and critical levels obtained by Cate and Nelson statistical procedure

| Soil P test | $R^2$ | Critical level |
|---|---|---|
| | Dry weight basis | mg/kg $^{-1}$ |
| 2.5 % HAc | 0.836** | 5.1 |
| Olsen's bicarbonate | 0.703** | 4.9 |

*** P <0.001, ** P <0.01, * P < 0.05

The critical level for available soil P was determined by applying the Cate and Nelson (1965) statistical method to the above relationships. Cate and Nelson statistical model (Cate and Nelson, 1971) provides a method for determining the dividing line, or the critical level between two categories of soils; viz., high probability of response (low soil P status) and low probability of response (high soil P status) to applied P.

Each soil P data set (Table 3) was arranged in the ascending order with corresponding RI values for *Pueraria phaseoloides* (Table 5), and by a simple iterative process a series of $R^2$ values were obtained for arbitrary divisions into high and low P status, at various levels of soil P. The $R^2$ was calculated for each arbitrary division and the division at which $R^2$ becomes maximum is taken as the critical level of soil P for the particular soil-plant combination, with respect to the method tested. The value of $R^2$ is also an indication of the degree of fitness of the data set to the model. The calculated $R^2$ values, and the critical level for each soil P test are given in Table 6.

Acetic acid P values showed the higher correlation with Relative Increase of *Pueraria phaseoloides* fitting significantly to the Cate and Nelson model with $R^2$ of 0.836 (P<0.01) for dry weight of vegetative parts. Thus the 2.5 % HAc-P values could account for the variation of 83 % of the production of vegetative parts of *Puerari phaseoloides* in different soils.

As seen from Figure 1 (1a, 1b, 1c, 1d, 1e and 1f) the RI values of all those crop parameters increased when both Olsen's bicarbonate P and 2.5 % Acetic acid – P in soils were less than 5.0 mg kg$^{-1}$. The RI values for dry matter weight, number of live nodules and number of leaves of *Pueraria phaseoloides* ranged between 0.2 to 9.72, 0.44 to 6.11 and 0.21 to 1.08 respectively when Olsen's bicarbonate P or 2.5% Acetic acid – P in the soil was greater than 5.0 mg kg$^{-1}$. On the other hand it ranged from 1.33 to 31.39 for dry matter weight, 2.81 to 46 for number of live nodules and 0.61 to 1.85 for number of leaves when Olsen's bicarbonate P or 2.5 % Acetic acid – P the soil was less than 5.0 mg kg$^{-1}$. It showed that soil P level of 5 mg kg$^{-1}$ was the critical level and P levels less than this value would provide higher growth response of *Pueraria phaseoloides* to TSP application in such soils.

There was a logrithmic relationship between the number of root nodules of *Pueraria phaseoloides* in control pots and the available soil P, determined by the each method (Figure 2a and 2b). The $R^2$ value of the logrithmic function for Olsen's method was 0.795** whereas that for 2.5 % acetic acid was 0.816** which indicated that more than 75 % of the variation of root nodulation could be explained by the logarithm of the soil test values of P. This relationship also indicates the importance of soil P status for improving root nodulation which in turn is linked to nitrogen fixation.

Thus it can be expected that the amount of nitrogen fixed by *Pueraria phaseoloides* on most of the soils used for the pot experiment would be low because their available P content was less than 5 mg kg$^{-1}$ compared to few soils of which available P content was more than 5 mg kg$^{-1}$.

The soils that contained high concentration of available P (5> mg kg$^{-1}$) such as Rathupasa series, Weliketiya series, Welipelessa series and Palugaswewa series soils represented only a small portion of the coconut growing area. The other soils that contained available P content less than 5 mg kg$^{-1}$ represented about 70 % of the major coconut growing areas of Sri Lanka.

Hence, the results of this experiment imply that phosphorus fertilizer application is necessary for cultivation of *Pueraria phaseoloides* on major soils of the coconut growing areas, eg; Tambarawa series, Andigama series, Kurunegala series, and Madampe series because of their low available phosphorus content.

The same experiment was conducted in the field, on five soil series to test the extent of response of *Pueraria phaseoloides* to phosphorus treatment and to calibrate the soil test for determination of critical level in the field condition. However, RI values for vegetative parts of *Pueraria phaseoloides* in the field experiment were very much lower compared to that in the pot experiment (Table 7). The RI values on Pallama series (PAL-A and B) and Boralu series (BOR-A only) were as low as 0.04 -0.06. The RI values for vegetative parts of *Pueraria phaseoloides* on the other soils could be considered as the high response category because the values ranged from 0.181 to 1.00. The 2.5 % acetic acid P values for the same soils ranged from 3.80 to 8.10 mg kg$^{-1}$. However the range of Olsen's bicarbonate P values was 4.19 to 14.7 mg kg$^{-1}$.

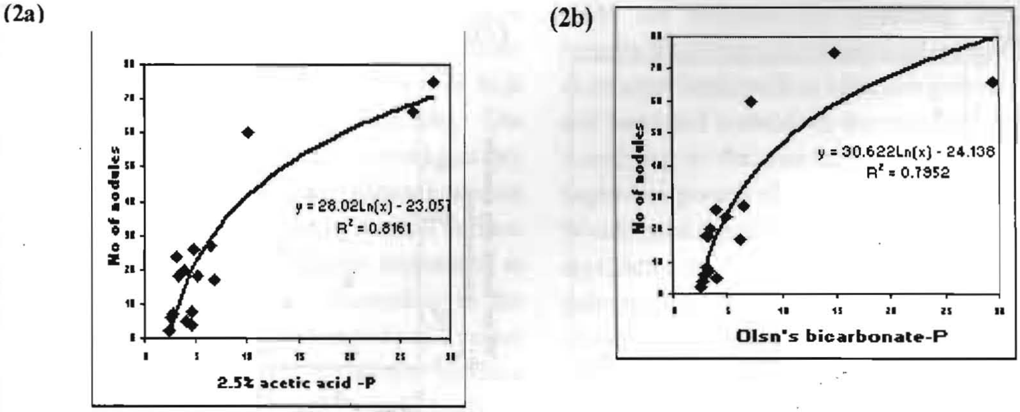



*Figure 2:* Relationship between soil P values of 2.5 % acetic acid extraction and Olsen's bicarbonate and number of nodules

**Table 7:** Relative Increase (RI) values of dry matter weight of Pueraria phaseoloides used for the field experiment

| Soil Series | RI of dry matter weight of vegetative parts |
|---|---|
| BOR – A | 0.040 |
| BOR – B | 0.252 |
| PLM – A | 0.047 |
| PLM – B | 0.062 |
| MDP – A | 1.000 |
| MDP – B | 0.342 |
| SUD – A | 0.682 |
| SUD – B | 0.474 |
| LUN – A | 0.181 |
| LUN - B | 0.215 |

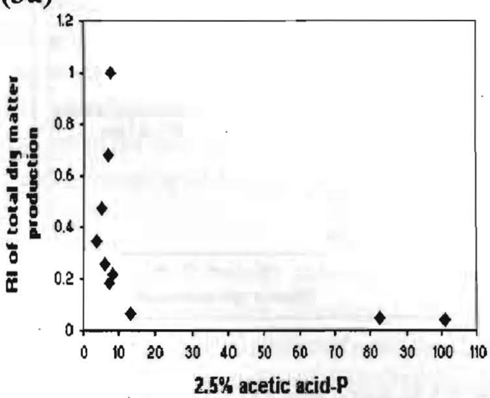
A-A horizon, B-B horizon

The relationships between RI of the weight of vegetative parts of *Pueraria phaseoloides* in the field experiment and inherent soil P determined by the two chemical extraction methods are shown in Figure 3: (3a & 3b). The 2.5% acetic acid -P values showed a better relationship between the decreasing P value and increasing RI ratio than the Olsen's bicarbonate P.

The critical value of soil test P, which can be used to identify the P deficiency category of soils was obtained by applying Cate and Nelson method to the above relationships.

The calculated $R^2$ values for field data, and the critical level for each soil P test are given in Table 8. Acetic acid P values showed higher correlation with Relative Increase of *Pueraria phaseoloides* fitting significantly to the Cate and Nelson model with $R^2$ of 0.792 ($P<0.01$) for dry weight of vegetative parts. Thus the 2.5 % HAc-P values could account for the variation of 79 % of the production of vegetative parts of *Pueraria phaseoloides* in different soils.

(3a)




(3b)

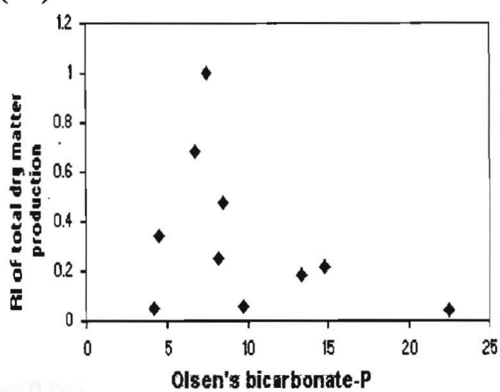



*Figure 3:* Relationship between Relative Increase (RI) of total dry matter content and soil P extracted by 2.5% acetic acid and Olsen's bicarbonate

**Table 8 :** Highest $R^2$ values by Cate and Nelson statistical procedure for the correlation between soil P by different methods and RI of dry weight of vegetative parts of Pueraria phaseoloides in field experiment

| Soil P test | $R^2$ | Critical level mg $kg^{-1}$ |
|---|---|---|
| 2.5 % HAc | 0.792** | 10 |
| Olsen's bicarbonate | 0.670** | 9 |

*** P <0.001, ** P <0.01, * P < 0.05

The 2.5 % Acetic acid P values fitted to :ate & Nelson model better than the Olsen's icarbonate P. It was somewhat difficult to ecide the critical value for Olsen's bicarbonate ' from the results of the field experiment ecause of the scatter of points (Figure 3b). ⁄Ioreover, the critical values determined from ot experiment and field conditions were ifferent. Also, under field conditions, 2.5 % ⁄cetic acid method proved to be more suitable han the Olsen's method for determination of a aboratory index.

The results showed that the growth response f *Pueraria phaseoloides* to phosphate fertilizer pplication on majority of soils was very high oth in green house and field conditions. The esults of the field experiment showed that dry natter production of *Pueraria phaseoloides* on even soils out of ten (including A and B horizon f five soil series) significantly responded to :RP fertilizer application. According to the elationships between RI values and soil P values y the chemical methods, it became obvious hat laboratory index for soil P, particularly by :.5 % acetic acid method, could be adopted to letermine the sufficiency or deficiency status of soil P. Considering the limiting values for soil P derived from both the field and the pot experiments, 10 mg $kg^{-1}$as determined by 2.5 % acetic acid method, could be taken as critical level for soil P for *Pueraria phaseoloides*. The critical level could be taken as 9 mg $kg^{-1}$ with respect to Olsen's bicarbonate method.

## CONCLUSION

The results of the present study showed that the phosphorus levels of some coconut growing soils of Sri Lanka that were considered in this study are deficient for obtaining optimum benefits out of *Pueraria phaseoloides* cover crops in coconut lands such as effective ground cover and increased nodulation for nitrogen fixation. According to the results, the nodulation and vegetative growth of *Pueraria phaseoloides* can be enhanced significantly by phosphate fertilizer application to those soils. The sufficiency or deficiency status of soil phosphorus for *Pueraria phaseoloides* cultivation on these soils can be determined by 2.5 % acetic acid method or the Olsen's bicarbonate method. The critical levels for soil phosphorus by the two methods are 10 mg $kg^{-1}$ or 9 mg $kg^{-1}$.

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