# Extractibility of Residual Rock and Superphosphate on Limed and Unlimed Bungor Soil

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Key words: rock phosphate; superphosphate; extractants; residual; aging.

## ABSTRAK

*Kemungkinan menggunakan larutan ekstrak untuk mengesan perubahan bentuk baja fosforus (P) dalam tanah siri Bungor telah dilakukan. Tiga larutan ekstrak; Bray 2, Ammonium asetat laktat (AAL) dan Olsen telah dicuba. Tanah telah dirawat dengan tiga paras P untuk tiap-tiap baja super-fosfat (SP) dan fosfat batuan (RP) pada kadar 0, 150 dan 300kg P/ha, tanpa kapur dan pengapuran pada 4 tan/ha dan perbezaan dalam pembajaan selama satu tahun. Bray 2 dan AAL dapat mengesan pembajaan yang baru daripada yang lama di mana jumlah P yang lebih tinggi didapati daripada pembajaan yang baru. Kedua-dua ekstrak ini juga dapat membezakan rawatan 150 dari 300kg P/ha tetapi tidak dapat membezakan bentuk P yang digunakan. Larutan Olsen telah dapat mengesan ben-tuk P yang digunakan juga menunjukkan pelepasan P daripada fosfat batuan mengikut waktu.*

## ABSTRACT

*The possibility of using soil extractants to monitor the transformation of phosphorus (P) ferti-lizer on a Bungor series soil was investigated. Three soil extractants — Bray 2, Ammonium acetate lactate (AAL) and Olsen — were evaluated. The soil was treated with three levels of P each from rock phosphate and superphosphate at 0, 150 and 300kg P/ha, no lime and limed at 4 tons/ha and a P fertilizer application interval of one year. Bray 2 and AAL were able to detect recent P from aged P applications with a higher amount of P being extracted from the recent. These extracts were able to differentiate between the 150 and 300kg P/ha treatments but were not able to distinguish the forms of P. Olsen extractant on the other hand was able to detect the two P forms and showed P release from rock phosphate with time.*

## INTRODUCTION

Phosphorus fertilizer when applied to the soil reacts with the soil constituents forming com-pounds that are less soluble resulting in the fixa-tion of P. In tropical soils, the main P compound forms are iron phosphate (Fe-P) and aluminium phosphate (Al-P) (Pushparajah 1977; Kawa-guchi and Kyumo, 1969). If, however, P rock was used as a source of fertilizer P, calcium phosphate (Ca-P) could be the main compound formed in the soil initially but with time it would be converted to Fe-P and Al-P.

Extractable P by soil extractants has been used as an indicator of plant available soil P. Acid flouride extractable P (Bray 2) was found to be highly correlated with P uptake by plants (Zaharah, 1982). The time between fertilizer P application and growing of crops would determine the amount of P available to plants. The effectiveness of fertilizer P decreases as time of P contact with soil increases (Devine *et al.,* 1968). These have been recorded in field trials (Mattingly, 1963). It is possible that soil extractants could be used to detect the trans-

formations of P forms that are occurring in the soil. It is the objective of this experiment to see whether extractants can be used to detect P transformations in the soil.

## MATERIALS AND METHODS

### Experimental Layout

A field experiment was set up at the Universiti Pertanian Malaysia farm at Puchong. The soil series is Bungor classified as Typic Paleudult. The chemical and physical analysis is presented in Table 1.

A split plot design was used with each of the four replicates of each treatment completely randomized within each whole plot. The treatments consisted of no lime and lime (main plots)

at 4 tons per ha, two forms of fertilizer phosphate namely rock phosphate (RP) and superphosphate (SP), three levels of P; 0,150 and 300kg P/ha and a one year difference in time of P fertilizer applications (sub-plot).

The treatments and replications gave a total of 80 plots, each with a size of 8m × 3m. *Setaria splendida* grass was planted on the plots by using cuttings. Soil sampling was done after the fifth *Setaria* harvest with 12 sampling points taken per plot, bulked, air dried and sieved (2mm).

### Soil Extractants

Three soil extractants were evaluated for their ability to detect the various treatments given. They were Bray no. 2 (Bray and Kurtz, 1945) which is the standard method of P determination

TABLE 1

The physical and chemical characteristics of the Bungor soil at the Punchong Farm

| pH ($H_2O$) | %N | %C | C.E.C. (meq/100g) | Bray 2P | Total P |
|---|---|---|---|---|---|
| | | | | $\mu g$ P/g | |
| 5.0 | .08 | 1.94 | 9.2 | 6.9 | 208 |

| Exchangeable bases (meq/100g) | | | | Particle size distribution (%) | | |
|---|---|---|---|---|---|---|
| Na | K | Ca | Mg | clay | silt | sand |
| .15 | .32 | .73 | .36 | 48.7 | 16.4 | 34.9 |

TABLE 2

AAL extractable P values from soils treated with aged and recent P fertilizer[#]

| Treatment | $P_0$ | $R_1$ | $S_1$ | $R_2$ | $S_2$ |
|---|---|---|---|---|---|
| | | | $\mu g$ P/g soil | | |
| Unlimed aged* | 1.9 | 15.3 | 20.9 | 33.4 [a1] | 60.5 [a2] |
| Unlimed recent | 2.1 | 27.1 | 21.7 | 60.7 [b1] | 89.9 [b2] |
| Limed aged* | 3.1 | 12.5 | 12.9 | 56.4 [a3] | 45.4 [a4] |
| Limed recent | 2.8 | 12.3 | 23.1 | 82.4 [b3] | 67.3 [b4] |
| Aged P* | 2.5 | 13.9 | 16.9 | 44.9 [a5] | 52.9 [a6] |
| Recent P | 2.5 | 19.7 | 22.4 | 71.5 [b5] | 78.6 [b6] |
| P (Mean) [+] | 2.5 [a] | 16.8 [a] | 19.6 [a] | 58.2 [b] | 65.8 [b] |

[#] $P_0$ – 0kg P/ha, $R_1$ – 150kg P/ha as RP, $R_2$ – 300kg P/ha as RP, $S_1$ – 150kg P/ha as SP, $S_2$ – 300kg P/ha as SP.
For this and subsequent tables, means with the same superscript are not significantly different using DMRT at P = 0.05.

*means compared are with superscript with the same number besides it within column.

[+] means compared within row.

in Malaysian soils, Ammonium acetate lactate (Zaharah, 1982) and Olsen (Olsen *et al.*, 1954). Phosphorus in solution was determined by colorimetric methods of Scheel (1936) for high P concentration and Murphy and Riley (1962) for low P concentration.

## RESULTS AND DISCUSSION

### Ammonium Acetate Lactate

This extractant was able to detect differences in extractable P due to the one year interval in P application at the 300kg P/ha with both forms of P in the limed and unlimed soil. P released from aged RP and SP reacted with Fe and Al in the soil and formed compounds that were less extractable to AAL. Lindsay *et al.* (1962) found that prolonging the contact time between P fertilizer and the soil increased the proportion of P that precipitated with Ca, Fe and Al.

In the limed soil, RP (300kg P/ha) gave higher extractable P value compared to RP in the unlimed soil. This could be due to the lower dissolution of RP in limed soil and as a result less P is released and interacted with Fe and Al as opposed to unlimed soil where RP would dissolve faster. AAL could have extracted more P from Ca-P form than from the Fe and Al-P forms. The low pH of the AAL (3.75) can dissolve the Ca-P and the acetate and lactate ions can form complexes with Ca with P thereby in solution (Olsen *et al.*, 1954; Thomas and Peaslee, 1973). This extractant was not able to differentiate between the RP and TSP at similar P levels. However, it was able to detect differences between 150 and 300kg P/ha applications in both P forms.

Since five harvestings of *Setaria* were done prior to the soil sampling, unequal P uptake by

*Setaria* from the various P treatments could have contributed towards the difference in the soil extractable P. The difference was, however, small as shown in Table 3.

### Bray 2 Extractant

Compared to the results from AAL, significant differences in extractable P due to the one year interval in P applications were noted using Bray 2 (Table 4). Extractable P values by Bray 2 were twice as high as in AAL. The increase in extractibility is due to the low pH acid solution of the Bray 2 which provides H ions activity to dissolve Ca-P and some of the Al-P and Fe-P (Thomas and Peasly, 1973). The flouride tions present in this extractant help in the complexing of Al ions and releasing the P from the AL-P (Chang and Jackson, 1957). Liming the soil did not affect extractable P from the P treated plots as compared to unlimed plots. However, aged P plots at the 300kg P/ha in both forms that were limed resulted in less P being extracted by Bray 2. Bray 2 was able to detect the different P treatment levels. Significant difference in extractable P between 0, 150 and 300kg P/ha was noticed. However, the difference in P forms i.e. between RP and SP was only detected at the 300kg P/ha level.

### Olsen Extractable P

More P was extracted by Olsen from plots treated with SP that received similar rates of P than from RP (Table 5). The bicarbonate ions in the buffered alkaline solution replace adsorped P and is effective in extracting Al-P and to some extent Fe-P but not from Ca-P present in RP (Tyner and Davide, 1962). This extractant was therefore able to differentiate forms of the P used, with a higher amount of P extracted from

**TABLE 3**

Difference in amount of P uptake by *Setaria* due to interval in P application (kg P/ha)

|  | $R_0$ | $R_1$ | $S_1$ | $R_2$ | $S_2$ |
|---|---|---|---|---|---|
| Aged P | 9.5 | 19.0 | 16.6 | 22.1 | 20.5 |
| Recent P | 9.9 | 21.2 | 20.4 | 21.8 | 24.7 |
| Difference* | 0.4 (.1) | 2.2 (.7) | 3.8 (1.2) | 0.3 (.1) | 4.2 (1.4) |

*number in ( ) refers to $\mu$g P/g soil.

## TABLE 4
### Bray 2 extractable P from soils treated with aged and recent P fertilizer

| Treatment | $P_0$ | $R_1$ | $S_1$ | $R_2$ | $S_2$ |
|---|---|---|---|---|---|
| | | | μg P/g soil | | |
| Unlimed aged | 36.8 | 15.3 | 57.4 | 64.8 | 85.1 |
| Unlimed recent | 35.9 | 55.9 | 55.3 | 80 | 93.1 |
| Limed aged* | 26.1 | 42.2 | 35.3 | 68.6 [a1] | 71 [a2] |
| Limed recent | 24.8 | 36.7 | 47.8 | 88.4 [b1] | 109.9 [b2] |
| Aged P* | 31.4 | 46.8 | 45. | 66.7 [a3] | 78 [a4] |
| Recent P | 30.3 | 46.3 | 51.5 | 84.2 [b3] | 101.5 [b4] |
| P (Mean) [+] | 30.9 [a] | 45.6 [b] | 48.3 [b] | 75.5 [c] | 89.8 [d] |

*means compared are with superscript with the same number besides it within column.

[+] means compared within row.

## TABLE 5
### Olsen extractable P from soils treated with aged and recent P fertilizer

| Treatments | $P_0$ | $R_1$ | $S_1$ | $R_2$ | $S_2$ |
|---|---|---|---|---|---|
| | | | μg P/g soil | | |
| Unlimed aged* | 10.7 | 19.9 | 23 | 31 [a1] | 44.7 [1] |
| Unlimed recent | 11.8 | 15.9 | 20.3 | 21.9 [b1] | 41.6 |
| Limed aged* | 9.7 | 13.1 | 18 | 16.3 | 35.9 [a2] |
| Limed recent | 7.9 | 11.9 | 20.8 | 13.4 | 61.1 [b2] |
| Aged P* | 10.2 | 16.5 | 20.5 | 23.7 | 40.3 [a3] |
| Recent P | 9.8 | 13.9 | 20.5 | 17.7 | 51.3 [b3] |
| P (Mean) [+] | 10 [a] | 15.2 [b] | 20.5 [c] | 20.7 [c] | 45.8 [d] |

*Means compared are with superscript with the same number besides it within column.

[+] Means compared within row.

SP and RP. Dissolution of RP under acidic soil conditions with the release of P from the Ca-P in RP with time was detected by Olsen extractant.

In the unlimed soil, aged RP at the 300kg P/ha treatment gave higher extractable P value than the recent RP. This indicates that the aged RP had dissolved and the P released was detected by Olsen.

When the soil was limed, amount of P extracted by Olsen from RP decreased. P extracted from aged RP was similar to recent

RP. This indicates either slow release of P from RP or that the P released had interacted with Ca from the lime or a combination of both which resulted in lower extractable P. Indication that P had reacted with Ca was seen with the SP (300kg P/ha) where aged SP gave lower extractable P value. Olsen extractant was able to detect the different P treatments levels applied, the highest P being extracted from SP at the 300kg P/ha. Similar P values were extracted from RP at 300kg P/ha rate and 150kg P/ha of the SP.

These values were, however, lower compared to values from AA1 and Bray 2.

## CONCLUSION

AAL and Bray 2 extractants were able to distinguish the P application interval; higher amounts of P were extracted from the recent as compared to the aged P application. This difference indicates that transformation of applied P does occur in the soil resulting in aged P being less extractable to Bray 2 and AAL. Transformation of recent applied P, being less pronounced, results in higher amounts of P extracted by Bray 2 and AAl. These extractants were able to detect between the 150kg and 300kg P/ha treatment levels. However, they were not able to differentiate between the two forms of P used.

Olsen extractant on the other hand was able to differentiate between the RP and SP sources with more P being extracted from the SP. It was also able to trace the amount of P that was released by the solubilization of RP with time. This was indicated by a higher amount of P being extracted from the aged RP than from the recent RP applications.

## ACKNOWLEDGEMENTS

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