

## Phosphorus Accumulation by Sesame Seedlings as Influenced by Burned Rice Husk, Aluminum and Phosphorus

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### ABSTRACT

The influence of burned rice husk, aluminum, and phosphorus on growth and P content of 30 - d - old sesame ( *Sesamum indicum* L., cv. Roi Et 1 ) grown in Yasothon sandy loam ( Oxic Paleustult ) soil was studied in a greenhouse experiment. Treatments, replicated three times, were 0, 1.25%, and 2.5% burned rice husk, 0, 25, 50, and 100 mg kg<sup>-1</sup> Al as AlCl<sub>3</sub>, and 0, 6, and 18 ppm P as Ca ( H<sub>2</sub>PO<sub>4</sub> )<sub>2</sub> · H<sub>2</sub>O in a randomized block with a factorial arrangement of treatments. The results indicated that increasing the P and burned rice husk supply significantly increased yield of both shoots and roots but increasing the Al supply depressed plant growth. Higher rates of phosphorus and burned rice husk applications were needed to obtain good yield as the Al levels were increased. Total P accumulation in the shoots dropped markedly as the Al treatments were increased from 0 to 100 mg kg<sup>-1</sup> Al. However, total P content and P concentration were increased by raising the burned rice husk supply from 0 to 2.5%. There was also a marked effect of increased burned rice husk supply on increasing soil pH and Bray II extractable soil P.

### INTRODUCTION

Soils in the Northeast region of Thailand are generally acid. More than 50% of the soils are reported to have pH values less than 5.6 ( Suwanarit, 1985 ). Chantanaparb *et al.* ( 1976 ) also report that many soils in the Northeast have low Bray II extractable P, usually in the range of 0 - 10 ppm. Acid soils which contain significant quantities of exchangeable Al can precipitate P

in these soils ( Sanchez and Uehara, 1980 ). Evans and Kamprath ( 1971 ) and Thomas ( 1975 ) demonstrated that increasing the organic matter in a soil could lower the Al saturation, Al toxicity, or both at a given soil pH.

The problem having been noted under field conditions when sesame has been grown on acid soils, with the cause of the problem being suspected but not verified. The present investigation was initiated to determine the effect of burned

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rice husk, aluminum, and phosphorus on growth and P content by sesame seedlings grown on acid soil.

## MATERIALS AND METHODS

A greenhouse study was performed using the topsoil ( 0 to 20 cm ) of a Yasothon sandy loam ( Oxic Paleustult ), collected from the Khon Kaen province in Northeast Thailand. Clay pots, lined with plastic bags, were filled with 4,000 g of air - dry soil for the study. Treatments were 0, 1.25, and 2.5% of burned rice husk; 0, 25, 50 and 100 mg kg<sup>-1</sup> Al ( AlCl<sub>3</sub> ), and 0, 6, and 18 ppm P ( Ca(H<sub>2</sub>PO<sub>4</sub>)<sub>2</sub> · H<sub>2</sub>O ). The soils were also treated with urea and KCl at rates providing 94 kgN and 94 kgK<sub>2</sub>O/ha, respectively. The burned rice husk, aluminum, phosphorus, and fertilizers were thoroughly mixed with the soil in each pot. The pot mixture was incubated for two weeks at field capacity. Ten sesame seeds of the variety Roi Et 1 were planted per pot and later thinned to four plants per pot 7 days after germination. The 3 × 4 × 3 factorial experiment was laid out in randomized complete block design with three replications.

Harvesting took place at 30 days with plant being separated into shoots and roots, these being dried at 70°C for dry weight determination. The shoot components were ground, dry ashed and digested for analysis. Phosphorus content in the digest was measured colorimetrically using the vanadomolybdophosphoric yellow method ( Jackson, 1973 ). The soil remaining in the pots was sampled for determination of pH ( 1 : 1, soil/water ) and Bray II extractable P ( 0.1N HCl + 0.03 N NH<sub>4</sub>F ) as determined colorimetrically by the molybdenum blue method ( Jackson, 1973 ). The data were subjected to analysis of variance, linear regression and correlation analyses.

## RESULTS AND DISCUSSION

### Soil Chemical Properties

The addition of burned rice husk to Yasothon soil significantly increased soil pH ( Tables 1 and 2 ), rising from pH of 5.71 in the control treatment, to pH 7.01 with 2.5% burned rice husk. This rise in pH was probably due to the release of K, Ca, and Mg as a result of burning the rice husk. Lerner and Utzinger ( 1986 ) found that increased rates of application of wood ash which high in K, Ca, Mg constituent increased soil pH. Seripong ( 1988 ) also showed that burned rice husk had 1.08, 0.31, and 0.19% of K<sub>2</sub>O, CaO, and MgO, respectively.

Increasing the rate of aluminum application reduced soil pH from 5.71 to 5.35 at the highest rate ( Table 2 ). Brady ( 1974 ) reports that the effect of the aluminum ions in the soil solution is to contribute to soil acidity through their tendency to hydrolyze. Veith ( 1977 ) also found that H<sup>+</sup> in the exchangeable acidity of various Al<sup>3+</sup> saturated exchangers was a result of hydrolysis of exchanged Al<sup>3+</sup> and of adsorbed non - exchangeable Al.

The data in Table 2 illustrate that the concentration of extractable P in the Yasothon soil was affected by both phosphorus and burned rice husk treatments. As expected, the Bray II extractable P was significantly increased by increasing the P supplied from 0 ppm P to 18 ppm P. Likewise, burned rice husk treatments resulted in a significant increase in P extracted by Bray II extractant. The extractable soil P increased from 5.73 to 37.50 ppm with increasing rates of burned rice husk. This was presumably due to the burned rice husk on raising the soil pH ( Table 2 ). Jones ( 1982 ) has clearly shown that the availability of phosphorus is influenced by soil acidity. In general, the release of inorganic phosphorus from organic materials added to the soil is governed by

**Table 1 Summary of Results of Analysis of Variance for shoot and root dry weights, shoot P concentration and P uptake, soil pH and extractable soil P.**

Source	Degrees of Freedom ( DF )	Mean Square ( MS )					
		Dry Weight		P Shoot Content		Soil Properties	
		shoots	roots	conc.	uptake	pH	extractable P
Blocks	2	0.716	0.008	0.002	11.612	0.266	65.865
Burned rice husk ( A )	2	1.335**	0.010**	0.182**	74.288**	9.232**	7743.626**
Aluminum ( B )	3	1.863**	0.022**	0.014*	41.257**	1.086**	1.673±
Phosphorus ( C )	2	3.308**	0.033**	0.174**	125.074**	0.050±	900.469**
AB	6	0.134±	0.001±	0.006±	1.192±	0.028±	5.617±
AC	4	1.182**	0.011**	0.010*	16.755**	0.077±	16.814±
BC	6	0.124±	0.001±	0.003±	2.844±	0.024±	4.287±
ABC	12	0.131±	0.002±	0.003±	2.496±	0.048±	3.694±
Error	70	0.123	0.001	0.004	2.209	0.057	16.100

\*, \*\* Significant at the 5 and 1% levels, respectively. ± Nonsignificant.

**Table 2 Effect of burned rice husk, aluminum and phosphorus on pH and Bray - II extractable P in the Yasothon soil at the end of the growing period.**

Aluminum ( mgkg <sup>-1</sup> Al )	Percent Burned Rice Husk								
	0%			1.25%			2.5%		
	ppm of P			ppm of P			ppm of P		
	0	6	18	0	6	18	0	6	18
	Soil pH ( 1 : 1 H <sub>2</sub> O )								
0	5.71	5.84	5.92	6.10	6.18	6.19	7.01	6.91	6.56
25	5.64	5.62	5.76	6.04	6.06	5.95	6.48	6.91	6.44
50	5.45	5.45	5.61	5.87	5.90	5.83	6.29	6.62	6.45
100	5.35	5.38	5.34	5.62	5.56	5.66	6.42	6.40	6.50
LSD ( 0.05 ) for burned rice husk	0.112								
LSD ( 0.05 ) for aluminum	0.129								
	Available P ( Bray - II ), ppm								
0	5.73	8.65	15.83	19.90	22.71	29.17	37.50	41.46	43.86
25	6.77	7.81	16.46	18.54	22.92	30.84	32.61	39.27	44.69
50	6.04	9.27	15.73	19.06	24.69	29.90	32.81	42.19	44.67
100	6.88	10.10	17.29	19.27	21.88	28.13	34.80	39.38	43.56
LSD ( 0.05 ) for burned rice husk	1.886								
LSD ( 0.05 ) phosphorus	1.886								

phosphorus from organic materials added to the soil is governed by phosphorus content of the organic materials in relation to microbial demand for this element. Enwezor ( 1976 ) reports that initial P immobilization occurs when organic materials with C : P ranges from 501 to 112 decompose in the soil.

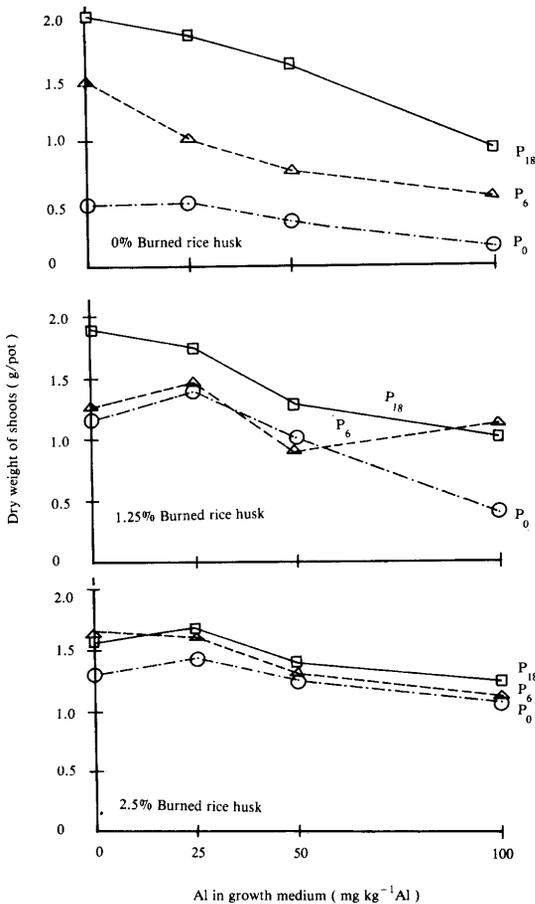
**Growth of Shoots and Roots**

The dry weight of shoots decreased with increasing Al application ( Figure 1 ), declining from a mean pot yield of 0.44 g/pot for the control treatment, to 0.12 g/pot for 100 mgkg<sup>-1</sup> Al treatment. At 100 mgkg<sup>-1</sup> Al, the plants appeared to

have very little live tissue. The decrease in dry weight was highly correlated with the increased rate of Al application (  $r = -0.76^{**}$ ; Table 3 ). This decrease was reduced with the addition of burned rice husk and phosphorus. The slope of the linear regression, b, derived from the results of the Al treatments was halved by the addition of 2.5% burned rice husk when compared to the Al treatment alone ( from  $b = -0.004$  to  $-0.003$ ; Table 3 ). It was reduced to 15 - 20% when the addition of the burned rice husk was combined with the 18 ppm P, when compared to the application of 18 ppm P without the addition of the burned rice husk ( from  $b = -0.011$  to  $-0.002$  ).

The dry weight of shoots increased significantly as the burned rice husk was added ( Figure 1 ), rising from 0.44 g/pot at 0% burned rice husk to 1.32 g/pot at 2.5% burned rice husk. The phosphorus treatment alone also increased dry matter production, rising from 0.44 g/pot at 0 ppm P to 2.02 g/pot at 18 ppm P. The data showed that phosphorus applications of 6 and 18 ppm P resulted in significantly higher dry matter production than the addition of burned rice husk with no phosphorus. The Bray II extractable soil P was considered very low for plants ( Table 2 ) and a yield response was expected to P application.

Root yield responded similarly to the shoots in the various treatments ( Table 4 ). Again, the dry weight of roots was reduced as the level of Al was increased. Root appearance is shown in Figure 2. At 100 mgkg<sup>-1</sup> Al, primary root growth was reduced and lateral growth appeared inhibited, with few branches. Marschner ( 1986 ) reports that signs of aluminum toxicity first appear in the root system which becomes stubby as a result of the inhibition of elongation of the main axis and lateral roots. In contrast, root growth was improved by the addition of phosphorus and burned rice husk treatments ( Figure 3 and 4 ). These results agree with those of Sewell



**Figure 1. Dry weight of Sesame shoots as affected by burned rice husk, aluminum, and phosphorus rates.**

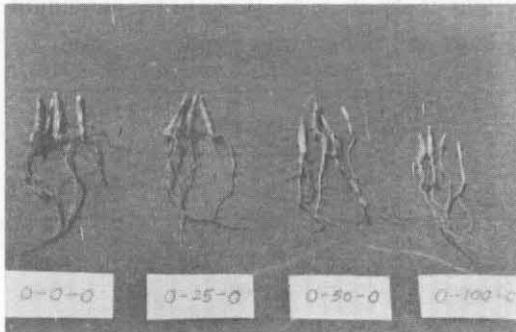


Figure 2. Root growth of sesame plants at 0, 25, 50, and 100 mgkg<sup>-1</sup> Al in the absence of burned rice husk and phosphorus applications. ( left to right )

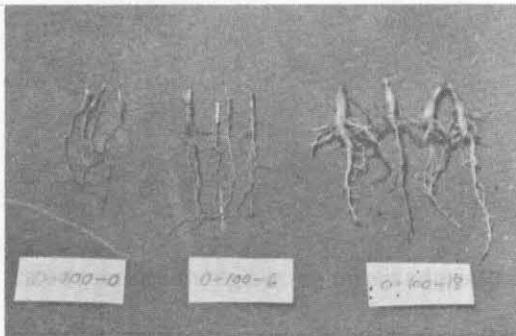


Figure 3. Root growth of sesame plants at 100 mgkg<sup>-1</sup> Al, receiving 0, 6, and 18 ppm P. ( left to right )

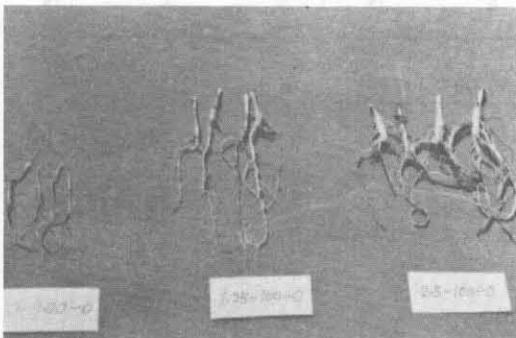


Figure 4. Root growth of sesame plants at 100 mgkg<sup>-1</sup> Al, receiving 0, 1.25, and 2.5% burned rice husk. ( left to right ).

and Ozanne ( 1970 ) who found that proliferation of roots near the soil surface was largely due to P.

### P Accumulation in Shoots

Data for P concentration and total P content of shoots as influenced by burned rice husk, aluminum, and phosphorus are shown in Table 5. As expected, concentration of P and total P content of shoots increased with increased level of P application. Total P content followed the same pattern as for dry matter yield ( Table 5 ). For 30 - d - old plants grown at 0 mgkg<sup>-1</sup> Al and 0% burned rice husk, P concentration and total P content were 0.26% and 1.18 mg/pot, respectively; at the highest P application rate they had risen to 0.43% and 8.81 mg/pot, respectively. The response to added P was obtained due to extreme P deficiency, as indicated by the very low Bray II extractable P in this soil ( Table 2 ). With applications of burned rice husk from 0 to 2.5% ( at 0 ppm P ), both the P concentration and total P content of the shoots increased markedly ( Table 5 ). This was probably due to burned rice husk increased the availability of soil P ( Table 2 ). The increased P content found in the shoots of plants as a result of the use of amendment materials agrees with results reported by Mbagwu ( 1985 ) who found that total P content in maize tops increased when the soil was amended with rice husk.

The P concentration and total P content of the shoots decreased with increasing rates of Al application ( Table 5 ). In the data for plant growth, a marked reduction in shoot and root growth were noted due to the presence of Al in the growth medium ( Figure 1 and Table 4 ), which reduced the plant's demand for nutrients and lowered total uptake. Baligar *et al.* ( 1987 ) also found that there were significant inverse relationships between P uptake and Al concentration in shoots under varying Al treatments. The authors also showed the order of Al inhibition of the content of macronutrients in red clover cultivars to be Ca > Na > P > Mg > S > K; for

**Table 3** Linear regressions and correlations of dry weight of shoots as functions of the aluminum added at each combination of burned rice husk and phosphorus application rate.

	Phosphorus added ( ppm of P )	Burned rice husk added ( % )		
		0	1.25	2.5
0	Intercept ( a )	0.49	1.39	1.42
	Slope ( b )	-0.004	-0.009	-0.003
	Correlation coefficient ( r )	-0.76**	-0.71**	-0.38
6	Intercept ( a )	1.35	1.31	1.70
	Slope ( b )	-0.009	-0.002	-0.006
	Correlation coefficient ( r )	-0.90**	-0.18	-0.57*
18	Intercept ( a )	2.09	1.92	1.41
	Slope ( b )	-0.011	-0.009	-0.002
	Correlation coefficient ( r )	-0.76**	-0.75**	-0.13

\* , \*\* Significant at the 5 and 1% levels, respectively.

**Table 4** Effect of burned rice husk, aluminum, and phosphorus on dry weight of sesame roots.

Aluminum ( mg kg <sup>-1</sup> Al )	Percent Burned Rice Husk								
	0%			1.25%			2.5%		
	ppm of P			ppm of P			ppm of P		
	0	6	18	0	6	18	0	6	18
	<b>Dry weight of roots ( g/pot )</b>								
0	0.04	0.13	0.20	0.11	0.14	0.19	0.15	0.14	0.16
25	0.03	0.13	0.17	0.18	0.14	0.14	0.11	0.12	0.19
50	0.03	0.08	0.18	0.10	0.10	0.13	0.10	0.12	0.12
100	0.02	0.04	0.10	0.04	0.12	0.09	0.12	0.09	0.09
LSD ( 0.05 ) for burned rice husk				0.014					
LSD ( 0.05 ) for aluminum				0.017					
LSD ( 0.05 ) for phosphorus				0.014					
LSD ( 0.05 ) for burned rice husk × phosphorus				0.025					

**Table 5** Effect of burned rice husk, aluminum, and phosphorus on P concentration and total P content in shoots of sesame seedlings.

Aluminum ( mg kg <sup>-1</sup> Al )	Percent Burned Rice Husk								
	0%			1.25%			2.5%		
	ppm of P			ppm of P			ppm of P		
	0	6	18	0	6	18	0	6	18
	<b>P concentration ( ppm )</b>								
0	0.26	0.27	0.43	0.31	0.39	0.48	0.54	0.53	0.52
25	0.23	0.37	0.41	0.29	0.34	0.42	0.43	0.44	0.48
50	0.25	0.31	0.38	0.28	0.36	0.47	0.38	0.43	0.52
100	0.23	0.29	0.42	0.28	0.32	0.46	0.37	0.40	0.48
LSD ( 0.05 ) for burned rice husk				0.029					
LSD ( 0.05 ) for aluminum				0.034					
LSD ( 0.05 ) for phosphorus				0.029					
LSD ( 0.05 ) for burned rice husk × phosphorus				0.051					
	<b>Total P content ( mg/pot )</b>								
0	1.18	4.04	8.81	3.73	4.93	9.23	6.65	8.91	8.66
25	1.03	3.95	7.73	4.20	4.93	7.38	6.44	7.18	5.27
50	0.81	2.40	6.07	2.86	3.25	6.29	4.86	5.43	7.35
100	0.30	1.64	3.90	1.11	3.73	4.66	4.04	4.21	5.76
LSD ( 0.05 ) for burned rice husk				0.696					
LSD ( 0.05 ) for aluminum				0.804					
LSD ( 0.05 ) for phosphorus				0.696					
LSD ( 0.05 ) for burned rice husk × phosphorus				1.206					

micronutrients it was Fe > Mn. Aluminum may also affect the uptake of phosphorus directly through the precipitation of aluminum phosphate at the root surface and/or within the root tissue itself ( Marschner, 1986 ).

### CONCLUSIONS

The results indicated that sesame growth on Yasothon soil were severely affected by increased Al treatments. Burned rice husk application enhances sesame growth by increased the

availability of soil P and reducing Al toxicity. Adequate P content in the soil appears to be the key for sesame grown in this acid soil. Additional studies are needed to evaluate these management practices under field conditions on different soils with various crops.

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