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Residues of *Aleurites fordii* (Euphorbiaceae) as a Component for Plant Substrates

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Abstract

The Chinese Tung tree is cultivated to obtain the raw material for the tung oil industry. Tung husk (TH) is a by-product of this industry, composed of seed coats and fruit walls. The high content of long-lasting fibers suggests that TH could be appropriate to be mixed in substrates for potted plants. This study was conducted to verify the properties of TH as a component for growing media. Samples of 6-month-aged TH were separated into granulometric fractions: <4.75 mm; >4.75 <9.5 mm; >9.5 <16 mm; <9.5 mm, and <30 mm representing the whole sample as received. TH presented about 80% DM of particles <9.5 mm with a large amount (22% DM) of very fine particles <0.5 mm. Particles > 9.5 mm represented about 11% DM. All size fractions showed high values of CEC (40 to 50 $cmol_c$ L^{-1}) and pH 7. The natural salinity was low (0.3 to 0.4 g KCl L^{-1}), adequate even to the most sensitive plants. The effect of particle sizes was more evident on the physical properties. Smaller particles influenced the values of bulk density, total porosity, easily available water and remaining moisture at 100 hPa, increasing density, porosity and water retention in micropores. A high amount of humidity even after the drainage at 100 hPa is characteristic for TH, especially in samples with smaller particles. Differences in mechanical impedance were observed between loose and firmed samples, especially for the smaller particle size. Loose samples with particles sizes < 9,5 mm showed less resistance to penetration (< 100 kPa) while all of the others can be classified as of intermediate resistance (> 100 kPa). Considering the analyzed properties, TH is suitable as a potting media component. The excessive moisture retention in micropores, however, can limit the use of TH in plugs and shallow containers.

INTRODUCTION

Most greenhouse crops are grown in lightweight soilless media, which are combinations of two or more components, formulated to achieve desirable chemical and physical properties (Fonteno et al., 1981). Using local available residues helps to reduce the costs of the mixtures. The Tung tree (*Aleurites fordii* Hemsl. - Euphorbiaceae) is native from China and has been cultivated by small farmers in Rio Grande do Sul (RS), Brazil, since the beginning of the 20th Century. Tung oil, also known as wood-oil, is a raw material for the manufacture of resins, varnishes, paints and other correlated products.

The fruit contains heavy-shelled seeds with the kernels from which the oil is obtained. “Tung husk” (TH) is a by-product of this industry, composed of two anatomical parts of the fruit: fruit wall (pericarp) and the hard outer seed coat (testa), which are separated from the kernel (endosperm) before the oil extraction. The middle layer of the pericarp (mesocarp) is rich in long-lasting fibers, so the wall pieces do not deteriorate rapidly. Rose and chrysanthemum producers in RS have been using TH as organic matter for soil amendment. The high level of fibers in the fruit walls (50.6 %), according to Gengling (2001) and the low rate of their decomposition suggest that TH could be appropriate to be mixed in substrates for potted plants. This study was conducted to verify the properties of Tung husks as a component for growing media.

MATERIALS AND METHODS

Samples of 6-month-aged TH were separated into granulometric fractions, here considered as five treatments: 1. <4.75 mm; 2. >4.75 <9.5 mm; 3. >9.5 <16 mm; 4. <9.5 mm, and 5. the whole sample “as received” (<30 mm). The particle size was gravimetrically determined using 100 g oven dry samples (Drzal et al., 1999) in five replications, sieved and shaken with a Ro-tap shaker at 160 rpm for three minutes using standard sieves with openings of 0.5, 1, 2, 4.75, 9.5 and 16 mm. The pH value (H_2O 1:2.5 v: v), salinity and bulk density (BD) were determined according to Röber and Schaller (1985). Cation exchange capacity (CEC) was evaluated following Tedesco et al. (1985). Water release curves (De Boodt & Verdonck, 1972) were measured to determine total porosity (TP), air space (AS), easily available water (EAW), water buffering capacity (WBC), and remaining moisture at 100 hPa (RW_{100}), defined by Haynes and Goh (1978) as micropore water. The penetrability of TH was measured through the mechanical impedance (Kämpf et al., 1999). Plastic pots (volume capacity: 470 ml) were filled with samples of the five treatments at two levels of compaction: 1. Loose (lightly compressed under the impact of a three times repeated fall from a vertical height of 1 cm) and 2. Firmed (filled with the in Table 3 defined bulk density). The required pressure to penetrate a pointed metal probe of 6.5 mm diameter vertically 5 cm into the medium was measured with a penetrometer (Chatillon Digital Force Gauge) as Peak C (compression). The pressure (Q) is calculated by $Q=F/A$ (Bengough & Mullins, 1990), where F is the value displayed on the penetrometer in Newton and A is the cross-sectional area of the probe. Data were analyzed by ANOVA and Correlation (SAS, 1999) with mean separation by Tukey’s LSD at $p < 0.05$.

RESULTS AND DISCUSSION

Six-month-aged TH presented about 80% of the particles smaller than 9.5 mm with a large amount (22% DM) of very fine particles < 0.5 mm (Table 1). Particles <4.75 mm were mainly fragments of mesocarpic fibers, whereas particles > 4.75 mm were broken pieces of fruit walls and some whole seed coats. Particles > 9.5 mm (11,5%), ranging up to 30 mm, represented empty seed coats and partially decomposed fruit walls. Some TH properties varied according to the grain size of the samples (Table 2). Although the values of CEC are considered high in all samples (Fonteno, 1996), significant differences can be observed between the treatments 2 and 3. The natural salinity was low, adequate even to the most sensitive plants (Penningsfeld, 1983). Considering the concentration of total dissolved salts (as g KCl per liter substrate) there are significant differences among the treatments and these values are correlated ($R^2 = 0.97$; P> I R I 0.006 - Pearson Correlation) to the dry bulk density of the samples (Table 3).The pH value was similar in all fractions, but for many potted plants a pH 7.0 is considered too high for mixtures based on organic matter (Handreck & Black, 1999). The effect of the particle sizes is more evident on the physical properties. The presence of smaller particles in the samples of the treatments 1, 4 and 5 had influences on BD, TP, EAW and RW_{100}. Smaller grains clog the pores between the bigger particles (Handreck & Black, 1999) increasing density, porosity and water retention in the micropores.

The moisture release curve was similar between the samples "as received" (< 30 mm) and < 9.5 mm (Figure 1). The small amount of large pieces (>9.5 mm) in the original sample (11.5% by weight) was not able to modify the pattern of water release. A high amount of humidity even after the drainage at 100 hPa is characteristic for TH, especially in samples with smaller particles. According to Bierbaum et al. (1999), high water holding capacity is a possible advantage to reduce water runoff. Although, the excessive moisture retention in micropores can limit the use of TH in plugs and shallow containers, where the limited drainage could lead to anaerobic conditions. Hence, depending on the size and shape of the container this property must be considered when choosing a conditioner material for mixtures. A parallel study using TH as rooting medium for chrysanthemum cuttings showed better results when this material was blended with carbonized rice hulls (Gruszynski et al., 2000).

Differences in mechanical impedance were observed between loose and firmed samples, especially for the smaller particle size (Table 4). According to the Soil Survey Manual (USDA, 1993) the treatments Loose 1, 2 and 4 (particles size < 9,5 mm) showed small resistance to penetration (< 100 kPa) while all of the others can be classified as of intermediate resistance (> 100 kPa). This effect is evident in the graphics of Figure 2.

CONCLUSIONS

Considering the analyzed properties, Tung Husks (TH) is suitable as a potting media component. All size fractions showed low density, high cation exchange capacity, high total porosity and small to intermediate mechanical impedance. To correct its high moisture retention in micropores, TH should be mixed to materials with good drainage. Further studies should be done to verify plant response and eventual presence of phytotoxic compounds.

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Tables

Table 1. Particle size distribution of Tung Husks.

Particle Size (mm)	% of Dry Weight	Standard Deviation	Accumulated %
<0.50	21.82	1.52	21.82
0.50 -1.00	8.52	1.18	30.34
1.00 - 2.00	11.98	1.37	42.32
2.00 - 4.75	22.02	1.31	64.34
4.75 - 9,50	24.19	0.91	88.53
9,50 -16	8.31	2.75	96.84
>16	3.16	3.55	100.00

Table 2. Salinity, pH value and cation exchange capacity (CEC) of the granulometric fractions of Tung Husks.

Granulometric Fraction	Salinity (1:10)		pH	CEC
	as g KCl L^{-1} substrate	EC µS cm^{-1} (25°C) [1]	H_2O (1:2,5)	$cmol_c$ dl^{-1} [1]
< 4.75 mm	0,44 a	200.0 a	7,0 ±0,0	49,95 a
4.75- 9.5 mm	0,39 b	197.5 a	7,0 ±0,0	39,5 b
9.5- 16 mm	0,31 c	174.5 b	7,1 ±0,0	51,3 a
<9.5 mm	0,44 a	193.0 a	7,0 ±0,0	47,9 ab
<30 mm ("as received")	0,43 a	188.5 ab	7,0 ±0,0	45,7 ab

[1]Mean separation in columns by Tukey Test , P<0.05

Table 3. Dry bulk density (BD), total porosity (TP), air space (AS), easily available water (EAW), water buffering capacity (WBC) and remaining moisture at 100 hPa (RW_{100}).[1]

Granulometric Fraction	BD kg m^{-3}	TP $m^3\ m^{-3}$	AS $m^3\ m^{-3}$	EAW $m^3\ m^{-3}$	WBC $m^3\ m^{-3}$	RW_{100} $m^3\ m^{-3}$
< 4.75 mm	179 a	0,94 a	0,37 ab	0,20 a	0,01 a	0,35 ab
4.75- 9.5 mm	163 b	0,85 a	0,44 a	0,07 d	0,01 a	0,33 b
9.5- 16 mm	151 b	0,72 b	0,34 b	0,09 c	0,01 a	0,28 c
<9.5 mm	184 a	0,90 a	0,38 ab	0,13 b	0,01 a	0,37 ab
<30 mm ("as received")	178 a	0,89 a	0,38 ab	0,13 b	0,01 a	0,38 a

[1]Mean separation in columns by Tukey Test, P<0.05

Table 4. Effect of the particle size of Tung Husks on the mechanical impedance (kPa), measured in 470 ml pots under two levels of packing density.

Average (n=10)	<4,75 mm	>4,5 <9,5mm	>9,5 <16mm	<9,5mm	<30mm
Loose	33,95	84,48	149,98	97,58	125,92
Firmed [1]	162,01	187,67	174,57	195,96	211,73

[1] The pots were filled after the bulk density as given in Table 3

Figures

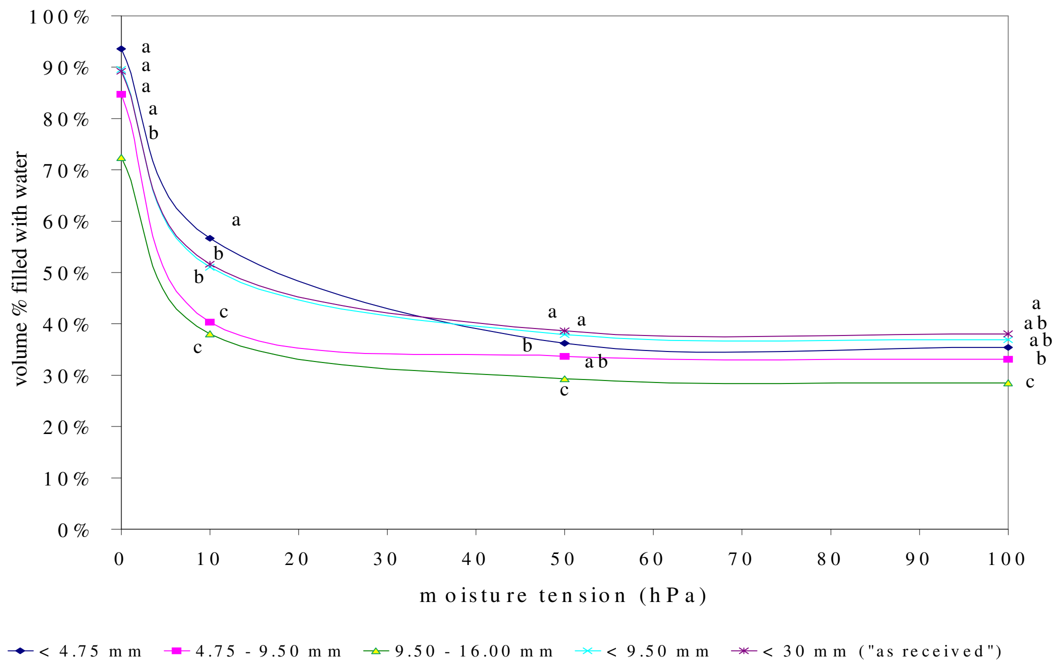

Fig.1. Moisture release curves of the Tung Husks size fractions. Mean separation by each moisture tension according Tukey Test P<0.05.

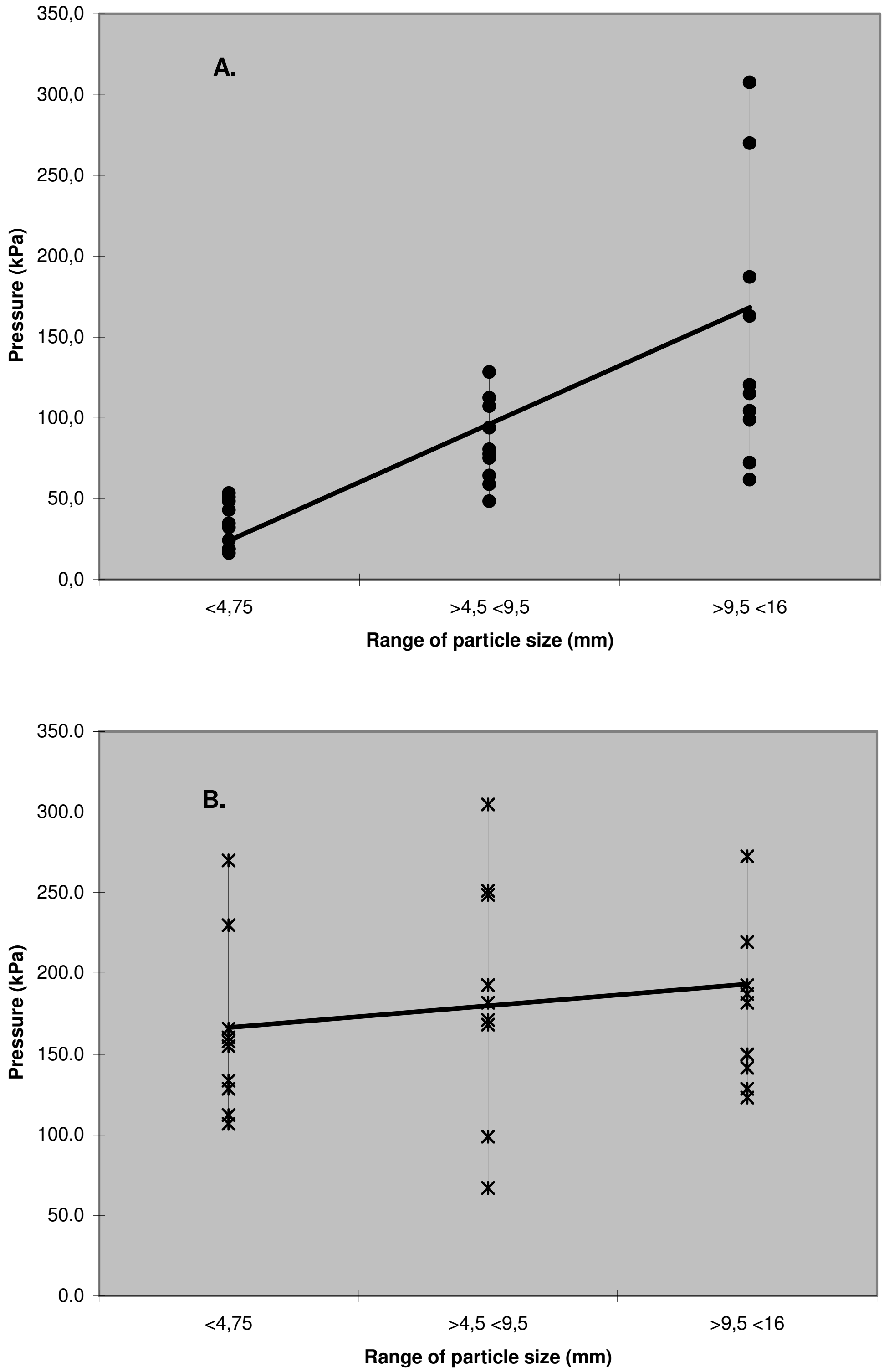

Fig. 2. Effect of three ranges of particle size on the mechanical impedance of Tung Husks in pots filled under two packing levels: A. Loose, B. Firmed. Trend Line of average values.