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Production of lettuce seedlings in substrates with tung compost, carbonized rice husk and earthworm humus

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ABSTRACT

Different properties of substrates based on tung compost (TC), carbonized rice husk (CRH) and earthworm humus (H) were analyzed, besides the effect of the formulations on the production of lettuce seedlings, cv. Veneranda. The experiment was carried out in Pelotas, Rio Grande do Sul State, Brazil, from December 2012 to February 2013, in a greenhouse, using completely randomized design with seven treatments and three replications. The used substrates were formulated on a volume basis: T1= commercial substrate S10® (control); T2= 90% carbonized rice husk (CRH) + 10% humus (H); T3= 75% CRH + 15% tung compost (TC) + 10% H; T4= 55% CRH + 35% TC + 10% H; T5= 35% CRH + 55% TC + 10% H; T6= 15% CRH + 75% TC + 10% H; T7= 90% TC + 10% H. Seedlings were produced in polystyrene trays with 200 cells, being evaluated 35 days after sowing. The substrate with larger proportion of CRH (T2 with 90% CRH) showed suitable dry density (DD) and total porosity (TP), high pH and aeration space (AS), low easily available water (EAW), electric conductivity (EC), and nutrient content, constituting an inert substrate, not being indicated as substrate due to the lower development of the seedlings. Using 15% TC, an increase was noticed in DD, AEW, EC and nutrients and, a decrease in TP, AS and pH due to, mainly, the size of tung compost particles, which accommodated themselves and altered physical and chemical properties of the substrates. Substrates with 90% and 75% TC (T7 and T6) provided the greatest shoot length, fresh and dry shoot mass and leaf area for lettuce seedlings due to higher nutrient content, also considering physical and chemical properties of these substrates. Pure CRH is not indicated to be used as substrate, but mixed with tung compost (T6), it provides high quality seedlings. Tung compost was effective in producing lettuce seedlings, since the composting is able to eliminate phytotoxic substances from this material which can hinder the seedling growth.

Keywords: *Lactuca sativa*, *Aleurites fordii*, chemical and physical properties.

RESUMO

Produção de mudas de alface em substratos com composto de tungue, casca de arroz carbonizada e húmus de minhoca

Analisou-se diferentes características em substratos a base de composto de tungue (TC), casca de arroz carbonizada (CRH) e húmus de minhoca (H), assim como, o efeito das formulações na produção de mudas de alface, cv. Veneranda. O experimento foi realizado no município de Pelotas-RS, de dezembro de 2012 a fevereiro de 2013, em casa de vegetação, utilizando delineamento experimental inteiramente casualizado com sete tratamentos e três repetições. Os substratos utilizados foram formulados em base de volume: T1= substrato comercial S10® (controle); T2= 90% CRH + 10% H; T3= 75% CRH + 15% TC + 10% H; T4= 55% CRH + 35% TC + 10% H; T5= 35% CRH +55% TC+10% H; T6= 15% CRH + 75% TC + 10% H; T7= 90% TC + 10% H. As mudas foram produzidas em bandejas de poliestireno expandido de 200 células e, aos 35 dias após a semeadura, foram avaliadas. O substrato com maior proporção de CRH (T2 with 90% CRH) teve densidade seca (DD) e porosidade total (TP) adequadas, altos pH e espaço de aeração (AS) e baixos água facilmente disponível (EAW), condutividade elétrica (EC) e teor de nutrientes, constituindo-se em um substrato inerte, não sendo indicado como substrato devido ao menor desenvolvimento das mudas. A partir de 15% de TC houve um aumento na DD, AEW, EC e nutrientes e redução na TP, AS e pH devido principalmente ao tamanho e composição das partículas do composto de tungue, que se acomodaram e alteraram as características físicas e químicas dos substratos. Substratos com 90% e 75% de TC (T7 e T6) proporcionaram o maior comprimento da parte aérea, massa fresca e seca da parte aérea e área foliar na mudas de alface, devido ao maior teor de nutrientes, aliado as características físicas e químicas desses substratos. A CRH pura não é indicada para uso como substrato, mas em mistura com o composto de tungue (T6) proporcionou a obtenção de mudas de qualidade. O composto de tungue foi eficiente em produzir mudas de alface, desde que a compostagem seja realizada de forma correta para eliminar os compostos fitotoxicos presentes neste material que poderiam prejudicar o desenvolvimento das mudas.

Palavras-chave: *Lactuca sativa*, *Aleurites fordii*, características físicas e químicas.

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In vegetable production, the seedling quality is one of the fundamental requirements for the productive system (Minami, 2010), making the exploitation of vegetable crops more competitive as it guarantees productivity and reduces risks for crops (Reghin *et al.*, 2007). Therefore, this is a determining factor for the suitable final plant performance in the production seedbeds. The use of high-quality seedlings, grown in trays containing substrate, provides higher yield in relation to traditional methods, since it induces higher precocity, for its lower possibility of contamination by phytopathogens, also spending less on seeds, besides providing more favorable conditions for seedling root system development (Lima *et al.*, 2009).

Substrates for vegetable seedling production should provide 20 to 30% of easily-available water, oxygen and nutrients, pH value from 5.0 to 5.8 (Kämpf, 2005), electric conductivity from 2.0 to 3.5 dS/m (Gruszynski, 2002), good drainage and low density. The substrates must be free of diseases and toxic substances (Kämpf, 2005), and also should favorably influence the root system architecture and the nutritional status of the plants (Guerrini & Trigueiro, 2004). All these characteristics in a substrate will promote seed germination and it is appropriate for seedling formation, which will contribute positively to the future crop development to be implanted (Ramos *et al.*, 2002).

Peat is still the main component of the commercial substrates for seedling production, however, in the latest years, concern about environmental impact associated with peat extraction (Bullock *et al.*, 2012) has increased efforts aimed at partial or total replacement of peat in horticulture for low-cost and high-quality alternative materials (Ceglie *et al.*, 2015).

One potential material to be used in the substrate composition is tung compost (*Aleurites fordii*), obtained from the agro-industrial residue of this oilseed, recently used as raw material for biodiesel production since it has about 50 to 60% of oil in its fruits (Cao *et al.*, 2014). From oil extraction process, the resulting residue is the press cake and the husk of the fruit. Since the peel contains high fiber content, it is used as soil conditioner for growing roses and cut-chrysanthemums and it is used as component for substrate composition (Gruszynski, 2002; Fermino *et al.*, 2015). The press cake has also been used in preparing substrates or as organic fertilizer (Gruszynski *et al.*, 2003), due to its high potassium (K) and nitrogen (N) contents (Eicholz, 2013).

However, phenolic compounds can be found in tung husk, like tannin (Gruszynski, 2002; Gruszynski *et al.*, 2003), which in high concentration in the substrate can negatively affect seedling development, since they are toxic to the plants (Nichols, 1981). About this inconvenience, Gruszynski (2002) verified that the tung husk compost had not eliminated the phenolic compounds during one month; however, in the husks which were decomposed for six months in the open area. Such compounds were absent, suggesting that the composting reduces the concentration of these compounds, due to greater decomposition of the material, through leaching by rain. The same author mentions that ferrous sulfate treatment for tannin complexation is indicated, being a practice used by producers in California, as well as, the addition of Polyvinylpyrrolidone, which was effective in inactivation of phenolic toxins in coniferous husk extracts. The composting is a correct and economically feasible method for solid residue treatment (Wei *et al.*, 2014); however, further studies can attest details of the procedures to minimize phenolic compounds in tung residues.

On the other hand, carbonized rice husk has been intensely used as substrate for plants, mainly mixed with other materials, and it is also important for improving final substrate physical properties (Pereira Neto, 2011; Pereira *et al.*, 2011; Freitas *et al.*, 2013). Earthworm humus has also been used for preparing substrates; studies indicated that the humus stimulate the plant mineral nutrition, root development, metabolic processes, respiratory activity, cell growth and flower formation in certain species (Souza & Resende, 2003).

Generally, the substrates are prepared with different raw materials and, in this sense; their properties are an appropriate combination of their components. On the other hand, the fraction of a phytotoxic residue minimized by the composting will provide a low concentration of any phytotoxic organic substances in the overall mixture-substrate, which will limit the seedling development. Thus, the aim of this study was to analyze different properties of substrates based on tung compost, carbonized rice husk and earthworm humus, as well as, the effect on lettuce seedling production.

MATERIAL AND METHODS

The experiment was carried out at Estação Experimental Cascata, belonging to the Brazilian Agricultural Research Corporation (Empresa Brasileira de Pesquisa Agropecuária), located in the municipality of Pelotas, Rio Grande do Sul State, Brazil (31º41'S, 52º21'W, altitude 181 m), from December, 2012 to February, 2013, during summer. The experiment was carried out under greenhouse and used polystyrene trays with 200 cells. The experimental design was completely randomized, with 7 treatments and three replications. Each tray represented one replication.

The authors used tung compost (press cake + husk), carbonized rice husk and earthworm humus for the substrates. The press cake and the husk of tung were obtained from a vegetable oil industry, located in the municipality of Fagundes Varela, Rio Grande do Sul State, and, then, composted for six months (Pereira Neto, 2011). The rice husk was carbonized and, to produce the humus, earthworms (*Eusenia andrei*) were used in cattle manure (Schiedeck *et al.*, 2006). The base fertilization consisted of the addition of 10% humus in the tested substrates, besides humus is known as plant resistance inducer.

The substrates used were formulated on a volume basis: T1= commercial substrate S10® (control); T2= 90% carbonized rice husk (CRH) + 10% humus (H); T3= 75% CRH + 15% tung compost (TC) + 10% H; T4= 55% CRH + 35% TC + 10% H; T5= 35% CRH + 55% TC + 10% H; T6= 15% CRH + 75% TC + 10% H; T7= 90% TC + 10% H.

The substrate analyzes were carried out in the Biotechnology Laboratory (Laboratório de Biotecnologia), Substrate Analysis at Agronomy College from UFRGS (Análise de Substratos da

Faculdade de Agronomia da UFRGS). The following data were determined: pH, electrical conductivity (EC), dry density (DD), total porosity (TP), aeration space (AS) and easily-available water (EAW). The interpretations were carried out according to Normative Instruction nº 14, December 15, 2004, of Ministry of Agriculture, which is about plant substrates, with its annexes and additions (IN SDA Nº 17, May 21, 2007 and IN SDA Nº 31, October 23, 2008). Chemical analysis of nutrient content was carried out in Soil Analysis Laboratory at Agronomy College from UFPel (Laboratório de Análise de Solos da Faculdade de Agronomia, UFPel).

During seedling production, the temperature management in the greenhouse was carried out through lateral curtains and entrance doors, during the hottest hours of the day (9 a.m. to 5 p.m.). The authors used greenhouse covered with polyethylene film, 200 micron thickness with dimensions of 8x10x3 m (width x length x heigth). Polystyrene trays, with dimensions of 18.5x19.0x11.0 cm, width, length and depth, respectively, and 200 cells were filled with substrates. On theses trays, two to three seeds per cell of lettuce 'Veneranda', crisphead type, were sown. Eight days after sowing, thinning was carried out, and one plant per cell of the tray was left. We evaluated daily the number of emerged seeds, considering emerged seeds, the seedlings which showed totally free and normal cotyledons. The percentage of emergency (%E) corresponded to the total percentage of emerged seeds up to the eighth day after sowing. Evaluation of the %E was carried out according to Labouriau & Valadares (1976), which considers the total number of seeds emerged in relation to the total number of seeds placed to germinate.

Final evaluation of the seedlings was carried out at 35 days after sowing, obtaining randomly five plants per tray in order to determine clod structure (CS), length of shoot (LS) and root system (LRS), number of leaves (NL), leaf area (LA), shoot fresh and dry mass (SFM and SDM), root system fresh and dry mass (RSFM and RSDM) of the lettuce seedlings. The clod structure analysis was carried out when the seedlings were removed from the trays, being scored on a scale from 1 (bad, structureless) to 5 (excellent), taking into account the cohesion of the clod. The number of leaves was obtained by counting the number of definitive leaves per plant. Shoot length of the seedlings was determined from the measurement of the base of the plant to the apex of leaves and LRS from base up to greater root volume area, after washing the roots, both with the aid of a ruler graduated in centimeters. Plant roots were washed in containers with water in order to remove the substrate particles adhered to roots and placed on paper towel to remove excess water. Plant root and shoot were weighed using a precision scale to determine SFM and RSFM, after being placed in paper bags, which were kept in a forced-air oven at 65°C to constant weight to determine SDM and RSDM. Leaf area was determined in a LI-3100 leaf area meter, by measuring all the leaves. When necessary, the authors made data transformation and the results were submitted to analysis of variance and the averages were compared using the Tukey test, at 5% probability.

RESULTS AND DISCUSSION

Substrate properties

As increased the proportion of the tung compost (TC), dry density (DD) and easily-available water (EAW) increased and total porosity (TP) and aeration space (AS) decreased (Table 1). This must be related to the decrease of the particle size in TC by the composting, damaging physical properties, according to Gruszynski (2002).

Substrates T1, T2, T3 and T4 showed DD values close to the reference values (100 to 300 kg/m^3) to fill the cells of a tray used for vegetable seedling production (Fermino, 2003; Kämpf, 2005), whereas substrates T5, T6 and T7 showed out-of-range values (Table 1). The low dry density of T2, T3 and T4 can be explained due to high CRH proportion in relation to TC, since CRH is known by their physical properties which provide good drainage and low density when added to the substrate (Freitas *et al.*, 2013; Castoldi *et al.*, 2014), being important for improving final substrate physical properties. However, using CRH as pure substrate is inconvenient for producing seedlings from seeds, due to low nutrient content, electric conductivity and easily-available water and high pH and aeration space (Steffen *et al.*, 2010). High dry density of T5, T6 and T7 must be linked to fine particles of TC in these substrates, which accommodate between the CRH particles and fill the empty spaces, increasing dry density. Substrate density should be sufficient to offer support to the plants (Fermino, 2003). Its value cannot be too high, though, due to the direct relation to porosity and consequent aeration and humidity (Fernandes *et al.*, 2006).

The substrates T2 (84.9%) and T3 (83.1%) showed total porosity values (TP) close to be considered optimal, 85% or 0.85 m^3/m^3 (De Boodt & Verdonck, 1972). However, the other substrates showed values lower than recommended; considering that the higher is the proportion of tung compost, the lower is TP value, ranging from 69% (T7) to 76.7% (T4) and 79% (T1) (Table 1). Substrate porosity is one of the properties which tend to change along cultivation due to particle accommodation. Thus, the substrate should have sufficient porosity to allow gas exchange, avoiding lack of oxygen for root respiration, as well as microbial activity (Steffen, 2008).

Recommended aeration space is between 20 to 40% (De Boodt & Verdonck, 1972; Abad & Noguera, 2000; Fermino, 2003) as of T5 (29.9%). High values as shown by substrates T2 (69%), T3 (55.4%) and T4 (44.8%) (Table 1) can cause water deficit in plants, especially when irrigation is infrequent. The reduced values, as T1 (16.5%), T6 (16%) and T7 (13.6%) (Table 1), can cause lack of oxygen for root development.

Substrates with higher proportion of tung compost (T6 and T7) and T1 have more easily-available water (EAW), within values considered optimal (20 to 30%) (De Boodt & Verdonck, 1972; Abad & Noguera, 2000), which allow to increase the intervals between irrigations, resulting in using less water to keep substrate moist. In tray cultivation, space has to be limited for root growing, because of this fact it is important that the substrate is able to keep the volume of easily-availabe water for plants without compromising oxygen concentration, though (Bunt, 1961).

In relation to pH, it is observed that the substrates T4, T5, T6 and T7 did not show pH variation among them, from 5.49 (T4) to 5.23 (T7) (Table 1), being these values considered optimal for organic-based substrates (Kämpf, 2005). However, T1, T2 and T3 showed pH 4.20, 9.1 and 6.09 respectively, and these values are out of range, since pH values which are below or above range, considered optimal (5.0 to 5.8), can be harmful to seedling development, may cause physiological imbalances and affect nutrient availability (Kämpf, 2005). High pH value of T2 (9.1) can be related to the management adopted for carbonization process, since as time of carbonization of rice husk increases, pH of the substrate prepared also increases, ranging from 4.37 for the shortest time (18 min) to 9.05 for the longest time (53 min), due to the increase of oxide content (Baitell *et al.*, 2008). This fact was also reported by Kratz *et al.* (2012) who obtained pH ranging from 8.44 to 8.48 in substrates with different grain size of pure CRH or in combination with other components in the production of eucalyptus seedlings.

Substrates T1 and T3 showed electric conductivity suitable for producing seedlings in trays, which is 0.75-2.0 mS/cm, whereas T4 and T5 are close to optimal electric conductivity for most of plants, which ranges from 2.0 to 3.5 mS/cm (Gruszynski, 2002). The other substrates showed values below the optimal (T2) or above (T6 and T7) (Table 1). For every unit increase in EC above 1,3 mS/cm, a 13% reduction in lettuce phytomass can be noticed (Viana *et al.*, 2001), since high soluble salt content can cause burning and necrosis of the roots (Carneiro, 1995). Fabri (2004) observed that lettuce seedlings showed better growth in substrates consisted of barnyard manure and earthworm humus, presenting electrical conductivity 3.73 and 4.87 mS/cm. Buffering is related to organic matter content of the substrates, offering resistance to changes (Silva, 2010).

Table 1. Dry density (DD), total porosity (TP), air space (AS), easily available water (EAW), electric conductivity (EC) and pH in substrates based tung comost (TC), carbonized rice husk (CRH) and earthworm humus (H) . Porto Alegre, UFRGS, 2013.

Substrate	DD (kg/m^3)	TP	AS	EAW	pH	EC (mS/cm)
			(%)			
T1	306.3	79.2	16.5	24.8	4.20	1.45
T2	131.0	84.9	69.0	4.7	9.08	0.28
T3	277.5	83.1	55.4	7.9	6.07	1.73
T4	340.5	76.7	44.8	10.6	5.49	2.60
T5	439.1	72.3	29.9	16.8	5.33	3.73
T6	490.3	70.4	16.0	25.2	5.29	4.47
T7	540.6	68.9	13.6	24.8	5.23	4.82
CV (%)	2.2	2.0	3.6	2.9	2.3	2.7

T1= commercial substrate S10® (control) ; T2= 90% CRH + 10% H; T3= 75% CRH + 15% TC + 10% H; T4= 55% CRH + 35% TC + 10% H; T5= 35% CRH +55% TC + 10% H; T6= 15% CRH + 75% TC + 10% H; T7= 90% TC + 10% H.

Table 2. Emergency percentage {E (%)}, clod stability (CS), number of leaves (NL), length of shoots (LS), fresh and dry mater of shoots (SFM and SDM), fresh and dry mater of roots (RSFM and RSDM) and leaf area (LA) of lettuce seedlings produced in different substrates based tung compost (TC), carbonized rice husk (CRH) and earthworm humus (H) . Porto Alegre, UFRGS, 2013.

Substrate	E (%)	CS	NL	LS[1] (cm)	SFM	SDM	RSFM	RSDM	LA (cm^2/plant)[1]
						(mg/plant)			
T1	99.4	4.9	3.13	3.9	332.4	36.7	31.4	25.2	12.2
T2	100a	3.9a	3.1a	2.2b	121.5b	17.4a	16.5a	13.5a	4.61b
T3	98.9a	4.6a	3.2a	3.5ab	280.7ab	27.0a	28.3a	23.5a	15.4a
T4	84.7a	4.9a	3.3a	3.6ab	305.5ab	24.3a	33.6a	27.8a	12.5a
T5	95.4a	4.1a	3.5a	4.1ab	357.0ab	29.8a	25.6a	21.4a	14.5a
T6	95.9a	4.8a	3.8a	4.6a	381.1ab	26.9a	28.5a	23.9a	15.9a
T7	96.1 a	4.6a	3.6a	6.6a	525.3a	36.6a	27.2a	23.1a	22.9a
CV (%)	11.6	10.4	9.6	14.6	33.3	35.9	33.6	32.5	8.5

Means followed by the same letter at column did not differ by Duncan Test (p<0,01); [1]data transformed through data *log* 10 for statistical analysis T1= commercial substrate S10® (control); T2= 90% CRH + 10% H; T3= 75% CRH + 15% TC + 10% H; T4= 55% CRH + 35% TC + 10% H; T5= 35% CRH +55% TC + 10% H; T6= 15% CRH + 75% TC + 10% H; T7= 90% TC + 10% H.

Table 3. Nutrient content in substrates based on tung compost (TC), carbonized rice husk (CRH) and earthworm humus (H). Porto Alegre, UFRGS, 2013.

Total nutrients (g/kg)	T1	T2	T3	T4	T5	T6	T7
N	10.04	8.48	13.50	15.80	18.35	18.18	26.59
P	1.40	1.11	2.28	2.41	2.18	2.84	7.13
K	5.49	3.40	9.42	10.73	10.20	13.08	28.26
C	4.60	4.39	4.73	4.67	5.41	5.34	18.39
Mg	3.00	2.44	2.55	3.26	3.53	3.59	6.36
S	7.41	1.56	2.09	2.94	3.18	2.41	4.94

T1= commercial substrate S10® (control); T2= 90% CRH + 10% H; T3= 75% CRH + 15% TC + 10% H; T4= 55% CRH + 35% TC + 10% H; T5= 35% CRH +55% TC+10% H; T6= 15% CRH + 75% TC + 10% H; T7= 90% TC + 10% H.

Effect on seedling production

All the substrates were able to grow lettuce seedlings, including T7 which has 90% of TC (Table 2). This fact suggests that the composting was efficient to reduce phenolic compounds to tolerable levels for lettuce. Lettuce is a sensitive species to phenols and in the presence of high concentrations no germination and radicle growth can be noticed and, consequently, plant growth; when the phenol content is reduced, growth of lettuce seedlings is stimulated (Ortega *et al.*, 2006).

Considering the evaluated phytotechnical parameters, those related to percentage of emergency (%E), number of leaves (NL), shoot dry mass (SDM) and root system fresh and dry mass (RSFM and RSDM) showed no statistically significant differences; it means, eventual variations, both physical and chemical properties of the substrates did not interfere on these aspects of the seedlings (Table 2).

The substrates showed a very satisfactory score for clod stability, with exception for T2, with a score lower than 4 (scale from 1 to 5) (Table 2). This suggests that factors related to components of the mixture influence on the clod formation, since T2 was composed mainly of CRH.The best clod structure of substrates T1, T3, T4, T5, T6 and T7 was surely due to the highest TC proportion, which has organic particles and rounded shape, in contrast to CRH which has silica particles and elongated shape promoting less aggregation of the substrate, providing worse conditions for root system development. This factor is important, mainly for seedling transplanting into the soil, since the adhesion of the substrate to the root system, at the time of removing the seedlings from the cells, avoids dryness and root damage, promoting field settings (Tavares Júnior, 2004).

Seedling shoot length (LS) was the longest in T7 and the shortest in T2 (6.6 and 2.2 cm, respectively). And the same results were verified for SFM (525.3 and 121.5 mg/plant) and still, T7 was 200% larger than T2 for SDM, 36.6 and 17.4 mg/plant, respectively (Table 2). This fact can be attributed to the highest nutrient content in the substrates with higher TC proportions (Table 3). Simões *et al.* (2015), evaluating the effect of different substrate conditioners on lettuce seedlings, observed that the substrate (organic compost) promoted higher dry mass accumulation in the seedlings due to higher content and balance of the nutrients in the compost. This provides vigorous lettuce seedling growth (Leal *et al.*, 2011; Carvalho *et al.*, 2012).

Seedlings grown in the substrate from 15% of TC showed 15.4; 12.5; 14.5; 15.9 and 22.9 cm^2 leaf area in the substrates T3, T4, T5, T6 and T7, respectively, being superior to T1 and T2 (Table 2). Plants grown in T2 (90% of CRH) obtained the lowest leaf area value (4.61 cm^2), differing from the other substrates (Table 2), probably, due to low supply of nutrients of this substrate (Table 3) combined with high pH (Table 1), causing nutritional deficiency in seedlings. The obtained results are in accordance with Steffen (2008) evaluating lettuce seedling production under different combinations of earthworm humus and CRH, in which the authors did not observe any seedling growth in 100% CRH substrate, and with Freitas *et al.* (2013) who evaluated the lettuce seedling production under different substrates and proportions of carbonized rice husk and in 100% CRH treatment, observing a reduction of seedling growth, attributing this fact to the low nutrient content of this substrate. The seedling leaf area is important at the beginning of the growth in the field for a higher light interception and its conversion into carbohydrates, necessary to plant growth, especially for green leafy (Larcher, 2004); the higher AF, the higher will be the crop yield.

We concluded that pure CRH is not indicated to be used as substrate, but mixed with tung compost, it provides high quality seedlings. Substrates containing tung compost produced suitable seedlings for lettuce, including the preparation of pure tung compost. Therefore, the tung compost indicates viability to compose substrate aiming to produce lettuce seedlings, since the composting is done properly to eliminate phytotoxic compounds of this material which could hinder seedling development.

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