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ABSTRACT

We examine in this study the possibility of using biodiesel industry waste mixed with urban sewage sludge as a source of nutrients for the production and seedling development in agriculture. Biodiesel industry waste is diatomaceous earth (DE) compounds and paraffin. We added DE with urban sewage sludge. The advantage of this operation is to eliminate the two wastes, residues of the biodiesel industry and sludge from wastewater treatment plants. We studied the behavior of Camaldulensis Eucalyptus and white mulberry (Morus Alba Yu vc-62).

The Dickson Quality Index (DQI) of White Mulberry and Eucalyptus Camaladulensis plants tested in different substrates (urban sewage sludge and DE) are all above the minimum recommended value of 0.2. The Camaladulensis eucalyptus and white mulberry (Morus Alba) plants have good growth in substrates containing urban sewage sludge and diatomaceous earth compared to commercial substrate used as control. Biodiesel industry waste can used up to 50% by volume of the substrate without compromising the quality of the plants with a reduction in the cost of production.

Keywords: Biodiesel, Diatomaceous earth, Sewage sludge, Eucalyptus, Morus Alba

INTRODUCTION

Recently, with the growing demand for biodiesel in the world, several plants for biofuel production, mainly from vegetable oils, are being installed in Brazil. For the elimination of various impurities, both the first and itself biodiesel material, these industries use filters of various types, particularly those using diatomaceous earth (D.E.) as a filter element.

The organic compounds formed from industrial waste can be used as sources of organic matter and nutrients in a substrate [1]. They increase the water retention capacity by improving aeration of the roots of plants and they increase the availability of nutrients from the growth of beneficial microorganisms. Can interfere with the increase of pH and levels of exchangeable cations of substrates.

To avoid environmental problems associated with deposits of residues biodiesel industry, we can use as a source of nutrients for the production and development of plants seems like a very good option. The residue D.E. has specific physical properties that can improve the soil properties.

The D.E. is a naturally occurring, soft, siliceous sedimentary rock, consisting of shells or frustules seaweed, which has many properties. It is a lightweight material with low-density porous structure with low thermal conductivity and non-toxic [2], [3]. At the end of the production, process of biodiesel, it is as a residue impregnated of organic material.

We added the DE residues of Biodiesel with sludge from urban wastewater treatment or manure to stimulate the activity of soil bacterial [4]. The advantage of this operation is to eliminate both wastes, residues Biodiesel industry and sludge treatment plants.

Given the economic and environmental importance of reusing these resources considered as waste, this study aims to evaluate substrate test (DE and sludge sewage) as an alternative for improving the composition of soils for plant production.

MATERIAL AND METHODS

The study was conducted in the period May-August 2014 at the Institute of Agricultural Sciences - ICA, of the Federal University of Minas Gerais - UFMG, Montes Claros, located in northern Minas Gerais state. The climate of the region is semi-arid, hot and dry tropical. The rainy season is concentrated between Octobers to March. The average annual rainfall is 1060 mm and uneven [5]. The experimental substrate was prepared from different proportions of commercial substrate control (Bioplant), DE, sewage sludge (SS) or manure (M) (table 1). Manure from breeding ICA-UFMG. Sewage sludge from the treatment plant wastewater Montes Claros - MG. Diatomaceous earth from the disposition of Petrobras biodiesel plant in Montes Claros, after use as a filtering agent of vegetable oils (soybean). Diatomaceous earth, before use, was submitted to the combustion process for the removal of residual oil.

The pots had a volume of 55 cm3 and the species studied were Camaladulensis Eucalyptus and white mulberry (Morus Alba Yu vc-62). The seeds of Eucalyptus Camaladulensis foram obtained from the ICA / UFMG and seeds of white mulberry Morus Alba vcYu-62 were CIA / Cuba. At the time of sowing three seeds were placed in each pot and 21 days after sowing took place clarified leaving only one plant per pot. The experiment consisted of two tests, one for each species. The experimental design was a randomized complete block design with three replications and four pots per experimental unit.

The composition of the pots were made on April 30 and May 1, 2014. The plants were sown on May 2. A shade sail was used with a rate 30% and 50% shade and was placed 1.5 m above the ground, oriented east-west to provide shade from the experimental unit. This shade sail was removed 30 days after the lifting of plant. Both treatments were irrigated three times daily.

Scanning electron microscopy (SEM) coupled with energy dispersive spectroscopy (EDS). Observations and elemental analyzes were performed on a scanning electron microscope Jeol JSM 6400 coupled to an Oxford EDS analyzer (ENSM-SE). Observations were carried out on secondary electrons mode in the case of granular raw unpolished samples and backscattered electron mode.

Table 1 The materials used and their proportions by volume for each substrate tests

Substrate Tests (ST)	
ST1	100% SC substrate control (Bioplant)
ST2	75% SC + 12.5% SS + 12.5% DE
ST3	75% SC + 12.5% SS + 12.5% DE
ST4	50% SC + 25% SS + 25% DE
ST5	50% SC + 16.7% SS + 33.3% DE
ST6	75% SC + 12.5% M + 12.5% DE
ST7	75% SC + 8.3% M + 16.7% DE
ST8	50% SC + 25% M + 25% DE
ST9	50% SC + 16.7% M + 33.3% DE

Physical and chemical analyzes of different substrates tests and control substrate (commercial substrate Bioplant) were performed at the Laboratory of Solid Waste UFMG following the methodology of Embrapa [6]. The diameter and height of the stem of the plants were measured from the 49th day to the 118th day. Starting at thirty days, we calculated the rate of emergence of two cultures. Where the species reached a height greater than 10 cm and 42 days after planting, we add the ammonium sulfate fertilizer.

The number of leaves per plant was calculated. Fresh weight of shoots, leaves and roots were measured by weighing. After drying in an oven at 65 ° C for 72 hours to constant weight, the dry weight matter was weighed.

We evaluated the relationship between shoot dry weight and root dry weight. All data were subjected to analysis of variance and means were compared by the Scott-Knott test at 5% probability.

Table 2 The chemical characteristics of substrate tests (ST2 to ST9) and substrate control (ST1)

ST	pH	CE											
		dS m^{-1}	P	K	Ca	Mg	H + Al	SB	t	T	V	MO	C
ST1	6.4	1.54	- mg dm^{-3} --		------------------------ cmol$_c$ dm^{-3} -------------						%	--- dag kg^{-1} --	
ST2	6.4	1.72	900	249	7.3	5.4	0.91	13.34	13.34	14.25	94	18.57	10.79
ST3	6.4	1.68	1.020	497	8.2	3.4	2.32	12.88	12.88	15.2	85	38.44	22.34
ST4	6.4	1.64	980	298	9.3	3.0	2.32	13.07	13.07	15.38	85	18.19	10.57
ST5	6.7	1.71	960	497	9.6	3.5	1.38	14.38	14.38	15.75	91	13.6	7.9
ST6	6.9	1.82	880	895	8.0	3.0	1.39	13.30	13.3	14.69	91	14.6	8.48
ST7	6.8	1.78	510	970	7.0	3.6	1.55	13.09	13.09	14.64	89	16.34	9.5
ST8	7.6	1.65	960	990	6.0	4.0	1.55	12.54	12.54	14.09	89	16.7	9.7
ST9	7.5	1.35	960	846	4.0	4.8	0.85	10.97	10.97	11.82	93	16.34	9.5

RESULTS

The pH in the control substrate ST1 chosen as substrates tests mixtures of ST2 to ST4 is the same 6.4; it passes to 6.7 in the mixture T5 (33% of DE). The pH was higher in mixtures with manure between 6.9 and 7.6. The electric conductivity (1.64 to 1.82 dS / m) in the mixtures ST2 to ST8 is higher, compared with control substrate (1.54 dS/m). Except for the case ST9, manure mixture, is very low 1.35 dS/m. K is high 880 mg/dm3 in the mixture T5. K remains high in the mixtures Manure (647-990 mg/dm3) compared with the control substrate (249 mg/dm3). The organic matter (OM), total porosity, water holding capacity (WHC) and density decrease significantly in mixtures ST4, ST5 and ST9 (table 2 and 3).

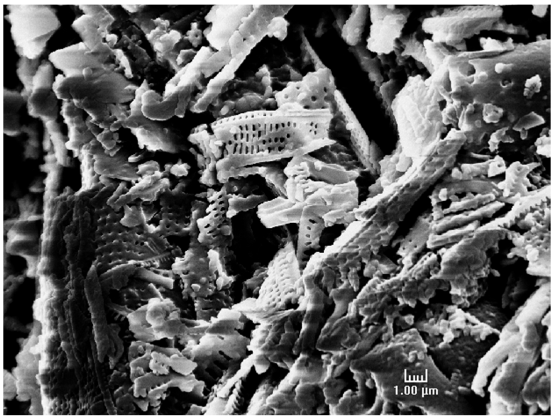

Fig. 1 Image scanning electron microscopy of biodiesel industry waste from Petrobras plant in Montes Claros, MG, Brazil.

The root volume of Eucalyptus Camaldulensis is very low in the ST5 (2.5 cm^3) compared to the control substrate ST1 (3.69 cm^3) or ST2 (5.42 cm^3), ST3 (4.92 cm^3) e ST4 (4.53 cm^3). It is similar to the root volume of Eucalyptus Camaldulensis growing in substrates with manure (1.69 to 3 cm^3). The heights of rods, the diameter, number of leaves and the root volume are determines the seedling quality higher in all the substrates tests than in the control substrate. However, all the morphological characteristics and weight biomass of the seedling in substrates with manure are less than those seedlings growing in substrates tests with sewage sludge and diatomaceous earth. Seedlings treatments ST4 and ST5 have the largest diameter 4.46 mm and 4.76 mm respectively. All other values are higher than the minimum required (2.0 to 2.5 mm). DQI [7] seedlings Morus Alba is high in the treatment with sewage sludge and diatomaceous earth T4 (0.42) and T5 (0.55) and very low in treatment with manure T7 (0.13), T8 (0.18) and T9 (0.11).

Table 3 Water retention capacity (WHC), density (ρ) and total porosity (TP) of substrate tests (ST2 to ST9) and substrate control (ST1).

Substrate tests	WHC	ρ	TP
	mL g^{-1}	gcm^{-3}	%
ST1	0.56	0.35	64.7
ST2	0.49	0.46	73.4
ST3	0.42	0.47	62.2
ST4	0.38	0.55	58.4
ST5	0.43	0.55	56.3
ST6	0.60	0.43	63.5
ST7	0.53	0.43	64.3
ST8	0.57	0.46	64.4
ST9	0.44	0.50	62.6

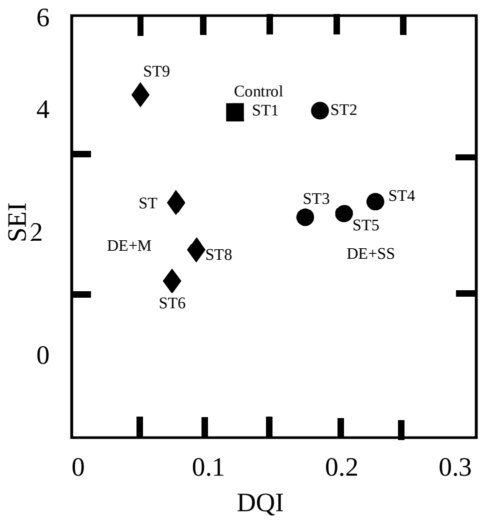

Fig. 2 Dickson Quality Index (DQI) versus Speed Emergency Index (SEI) of Eucalyptus Camaldulensis seedlings from different substrates tests and control substrate.

DISCUSSION AND CONCLUSION

Eucalyptus Camaladulensis

The observed values of the plant height, diameter of the stem and the fresh and dry weight of roots and shoots in the treatment with a manure and diatomaceous earth were statistically lower, compared with the control substrate (fig. 1). Whereas the physical and chemical properties of the substrates were similar in all treatments (Table 2 and 3), with the exception of pH, the effects observed may be attributed to the higher pH (higher than 6.5) of these substrates.

In more alkaline pH conditions, there may be nutrients and micronutrients are not available which will cause a physiological disequilibrium plants. The pH should be in the range of pH 5.5 to 6.5 to obtain the recommended quality of seedlings. According to [8] and [9], the precipitation of the solution of aluminum ground causes, among other effects, the increase of pH. Moreover, the application of manure may cause complexing Al by organic acids released by these materials. The high acidity of the soil caused by the sludge can be associated with the nitrification of ammonium nitrogen and the oxidation of sulfites and feasible production of organic acids during the degradation by microorganisms of the residue [10]. If we consider that seedlings good quality must have a minimum stem diameter of 2.0 to 2.5 mm [11], [12], the treatment with the substrate containing sludge sewage and diatomaceous earth corresponds to the desired quality (fig. 2).

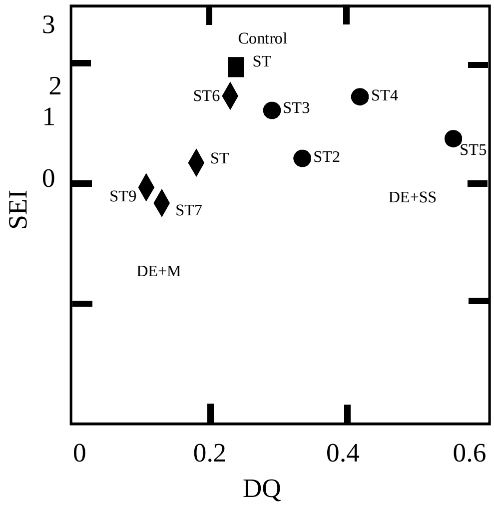

Fig. 3 Dickson Quality Index (DQI) versus Speed Emergency Index (SEI) of Morus Alba seedlings from different substrates tests and control substrate.

The seedlings may be placed on the field after 120 days of growth, with an average diameter stem from 2.65 to 2.95 mm. The emergency speed index of T2 and T9 is statistically equivalent to treatment with substrate control (Table 4). This result differs from that observed by [13]; these authors studied the value of speed emergency index based on mixtures of the substrate with rice husk, cow manure, powdered coconut and fine vermiculite.

Different mixtures had no effect on the speed emergency index of Eucalyptus urophylla. It should be noted that the decline in the rate of seedling emergence is an undesirable feature, because most of the time in the early stages of growth, it makes plants more vulnerable to adverse environmental conditions [14]. The faster root development is important, the better the vegetative development and stability of the plant [15].

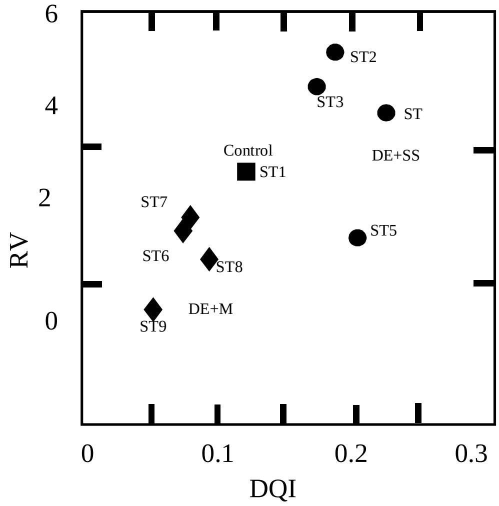

Fig. 4 Dickson Quality Index (DQI) versus root volume (RV cm^3) of Eucalyptus Camaldulensis from different substrates tests and control substrate.

The GPDM/RDM ratio showed no statistical difference between the different substrates (Table 5). However, DQI is more important in the substrate test mixture of sludge sewage and DE (0.17-0.23), whereas it is very low in substrates based on manure and DE (0.05-0.09) and in the order of 0.12 in the control substrate (fig. 2, 3 and 4); we have a good correlation with total dray matter TDM and DQI. This links up the observations [16] and [17] found that on the field the best results in the survival of eucalyptus seedling are those substrates containing sewage sludge. These authors also noted that 2/1 of GPDM/RDM is a good balance for the growth of plants. In our case, the values are slightly higher but still reasonable for the different substrates tests. We find that the ratio between the stem height and diameter of the plant did not differ significantly between the substrates tests studied (Table 4), but the root volume of Eucalyptus Camaldulensis is higher (more 4 cm^3) in blended substrate with DE and SS comparatively to control substrate and amended substrate with manure (fig. 4). Greater the value of this ratio is, the better the ability to survival and establishment of seedlings in the field [18]. The best treatments are those with sewage sludge and diatomaceous earth (fig. 4). The DQI is above the recommended minimum [19]. These authors argue that DQI should be greater than 0.2. DQI than, the higher the quality standards seedlings. The study of seedlings of Eucalyptus urophylla by [19] showed higher values for the DQI treatments with manure than what we got.

Morus Alba Yu vc-62

Tests substrates with sewage sludge and diatoms favor the growth of white mulberry (Morus Alba) seedlings (fig. 5). They are usually better than the control substrate (Table 5). For all treatments the chemical and physical properties were similar except for pH (Tables 2 and 3), we can consider that sewage sludge played an important role in nutrient level and diatoms have improved physical properties including porosity, water capacity and density of retention substrates tested.

These observations are consistent with the Maia [20] found that sewage sludge should not be used pure, despite its relative fertility [21], sewage sludge cause compression of the substrate. Diatomaceous earth is an important addition to the growth of seedlings.

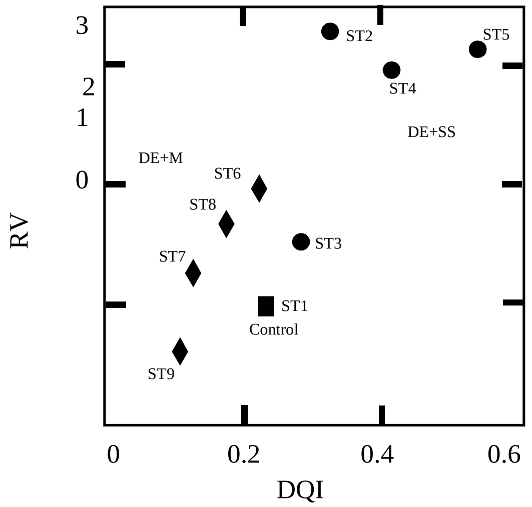

Fig. 5 Dickson Quality Index (DQI) versus root volume (RV cm^3) of Morus Alba from different substrates tests and control substrate.

All treatments showed levels of potassium (Table 2) very good according to the classification of [22], which explains the high values of stem diameter of seedlings. Valeri and Corradi [23] showed that the potassium regulates the opening of the stomata and promotes the thickening of the stem of the seedling. According to Daniel [24], the diameter of the stem is the most appropriate to evaluate the ability of seedling survival. It is also the most widely used to help determine the doses of fertilizer must be applied in the production of seedlings.

The speed emergence index of Morus Alba show (fig. 3) no statistical difference between treatments. At the stage of the germination and emergence of seeds, nutrients are not necessary for the reactions leading to the formation stem and root (fig. 5). Only hydration and aeration of the substrate and good porosity of the substrate allows a movement of the air and water favoring the quickest germination [25].

The GPDM/RDM ratios of Morus Alba seedling are not statistically different for all treatments. They indicate that the seedlings have the same probability of survival. The GPDM/RDM ratio and TDM is directly related to the composition of substrate tests strongly influenced by the availability of water, which favors the flow of nutrients and seedling growth.

The HI ratio (H/D stem height /stem base diameter) of seedlings Morus Alba shows no statistically significant difference 2.35 to 3.12. This ratio is less than that observed for the Eucalyptus (7.47 to 9.63) for the same experimental conditions. The HI ratio and root volume are likely to depend on the species of seedlings because in spite of the low values, seedlings showed good conditions for adaptation and resistance on the ground. The DQI values Morus Alba seedlings growing in test substrates with sewage sludge and diatomaceous earth, are all higher than the recommended minimum value of 0.2, with high value for ST4 and ST5 rich substrate diatomaceous earth (fig. 5). Treatments with manure does not meet the desired quality standard.

The DQI is obvious that the morphological parameters' used to evaluate the quality of seedlings and morphological parameters should not be analyzed separately to determine the quality level.

The Eucalyptus and Morus Alba seedlings produced with test substrates (sewage sludge, diatomaceous earth and commercial substrate) showed similar results to those obtained with the use only commercial substrate.

The Eucalyptus and Morus Alba seedlings have good growth in substrates containing sewage sludge and diatomaceous earth. They show better results than using only the commercial substrate. They can be used up to 50% by volume of the substrate without compromising the seedlings quality with a reduction of cost of seedlings production.

Table 4 Means of the variables total height (H), collar diameter (D), number of branches (NB), number of leaves (NL), root volume (RV), fresh biomass of the above ground part, (GPFM), root fresh matter (RFM), dry biomass of the above ground part (GPDM) and root dry matter (RDM) seedlings of Eucalyptus Camaldulensis from different substrates tests and control substrate.

Substrates tests	H	D	NB	NL	RV	GPFM	RFM	GPDM	RDM
	cm	mm	-- -- n° /seedling --		Cm3	------------------ g ---------------------------			
T1	22.03	2.43	1.62	5.12	3.69	2.59	1.14	0.86	0.45
T2	24.51	2.95	1.60	5.85	5.42	3.96	1.57	1.50	0.54
T3	23.25	2.65	1.75	5.49	4.92	3.83	1.39	1.41	0.54
T4	20.34	2.75	1.85	6.08	4.53	4.24	1.58	1.52	0.65
T5	21.98	2.89	1.79	5.97	2.72	4.15	1.43	1.36	0.61
T6	16.55	1.78	1.65	4.78	2.83	1.89	0.65	0.55	0.27
T7	16.97	2.02	1.55	4.57	3.00	1.86	0.80	0.55	0.26
T8	13.49	1.85	1.62	5.05	2.44	1.93	0.69	0.61	0.27
T9	15.36	1.59	1.66	5.03	1.69	1.57	0.58	0.39	0.20

Table 5 Means of the variables total height (H), collar diameter (D), number of leaves (NL), root volume (RV), fresh biomass of the above ground part, (GPFM), root fresh matter (RFM), dry biomass of the above ground part (GPDM) and root dry matter (RDM) seedlings of Morus Alba from different substrates tests and control substrate.

Substrates tests	H	D	NL	RV	GPFM	RFM	GPDM	RDM
	cm	mm	-- n° /seedling ---		Cm^3	------------------g----------------------		
T1	7.49 C	3.04 C	2.75 A	1.00 B	1.00 C	1.45 B	0.35 B	0.43 C
T2	7.96 A	3.83 B	2.47 B	3.28 A	1.61 B	2.01 A	0.57 B	0.63 B
T3	10.10 A	3.78 B	2.67 B	1.50 B	1.47 B	1.75 B	0.48 B	0.56 B
T4	12.38 A	4.46 A	2.48 B	2.92 A	2.27 A	2.51 A	0.83 A	0.78 A
T5	11.11 A	4.76 A	2.54 B	3.11 A	2.19 A	2.90 A	0.82 A	0.94 A
T6	9.06 B	3.53 B	2.84 A	1.67 B	1.28 B	1.55 B	0.37 B	0.43 C
T7	7.96 C	2.90 C	2.86 A	1.25 B	1.03 C	0.99 C	0.29 B	0.23 D
T8	8.98 B	3.49 B	2.91 A	1.67 B	1.31 B	1.35 B	0.38 B	0.30 D
T9	9.24 B	2.99 C	3.06 A	0.64 B	1.12 C	0.92 C	0.28 B	0.20 D

Note: Means without letters or followed by the same letter are not statistically different according to the Scott-Knott test at 5% probability

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