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Development of pre-sprouted seedlings (PSS) of sugarcane under different amounts of filter cake and application modes

Desenvolvimento de mudas pré-brotadas (MPB) de cana-de-açúcar sob diferentes quantidades de torta de filtro e modos de aplicação

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Abstract

The sugarcane pre-sprouted seedlings (PSS) system is a new multiplication technology that contributes to the rapid production of seedlings and is associated with a high standard of vegetal health, vigour and uniformity of planting, as well as a drastic reduction in the use of seedlings per area. Due to the high moisture required during the initial period of growth, the filter cake can be an ally in the development of this technology. Thus, this work aimed to evaluate the development of sugarcane PSS, under different amounts of filter cake and application modes. The treatments included five doses of filter cake at 0, 7.5, 15, 30, and 45 t ha^{-1} and two forms of application: depth (0.30 m) and surface. Once formed, the sugarcane PPS were planted in Eutroferric Red Latosol, with due treatments. For aerial development analyses, leaf area, stem length and diameter and shoot dry mass were evaluated at 15, 30, 45, 60, 75 and 90 days after planting. The filter cake positively influenced the development of pre-sprouted seedlings, promoting greater leaf area and stalk diameter when applied on the surface. The dose of 30 t ha^{-1} to the surface, provided 54% higher shoot dry weight and 56% more dry weight of roots compared to cultivation without its application, demonstrating its usefulness to improve the development of pre-sprouted seedlings.
Key words: Biometrics. Organic fertiliser. Root system. *Saccharum* spp.

Resumo

O sistema de mudas pré-brotadas (MPB) de cana-de-açúcar é uma nova tecnologia de multiplicação que contribui para a rápida produção de mudas, associando elevado padrão de fitossanidade, vigor e uniformidade de plantio, bem como drástica redução na utilização de mudas por área. Por outro lado, a torta de filtro pode ser uma aliada no desenvolvimento dessa tecnologia que necessita de elevada umidade no período inicial de crescimento. Assim, esse trabalho teve como objetivo avaliar o desenvolvimento de mudas pré-brotadas de cana-de-açúcar sob diferentes quantidades de torta de filtro e modos de aplicação. Os tratamentos foram cinco doses de torta de filtro, equivalentes a 0; 7,5; 15; 30; 45 ton. ha^{-1} e duas formas de aplicação: em profundidade (0,30 m) e em superfície. Após a formação das MPB, essas foram plantadas em Latossolo Vermelho eutroférrico, com os devidos tratamentos. Para as análises de desenvolvimento aéreo foram avaliados em seis períodos: 15, 30, 45, 60, 75, 90 dias após o

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plantio, a área foliar, comprimento e diâmetro de colmos e massa seca da parte aérea. A torta de filtro influenciou positivamente o desenvolvimento das mudas pré-brotadas promovendo maior área foliar e diâmetro de colmos quando aplicada em superfície. A dose 30 ton. ha^{-1} em superfície proporcionou produção 54% maior de massa seca de parte aérea e 56% mais massa seca de raízes em comparação ao cultivo sem sua aplicação, podendo ser utilizada para melhor desenvolvimento de mudas pré-brotadas.
Palavras-chave: Biometria. Adubo orgânico. Sistema radicular. *Saccharum* spp.

Introduction

Brazil is the world's largest producer of sugarcane and the largest exporter of sugar, with a cultivated area of approximately 9,000,000 ha (CONAB, 2018). The conventional system of planting, however, presents some problems, such as the high consumption of seedlings, low phytosanitary control and irregular planting lines.

Considering that sugarcane is a plant with high tillering potential, the excessive use of gems in planting, as it is currently done, increases the competition for water, light and nutrients, resulting in increased tiller mortality. The failures occurring in the areas of conventional plantings result from the lack of uniformity of sprouting and several other factors of the current planting system.

A proposed new technology for solving these problems is the use of the system of pre-sprouted seedlings (PSS). This multiplication system contributes to the rapid production of seedlings and is associated with a high standard of plant health, vigour and uniformity of planting. Another great benefit is in reducing the number of seedlings that goes into the field. For the cultivation of 1 ha of sugarcane, the consumption of seedlings falls from 18 to 20 t, in the conventional plantation, to 3 t in the PSS system (LANDELL et al., 2012).

However, one of the main problems faced in the implementation of this new technology is the need for high soil moisture, in the initial period after planting. In this sense, the filter cake, a residue resulting from the filtration process of the sugarcane juice, already widely used in conventional winter planting, can be an alternative to favour the development of this technology, by the maintenance of the soil moisture and temperature, encouraging budding. The filter cake contains 1.2 to 1.8% P and approximately 70% moisture, which is important to ensure the sprouting of cane in plantations made during winter seasons in the south and southeast. In addition, it has a high Ca content (about 2% of dry matter) and high amounts of micronutrients (B, Zn, Mo, Mn, Co), which enhances the development of sugarcane (ROSSETO; SANTIAGO, 2017). The importance of this residue results not only from the large volume generated but also from being an organic fertiliser.

According to Fravet et al. (2010), filter cake together with vinasse can replace chemical fertilisers and lead to a cost reduction of around \$60 ha^{-1}. Each tonne of ground cane generates about 30 to 40 kg of filter cake that has a considerable percentage of organic matter and essential plant nutrients, which contributes to the macro- and microbiota of the soil.

Despite the good results already obtained in the cane plant and ratoon productivity (ALMEIDA JÚNIOR et al., 2011; FRAVET et al., 2010; SANTOS et al., 2010), it is not yet known what the effects on the development of sugarcane pre-sprouted seedlings (PSS), and what quantity or mode of application is most appropriate for this new technology. Thus, this work hypothesised that the use of filter cake, as well as the mode of its application, changes the development of PSS, contributing to the improved performance of this new technology. Hence, the study aims to evaluate the initial development of pre-sprouted sugarcane seedlings, under different amounts of filter cake and modes of application.

Material and Methods

The experiment was carried out in a greenhouse at the State University of Londrina, Paraná State, Brazil, with geographical coordinates 23°23' S and 51°11' W, and an average altitude of 566 m.

The stems used for the production of the seedlings were provided by Usina de Açúcar e Álcool Bandeirantes (Usiban), city Bandeirantes, Paraná, Brazil. The cultivar used was RB867515, which presents high agro-industrial productivity, optimum adaptability and stability of production in soils with low natural fertility.

The seedlings were produced in March 2017, according to the system of multiplication of PSS, idealised by Landell et al. (2012), which involves the planting of a gem coming stems aged 10 to 12 months. After the production period, the seedlings were transplanted to the experimental units, composed of polyethylene vessels (0.35 m in diameter and 0.45 m in height), filled with eutrophic Red Latosol (EMBRAPA, 2013). The soil was collected from the farm school of the State University of Londrina, at depth from 0 to 40 cm, and had the following chemical attributes: pH ($CaCl_2$) 5.6; Ca, Mg, K and Al, at 8.04, 1.46, 1.54 and 0.00 $cmol_c\ dm^{-3}$, respectively, P (102 mg dm^{-3}) and organic matter (26.2 g kg^{-1}). Each vase received a PSS. The filter cake was supplied by Usina de Açúcar e Álcool Bandeirantes (Usiban), with the following chemical composition (dry matter basis): pH ($CaCl_2$) 5.6; lost moisture at 65 ºC of 72%; 58% organic matter; 9.7, 3.5, 4.8, 9.5, 2.5 and 7.5 g kg^{-1} of P, K, Ca, Mg and S, respectively; and 120, 765, 288 and 23603 mg kg^{-1} of Cu, Mn, Zn and Fe, respectively.

The design was completely randomised with four replicates and a 5×2 factorial arrangement of treatments, constituting five doses of filter cake equivalent to 0, 7.5, 15, 30 and 45 t ha^{-1} and two modes of application: on the surface (simulating the application in the planting line), and at depth. The respective doses were applied at 0.30 m depth, before planting the seedlings (depth application) or around the plant (surface application), considering the whole extension of the vessel (diameter of 0.35 m).

The developing shoots were evaluated at 15, 30, 45, 60, 75 and 90 days after planting (DAP), for leaf area (LA), and length and diameter of the stems. The dry mass of the aerial part and the root system was evaluated at 90 DAP.

The AF was obtained by measuring the top visible dewlap (TVD) leaf of each stem, using a portable leaf area meter (Li-Cor model LI 3100). The mean stalk length (m) was obtained from the measurement of each stem from the ground level to the first visible atrium, classified as TVD (sheet +1), using a tape measure. The mean diameter of the stems (cm) was obtained with the aid of a pachymeter, measuring the middle third of the stems.

The dry mass of the shoot was obtained by oven drying at 65 °C until reaching constant weight, as determined using a precision scale.

To evaluate the root system, the soil and roots of each vase were placed in a plastic container with water and shaken by hand; the water and the suspended roots were poured into a 1-mm mesh sieve. This operation was repeated until there was no more soil attached. All roots retained in the sieve were collected and oven-dried at 65 ºC until constant weight, measured using a precision scale. The results were presented as grams of roots per pot. The roots of the cake filter treatment at depth was not evaluated.

The results were submitted to analysis of variance, and the comparison of means by Tukey's test at 5% of significance.

Results and Discussion

There was a significant effect of the application of filter cake on the AF and interaction of the mode of application and amount applied at 60, 75 and 90 DAP (Table 1).

At 60 DAP, the application of 30 t ha^{-1} filter cake on the surface promoted a greater AF (146.1 cm^2) compared to the application at depth (112.5 cm^2). At 75 DAP, the dose of 30 t ha^{-1} applied on the surface, continued to provide a higher AF mean (187.8 cm^2), now relative to the control (130.4 cm^2). This result continued until 90 DAP, where the treatments 30 and 45 t ha^{-1} presented the highest values (229.5 and 230 cm^2, respectively), in comparison to the control (169.3 cm^2), when applied on the surface. It is observed, therefore, that the surface application of the filter cake positively influenced the AF development. Several authors (AQUINO; MEDINA, 2014; AQUINO et al., 2017; TAVARES et al., 2010) have verified that there is a significant association between sugarcane productivity and total photosynthetically active surface, represented by AF. These findings corroborate those obtained by Santos et al. (2012), which verified that in Distroferric Red Argissolo, the filter cake positively influenced the AF index. Similar values of AF were observed by Marques and Silva (2008), in the variety RB7515. When comparing the biometric parameters of three varieties, they noted that this variety reached 110 cm^2 at 80 DAP.

Regarding the height of the plants (Table 2), the 30 and 45 t ha^{-1} doses of filter cake applied on the surface at 15 DAP, resulted in lower plant height (6.3 and 6.2 cm, respectively) compared to the control (9.5 cm). This trend continued at 30 DAP, only at the surface filter cake dose of 45 t ha^{-1}, which presented a lower height (11 cm) than the control (17.8 cm). When the filter cake was applied at depth, there was no significant difference between the treatments. It implies that in the initial period after planting, the surface application of the filter cake negatively influenced the development of the seedlings, as also reflected in the height of the plants. However, after 30 days, this effect was no longer observed.

According to Landell and Silva (1995), the agricultural productivity can be estimated by biometric parameters, such as the height of plants. Thus, after 30 days, the filter cake did not influence the height of plants. The height values obtained agree with those verified by Marques and Silva (2008), for this variety.

For stem diameter (Table 3), at 75 days, the filter cake doses applied, both on the surface and at depth, provided statistically higher values (mean of 2.09 and 2.02, respectively) than the control (1.77 cm). In the same period, among the doses applied on the surface, the largest diameter (2.2 cm) was obtained with the 30 t ha^{-1} dose. At 90 days, the same tendency was seen with the applied surface doses of 30 and 45 t ha^{-1}, which provided a higher diameter (2.25 and 2.27 cm, respectively) relative to the control (1.86 cm).

Based on the findings, the surface application of filter cake, from 30 t ha^{-1}, positively influenced the stem diameter of sugarcane in its initial development. According to Landell and Silva (1995), agricultural productivity can be estimated by biometric parameters, such as stem diameter.

Table 1. Leaf area (cm^2) of pre-sprouted sugarcane seedlings at 15, 30, 45, 60, 75 and 90 days after planting (DAP) when grown in the presence of filter cake at different doses (0, 7.5, 15, 30 and 45 t ha^{-1}) and application modes surface (surf.) and depth(dep.). Londrina, 2017.

Doses ($t.ha^{-1}$)	PERÍODO (DAP)											
	15		30		45		60		75		90	
	MODOS DE APLICAÇÃO											
	Surf.	**Dep.**	**Surf.**	**Dep.**	**Surf.**	**Dep.**	**Surf.**	**Dep.**	**Surf.**	**Dep.**	**Surf.**	**Dep.**
0	25,2 a	25,2 a	59,2 a	59,2 a	72,3 a	72,3 a	100,6 a	100,6 a	130,4 b	130,4 a	160,3 b	160,3 a
7,5	25,5 Aa	29,1 Aa	41,6 Aa	41,3 Aa	73,2 Aa	63,9 Aa	104,4 Aa	91,3 Aa	135,8 Ab	129,7 Aa	167,3 Aab	168,0 Aa
15	26,6 Aa	28,3 Aa	43,5 Aa	45,0 Aa	79,0 Aa	75,0 Aa	117,4 Aa	97,9 Aa	150,3 Aab	138,4 Aa	183,3 Aab	179 Aa
30	23,9 Aa	22,7 Aa	43,5 Aa	43,2 Aa	84, Aa	59,6 Aa	146,1Aa	112,3 Ba	187,8 Aa	157,3 Aa	229,5 Aa	202,3 Aa
45	25,4 Aa	27,0 Aa	37,0 Aa	39,0 Aa	74,8 Aa	65,9 Aa	119,6 Aa	107,3 Aa	174,8 Aab	147,9 Aa	230 Aa	188,5 Aa
Cv (%):	17		26		27		21		16		17	

Uppercase letters compare the mean modes of application, and the lowercase letters compare the doses, within each period. Means followed by the same uppercase letter in the row and same lowercase letter in the column do not differ from one another by Tukey's test, at 5% significance. CV:coefficient of variation.

Table 2. Height of plants (cm) of pre-sprouted sugarcane seedlings at 15, 30, 45, 60, 75 and 90 days after planting (DAP) when grown in the presence of filter cake at different doses (0, 7.5, 15, 30 and 45 t ha^{-1}) and application modes surface (surf.) and depth(dep.). Londrina, 2017.

DOSES (t/ha^{-1})	PERIOD (DAP)											
	15		30		45		60		75		90	
	APPLICATION MODES											
	Surf.	**Dep.**	**Surf.**	**Dep.**	**Surf.**	**Dep.**	**Surf.**	**Dep.**	**Surf.**	**Dep.**	**Surf.**	**Dep.**
0	9,5 a	9,5a	17,8 a	17,8 a	25,8 a	25,8 a	32,3 a	32,3 a	56,3 a	56,3 a	64,3 a	64,3 a
7,5	8,3 Bab	10,5 Aa	14,0 Aab	14,8 Aa	24 Aa	24,3 Aa	30 Aa	31,3 Aa	56,5 Aa	54,8 Aa	62,8 Aa	63,8 Aa
15	7,9 Bab	10,5 Aa	15,0 Aab	15,3 Aa	25,8 Aa	26 Aa	31,8 Aa	31,5 Aa	57,8 Aa	57,3 Aa	69 Aa	69,3 Aa
30	6,3 Bb	10 Aa	13,8 Aab	13,3 Aa	27,5 Aa	27,3 Aa	35 Aa	35,3 Aa	58,3 Aa	55,5 Aa	68,8 Aa	63,5 Aa
45	6,2 Bb	9,5 Aa	11,0 Ab	13,8 Aa	25 Aa	24,5 Aa	33,3 Aa	32,3 Aa	62,3 Aa	55,3 Aa	74,3 Aa	65 Aa
CV (%):	14		22		14		12		12		11	

Uppercase letters compare the mean modes of application, and the lowercase letters compare the doses, within each period. Means followed by the same uppercase letter in the row and same lowercase letter in the column do not differ from one another by Tukey's test, at 5% significance. CV: coefficient of variation.

Table 3. Diameter of stalks (cm) of pre-sprouted sugarcane seedlings at 15, 30, 45, 60, 75 and 90 days after planting (DAP) when grown in the presence of filter cake at different doses (0, 7.5, 15, 30 and 45 t ha^{-1}) and application modes surface (surf.) and depth(dep.). Londrina, 2017.

DOSES ($t.ha^{-1}$)	PERIOD (DAP)											
	15		30		45		60		75		90	
	APPLICATION MODES											
	Surf.	**Dep.**	**Surf.**	**Dep.**	**Surf.**	**Dep.**	**Surf.**	**Dep.**	**Surf.**	**Dep.**	**Surf.**	**Dep.**
0	0,93 a	0,93 a	0,95 a	0,95 a	1,20 a	1,20 a	1,45 a	1,45 a	1,77 c	1,77 b	1,86 ab	1,86 a
7,5	0,78 Aa	0,88 Aa	0,80 Aa	0,90 Aa	1,13 Aa	1,20 Aa	1,48 Aa	1,28 Aa	1,98 Ab	2,00 Aa	1,78 Ab	1,88 Aa
15	0,83 Aa	0,85 Aa	0,90 Aa	0,93 Aa	1,23 Aa	1,15 Aa	1,33 Aa	1,43 Aa	2,05 Aab	2,03 Aa	2,03 Aab	1,88 Aa
30	0,83 Aa	0,75 Aa	0,88 Aa	0,83 Aa	1,26 Aa	1,15 Aa	1,63 Aa	1,40 Aa	2,20 Aa	2,01 Aa	2,25 Aa	2,03 Aa
45	0,70 Aa	0,85 Aa	0,77 Aa	0,95 Aa	1,17 Aa	1,23 Aa	1,37 Aa	1,40 Aa	2,13 Aab	2,03 Aa	2,27 Aa	2,1 Aa
CV (%):	15		16		11		11		5		11	

Uppercase letters compare the mean modes of application, and the lowercase letters compare the doses, within each period. Means followed by the same uppercase letter in the row and same lowercase letter in the column do not differ from one another by Tukey's test, at 5% significance. CV: coefficient of variation.

The filter cake had a positive influence on shoot dry matter production (Table 4). The surface application of 30 t ha^{-1} provided 54% more dry mass (47.5 g) than the control (30.8 g). These results concurred with Fravet et al. (2010), in an experiment carried out in yellow Oxisol, in the municipality of Goianésia-GO, which observed an increase in productivity of sugarcane per hectare and reached its maximum point in the dose 58 t ha^{-1} filter cake in planting, and with Santos et al. (2010, 2012). Due to the P immobility, the location of the phosphate fertiliser influences the absorption by the plant. Thus, it would be important to increase the content of this element around the root system of plants because it would occur a greater root-nutrient contact and, therefore, an increase in the nutrient absorption (FRAVET et al., 2010). However, the organic matter of the filter cake, even when applied in the interline, reduces the fixation of the P, by the Fe and Al oxides, making this element available to the roots. In addition, the reaction of the organic matter of the filter cake, by allowing greater stability of aggregates, potentiates the absorption of nutrients (NUNES JÚNIOR, 2005). The authors attributed the increased productivity of the crop to the benefits provided by the organic matter of the filter cake and the nutrients found there, especially P and N. The results obtained in the present study differ from Fravet et al. (2010), in the sense that they did not observe a difference between the modes of application (surface line and incorporated) of the filter cake, in the productivity of sugarcane. It should be emphasised, however, that the same authors did not work with PSS.

Table 4. Dry mass of aerial part (g) pre-sprouted sugarcane seedlings at 90 days after planting (DAP) when grown in the presence of filter cake at different doses (0, 7.5, 15, 30 and 45 t ha^{-1}) and application modes surface and depth. Londrina, 2017.

DOSES (t.ha^{-1})	MODOS DE APLICAÇÃO	
	SURFACE	DEPTH
0	30,8 b	30,8 a
7,5	30,4 Ab	29,3 Aa
15	36,4 Aab	32,8 Aa
30	47,5 Aa	30,9 Ba
45	40,8 Aab	35,8 Aa

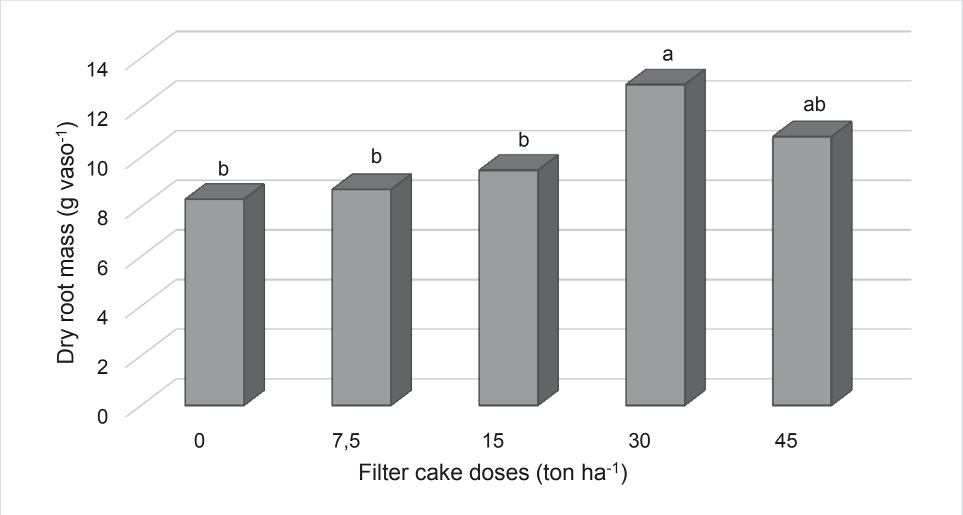
Uppercase letters compare the mean modes of application, and the lowercase letters compare the doses, within each period. Means followed by the same uppercase letter in the row and same lowercase letter in the column do not differ from one another by Tukey's test, at 5% significance. CV: 21%   CV: coefficient of variation.

There was a significant influence of the surface application of the filter cake on the root system (Figure 1). The 30 t ha^{-1} dose promoted a 56% higher root mass than the control and doses of 7.5 and 15 t ha^{-1}, which were insufficient to improve rooting. This residue, because it is hygroscopic, retains water up to six times its own weight (FRAVET, 2007), providing greater moisture, absorption of nutrients and consequently greater rooting. Aquino et al. (2015) also verified greater rooting of sugarcane when cultivated under cover residue.

According to Rossetto and Santiago (2017), the use of the filter cake in sugarcane elevates crop yield by providing organic matter, P, of which, 50% is in readily available form to the plant and the remainder is mineralised over time, in addition to, Ca and other macro- and micronutrients. The same authors also concluded that the most efficient use of the filter cake is to apply it in the planting groove, because the water contained in the cake favours the sprouting of the cane, and the P, when mineralised, is close to the formation of the roots.

Other authors (CALHEIROS et al., 2012; SANTOS et al., 2012) also emphasise that the P in sugarcane, besides contributing to the formation of a vigorous root system, significantly benefits sprouting and tillering, which can be verified in the present experiment. Arreola-Enriquez et al. (2004) studied the application of filter cake in an Argisol with sandy texture and noticed an increase in the P and K contents, which increased the yield of cane stems, up to 46%.

Figure 1. Dry root mass (g vase^{-1}) pre-sprouted sugarcane seedlings at 90 days after planting (DAP) when grown in the presence of filter cake at different doses (0, 7.5, 15, 30 and 45 t ha^{-1}) and application modes surface and depth. Londrina, 2017.



The organic matter present in the filter cake brings great benefits not only to sugarcane but also to the soil. Among them, the following stand out: an increase in the exchange capacity of cations of soils; better physical, chemical and microbiological conditions of the soil that contributes to the development of the plant; the capacity to retain larger amounts of water, which can supply water deficiencies, especially in sprouting; the micronutrients present, and the minerals, also contained within the filter cake, are less subject to leaching (ROSSETTO; SANTIAGO, 2017). Almeida Júnior et al. (2011) affirm that the application of filter cake promotes improvement in soil fertility because, in addition to increasing its macro- and micronutrient contents, it reduces the Al content, and increases the soil pH.

Considering that sugarcane seedlings are more vulnerable to drought and the attack of pests and diseases in the initial stages after planting (OLIVEIRA et al., 2014), the application of filter cake can provide conditions for increased rate of initial development and improved resistance to environmental stresses that will influence crop productivity. Thus, with better results in surface application than at the depth, this becomes, perhaps, a more economical option, since there would be no need of incorporation.

Conclusions

The filter cake positively influenced the development of the PSS, promoting an enhanced leaf area and stalk diameter when applied on the surface.

The surface dose of 30 t ha^{-1} provided a 54% greater dry mass production of shoot and over 56% dry weight of roots compared to cultivation without its application, demonstrating its usefulness in the further development of PSS.

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