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Effect of kelp extract on sugarcane plantlets biomass accumulation

Efecto del extracto de algas en la acumulación de biomasa de plántulas de caña de azúcar

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ABSTRACT

In order to improve the growth of sugarcane plantlets, this study examined the effects of a seaweed (*Ascophyllum nodosum*) extract on shoot and root dry mass accumulation of plantlets budding from segments taken from apical, medial and basal parts of culms of the RB867515 variety. The experiment was a 3 x 2 factorial (three culm sections x kelp extract applied at 2.0 $l.ha^{-1}$ and control) at the Sugar Cane Research Station at the Federal University of Paraná, Brazil. Results showed improvement in shoot and root dry mass accumulation in plantlets budding from the basal part of culms following treatment with the A. nodosum kelp extract.

Key words: *Ascophyllum nodosum, Saccharum* spp., growth.

RESUMEN

*Buscando la mejora del crecimiento de las plántulas de caña de azúcar, este estudio inicial examinó los efectos de un extracto de algas (*Ascophyllum nodosum*) en la acumulación de masa seca de la parte aérea y raíces de plántulas originadas de segmentos tomados de las partes apicales, mediales y basales de la variedad RB867515. El experimento en factorial 3 x 2 (segmentos apicales, mediales y basales x extracto de algas aplicada en 2,0 $l.ha^{-1}$ y control) se llevó a cabo en la Estación de Investigación de Caña de Azúcar de la Universidad Federal de Paraná, Brasil. Los resultados mostraron una mejoría de las acumulaciones de masa seca de los brotes y raíces en las plántulas originadas de segmentos basales por la aplicación de extracto de algas.*

Palabras clave: Ascophyllum nodosum, Saccharum *spp.*, *crecimiento*.

Introduction

Brazil is the world's largest producer of sugar cane (*Saccharum* spp.). As one of the most important crops in Brazil, sugar cane production results in a multitude of products such as sugar, ethanol and bagasse (dried fibrous refuse of sugar production) used to produce energy. There is a significant increasing global demand for sugar cane-derived products. As a result, there is a continuing increase in the area under sugar cane production (CONAB, 2012).

Besides adaptations to climate and soil conditions, pests and disease pressures, sugar cane development has also faced new challenges. These new challenges include how to improve the sprouting capacity of plants from under straw cover (due to restrictions on burning of the previous crop litter) to minimize sprout failures. In related studies, Sanguino (1986) emphasized the importance of using good quality cuttings in sugar cane crop establishment, given that the bud source is an important factor in helping minimize sprout failures caused by older buds originating from the basal part of culms. Advances in sugar cane cultivation need to focus on the development of growing techniques that promote budding and faster plantlets growth and establishment.

The commercial extract of *Ascophyllum nodosum* brown seaweed is a natural product that can stimulate the plant to increase endogenous production of cytokinins (Wally *et al.*, 2013), a class of plant hormones that promote cell division with implications in bud initiation (Taiz & Zaiger, 2006).

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Poly- and oligosaccharides are also frequently found in *Ascophyllum nodosum* extracts, which may induce different biological activities when applied to plants (Pessatti & Maraschim, 1998) and stimulate various growth and defense responses. Jenkins *et al.* (2004) and MacKinnon *et al.* (2010) detected a number of quaternary ammonium betaines, antioxidant and osmoregulator compounds in *Ascophyllum nodosum* extracts.

Taking into account the presence of bioactive compounds in *A. nodosum* commercial extract and beneficial effects of their use reported from different cultivation sites under Brazilian growing conditions (Storck, *et al.*, 2013; Koyama *et al.*, 2012; Silva *et al.*, 2010; Mógor *et al.*, 2008), this study was undertaken to examine the effect of *A. nodosum* extract in biomass accumulation of sugarcane plantlets budding from segments taken from apical, medial and basal parts of culms.

Materials and Methods

Experiments were initiated on September 2, 2011 at the Sugar Cane Research Station at the Federal University of Paraná (UFPR), latitude 22° 58 '44.04 S, longitude 27 º 27"52.57' W. Culms of 10-month old sugarcane (*Saccharum* spp.) variety RB867515 were collected from the field. The percentage Brix° (total soluble solids) was determined using a field refractometer at basal, medial and apical points of culms to determine their maturation index (IDM = Apical / Basal). The index was determined to be 0.60, indicating that the sugarcane culms were still immature (green) with little accumulation of sucrose in the stalk. This index reading indicates that the plants were in good condition to be planted.

Culm cuttings were removed from within the 7th, 15th and 22th internodes measured from base to apex, corresponding respectively to basal, medial and apical parts of culms. From each part, 8 cm sections containing one bud were separated, thereby providing buds of different physiological ages, the youngest derived from apical sections and the oldest from the basal part of the culm.

The commercial soluble liquid concentrate *Ascophyllum nodosum* extract (Acadian Seaplants Ltd.) was applied at a rate of 2,0 l.ha^{-1} (solution with 0,01%) and was compared to an untreated control. The culm parts with one bud were submerged in solution at the aforementioned dosage for 30 minutes. The control was submerged in distilled water for the same time period.

Culm parts were planted in 2L vessels filled with a pine bark substrate (Plant Max®), then placed in the experimental area in randomized complete blocks and 3 x 2 factorial design (three culm parts x kelp extract applied at 2 L.ha^{-1} and control) with 4 replications. The experiment was closely monitored using controlled irrigation to encourage bud sprouting. Plants were collected at 75 days after planting; shoots and roots were removed, separated and dried in a forced ventilation oven at 65 °C for 48 hours, then weighed in a precision balance.

Homogeneity of variance was evaluated with Bartlett's test and a mean-square analysis was performed as well as *a posteriori* comparisons of means using Tukey's test at $\alpha = 0.05$. Data were processed using the M-STAT program, version 2.11 (Michigan State University, 1989).

Results and Discussion

The mean squares analyses, levels of significance, as well as averages and coefficients of variation of shoot and root dry weights are presented in Table 1.

Significant differences were found between shoot and root dry mass taken from the different culm parts (CP). The kelp extract (KE) treatment produced a significant increase in root dry mass accumulation on plantlets that sprout exclusively from basal buds (p<0.01).

Table 1. Mean square analysis for data of shoot and root dry mass accumulation in plantlets grown from basal, medial and apical parts of sugarcane culms (CP), treated with kelp extract (KE). Sugarcane Experimental Station Paranavaí-PR, Brazil. (UFPR / SCA), 2012.

Contrasts	Shoot dry mass (g)	Root dry mass (g)
CP	56.63**	4.98**
KE	2.98^{ns}	2.41**
KE x CP	12.38*	3.50**
KE x CP Basal	23.19**	8.69**
KE x CP Medial	0.08^{ns}	0.20^{ns}
KE x CP Apical	4.47**	0.51^{ns}
Error (18 DF)	3.20	0.50
CV%	28.91	26.56

* P <0.05 is significant at the 5% probability F. ** P <0.01 is significant at 1% probability, and ^{ns} not significant. DF degrees of freedom CV% coefficient of variation.

Table 2. Average values (g) of shoot and root dry mass (Sdm, Rdm, respectively) of plantlets grown from basal, medial and apical parts of sugarcane culms (CP), under kelp extract (KE) treatments, and control. Sugarcane Experimental Station, Paranavaí-PR, Brazil. (UFPR / SCA), 2012.

	Culm parts (CP)					
	Apical		Medial		Basal	
	Sdm	Rdm	Sdm	Rdm	Sdm	Rdm
KE	7.54 a	3.58 a	6.97 a	3.06 a	5.10 a	2.84 a
Control	9.04 a	3.07 a	6.76 a	2.74 a	1.70 b	0.76 b
Mean	8.29	3.33	6.86	2.90	1.80	1.80

The results presented in Table 2 show the growth-promoting effect of KE due to greater dry matter production from the basal CP ($P<0.05$). Basal buds, being physiologically older, had lower amounts of reducing sugars (glucose and fructose), lower nitrogen reserves, and a lower concentration of plant growth hormones, with special attention given to cytokinins (Otto *et al.*, 2009).

Dry matter accumulation in sugarcane plantlets related to KE treatments of older buds, may be an important step in developing a sustainable technology to help minimize sprout failures and improve the initial growth of sugarcane plants.

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