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Improving Utilization of Sugarcane by Replacing Ordinary Propagation Material with Small Chips of Sugarcane Planted in Paper Pots

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Abstract**—**Sugarcane is an important resource for bioenergy. Fields are usually established by using 15-20 cm pieces of sugarcane stalks as propagation material. An alternative method is to use small chips with nodes from sugarcane stalks. Plants from nodes are often established in plastic pots, but plastic pots could be replaced with biodegradable paper pots. This would be a more sustainable solution, reducing labor costs and avoiding pollution with plastic. We compared the establishment of plants from nodes taken from three different part of the sugarcane plant. The nodes were planted in plastic and paper pots. There was no significant difference between plants established in the two pot types. Nodes from different part of the stalk had different sprouting capacity. Nodes from the top parts sprouted significantly better than nodes taken from the middle or nodes taken closed to the ground in two experiments. Nodes with a length of 3 cm performed better than nodes with a length of 2 cm.

Keywords**—**Nodes, paper pots, propagation, sugarcane.

I. Introduction

SUGARCANE (*Saccharum* spp.) is one of the most important crops in the world. The crop covers the third biggest area in Brazil. It arrived to Brazil in the colonial time, brought by the Portuguese colonizers in the beginning of the XVI century, and had since played a major role in the Brazilian economy and development [1].

The sugarcane industry in Brazil has experienced different phases with ups and downs, due to different factors such as economic crises and fluctuating policies. Changes in world tendencies and an increasing demand for renewable sources of fuel has made Brazil the current biggest producer of sugarcane in the world with an area of almost 8.8 million hectares in 2014 contributing to *c.* 2% of the national GDP. The production is continuously growing and 314 thousand hectares of new sugarcane fields were planted in 2015 [2]. The expansion of the sugarcane market has promoted the development of a high technological industry, and the production process is characterized by a high level of mechanization from planting to harvesting. However, with the increasing mechanization of the fields, gaps in the planting lines have become a problem. It is not uncommon that more than 20 tons per hectare of sugarcane stems are used in the planting process; sugarcane stems that could be used by the industry to produce sugar or ethanol. Other typical problems in the sugarcane fields are diseases and pests spread by infected stem material [3], [4].

Private companies and public research institutions have developed more efficient systems to propagate sugarcane using seedlings, and hereby reducing the amount of stems material to *c.* 3 tons$\cdot$hectare^{-1}. The aim is to produce high quality healthy propagation material with a vigorous root system, resulting in less failures in the planting lines and reduced risks of spreading pest and plant diseases [3].

The sugarcane seedlings are usually produced in plastic pots. In Brazil, more than a million hectares of sugarcane are planted every year. If a predominant part of this should be done by propagation of sugarcane plants in plastic containers the potential increase in waste will be enormous. Consequently, there is a need to investigate alternative materials that can contribute to the sustainability of the industry using more environmentally friendly containers as for example biodegradable paper containers [5].

The aim of this project was to compare sprouting and development of sugarcane seedlings established from small sugarcane chips (nodes from the sugarcane stalks) in paper and plastic pots, respectively, Chips were taken from different part of the stalk and had different length. We also studied how water stress affected the seedlings because the substrate in paper pots was supposed to dry out faster than in plastic pots.

II. Methods and Materials

The study was carried out in a greenhouse at the campus Umuarama, Federal University of Uberlandia, State of Minas Gerais, Brazil from December 2015 to March 2016. We used the sugarcane cultivar RIDESA- RB 867515 characterized by a fast growth, low nutritional demand and high content of sucrose.

Two container types with the same volume (180 cm^3), but with a slightly different shape were used. We used black plastic pots with a diameter of 52 mm in the top and 12 mm diameter in the bottom and 130 mm long (CM Asencio Indústria e Comércio de Plásticos, Aracatuba-SP, Brazil) (Fig. 1). The paper containers were 50 mm in diameter and 80 mm long (Ellegaard ltd. Esbjerg, Denmark) (Fig. 1). The growth substrate was Biogrow Germina Plus 30-001CA (AgroLink, Holambra, Brazil) composed of 10 % pine bark, 50 % pine acicula, 30 % sphagnum and 10 % rice hulls. The substrate was added 7.5 kg$\cdot$m^{-3} of limestone and 1 kg$\cdot$m^{-3} of the

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fertilizer PG mix [6]. pH was 5.8 and the electrical conductance was 0.8 mS · cm.

Sugarcane chips were cut in two sizes (2 and 3 cm) and divided into three groups according to their position on the sugarcane stalk: 1) The first five chips from the base of the stalk, 2) The five last chips from the top part of the stalk, and 3) chips from the middle of the stalk. Chips diameter in the Middle part of the stalk varied a lot.

Fig. 1 Plastic (black color) and paper containers used in the experiments

A. Experiment 1

Exp. 1 had a split-split-plot design with three blocks and three factors: 1) Chip position on the stalk (3 levels, each with 14 buds), 2) Pot type (paper and plastic) and irrigation (2 levels). In total 504 chips were used (168 per block). The 168 chips were originated from the three different parts of the stalk (56 from each) and distributed randomly into the two pot types. Furthermore, chips were randomly divided between the two different irrigation schemes.

All plants were irrigated equally the first 4 weeks to keep the substrate at field capacity and insuring high humidity in the greenhouse. After 4 weeks one treatment consisted of 4 irrigation periods with 4 mm day^{-1}. The other treatment got 5 mm day^{-1}. The seedlings were harvested after 50 days.

B. Experiment 2

Exp. 2 had a split-split-plot design with 3 factors: 1) chip size (2 and 3 cm), 2) pot type (paper and plastic) and 3) chip position on the stalk (3 levels). It was divided into 5 blocks with 60 chips in each. Chips were planted from 5th to 7th January. All five blocks were placed on the same table and was kept wet by regularly uniform irrigation.

In total 300 chips were used (60 chips per block). Thirty chips were placed in paper pots and 30 in plastic pots. These were divided into 2 sub-plots with 15 chips each (5 chips from each of the three parts of the stalk). The seedlings were harvested after 50 days.

III. Results

Exp. 1: There were no significant relation between root/shoot mass and chip weight, and chip weight did not significantly affect time to sprouting (Figs. 2 and 3). The two irrigation schemes did not affect the root and shoot biomass significantly differently. Fig. 4 shows the frequency of sprouted chips in relation the chip weight.

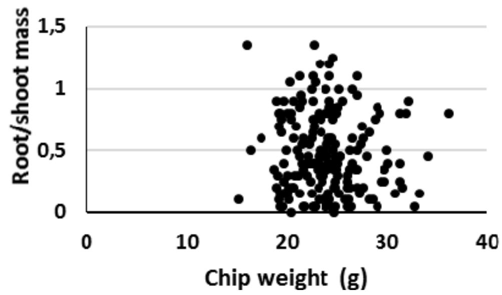

Fig. 2 Relation between chip weight (g) and root/shoot biomass: No significant relation was found

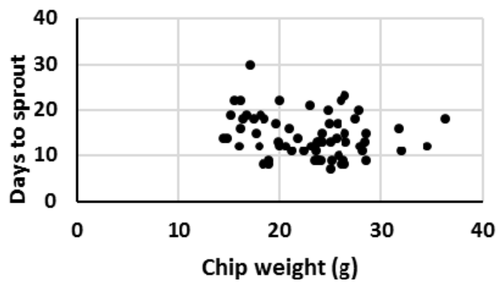

Fig. 3 Relation between chip weight (g) and day to sprout: No significant relation was found (Exp. 1)

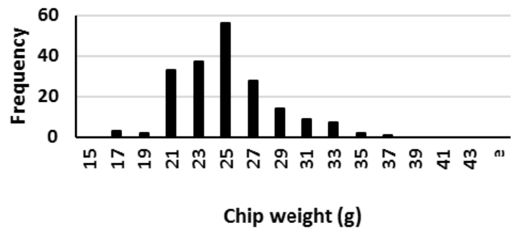

Fig. 4 Frequency of sprouted chips related to chip weight: Chips with a weight between 23-25 g seem to be the most successful (Exp. 1)

There was not a clear relation between chip weight and sprouting success, but chips with a weight about 23–25 g seem to be the most successful. Root biomass produced from chips in plastic pots was significantly affected by the chip position on the stalk ($p<0.001$) as in paper pots ($p<0.01$) under both irrigation schemes. Chips from the upper part of stalks produced more root biomass and had a larger root volume than chips from the lower parts and a larger proportion sprouted (Fig. 5). More chips in paper pots sprouted (100) than in plastic pots (91) but it was not statistical significant.

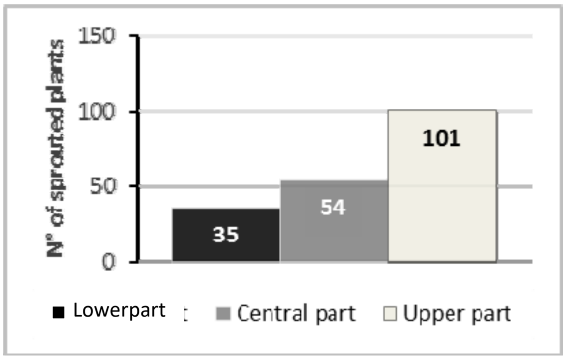

Fig. 5 Number of sprouted chips from each part of the Sugarcane stalks (exp. 1)

Exp. 2: There were no significant interactions between the three factors: chip size, pot type and chip position. Chips position significantly affected the sprouting success (p=0.0473). Chip from the upper part of the sugarcane stalk sprouted better than chips for the lower parts. Days to sprout did not vary significantly in relation to pot type. The 3 cm chips sprouted significant better than 2 cm chips (p=0.0473) (Fig. 6). 2 cm chips sprouted later than 3 cm chips. In average, 2 cm buds weighed only 17.7 g, which was *c.* 30 % less than 3 cm buds (25.4 g). More chips in paper pots sprouted than in plastic pots, but this was not statistical significant (p=0.16) (Fig. 7). Fig. 8 shows the root structure seen in the two pot types.

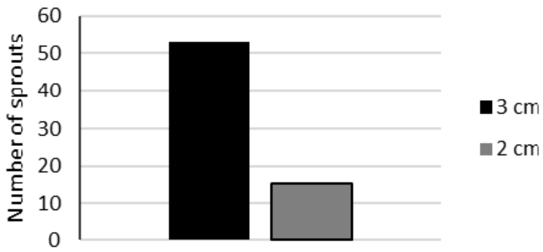

Fig. 6 Number of sprouted chips from two different lengths (2 and 3 cm) (Exp. 2)

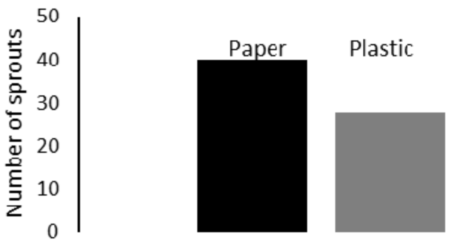

Fig. 7 Number of sprouted chips from paper and plastic pots (Exp. 2)

Fig. 8 (a) Root development in plastic pots and (b) in paper pots

IV. Discussion

The amount of nutrient reserves in the sugarcane chips is essential for its sprouting capacity. However, to reduce production costs there is an interest in using small chips, small pot sizes and small volumes of growth substrate. We found that 3 cm chips sprouted significantly better the 2 cm chips. Several scientists have reported, that bud reserves are fundamental for the sprouting and development of seedlings in the first weeks (e.g. [7]-[10]). Our experiments showed that a reduction of 1/3 of the chip volume or a reduction of 30% of the chip weight significantly affected the sprouting capability of the chips. Based on our research we recommend the chip size should not be reduced below 3 cm.

The above ground part of the seedlings produced in paper pots were not different from those produced in plastic pots. Chips from different parts on the stalk had different sprouting capability and vigor in both experiments. Chips from the top part of the sugarcane stalks sprouted significantly better than those from the middle or bottom parts.

In exp. 1, chip weight showed no relation with root and shoot dry mass (assessed 50 days after planting). Whiteman et al. [10] conducted similar experiments. They expected a linear relationship between bud weight and biomass of seedlings. However, the relation was not observed, probably because after five weeks the roots were developed to a stage where the seedlings did not depend on the nutrient reserves in the chips any longer. They failed to verify a linear relationship.

Although we could not measure significantly difference between seedlings developed in the two pot types, we did visually observed that the roots developed differently (Fig. 8) Sugarcane chips in plastic containers producing seedlings with coiling and crowding characteristics. This may negatively influence seedlings establishment in the field, and increases risk of root damage when plants are moved out of the plastic pots as several researchers has described [11]-[13].

Chips in paper pots had a more homogeneous distribution of roots in the growth substrate, because roots stopped growing when they reached the paper and began setting new roots within the substrate. Consequently, there might be less risk of damaging roots at planting. In the future, we need the investigate whether plants produced in paper pots will have a better establishment in the field compare to plant produced in plastic pots.

Even though we could not show that chips in paper pots were more sensitive to the reduced irrigation scheme we tested, coming users of paper pots should be aware that paper pots need more water than plastic pots because water can evaporate from all sides of the pot.

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