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SCIENTIFIC CORRESPONDENCE

Sugarcane Bagasse: A Potential and Economical Source for Raising Sugarcane Nursery in Sub-tropical India

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Abstract Sugarcane bagasse is produced by sugar mills as a by-product during cane processing. It is a rich source of several chemical components like lignin, cellulose, hemicelluloses, ash, etc. Bagasse being fibrous in nature retains moisture content for a longer period and can enrich the organic carbon and nutrients available in soil to the plant. In the present study, the utility of sugarcane bagasse as a natural cost-effective medium for raising sugarcane nurseries and transplanting the raised settlings in the main fields in sub-tropical India was attempted. Single bud setts of promising sugarcane varieties CoS 13235, CoSe 13452, and CoLk 14201 were used. The single bud settlings were raised in the poly tray and the mediums used for raising settlings from single bud sett comprised of seven different treatments as T1 = sugarcane bagasse alone, T2 = sugarcane bagasse + compost (3:1), T3 = sugarcane bagasse + press mud (3:1), T4 = sugarcane bagasse + soil (3:1), T5 = soil alone, T6 = soil, sand, and compost (1:1:1), and T7 = coco peat alone. The results revealed that the germination percent was achieved maximum (97 percent) in T1 followed by (T2) treatment (95 percent). However, the settlings produced in treatment T2 were lush green and healthier than treatment T1. Bagasse medium produced remarkable promising results in terms of germination and survival of the settlings after transplanting in the field as compared to the other treatments. Our study suggests that sugarcane bagasse can be used as an efficient and effective medium for growing sugarcane nurseries of promising cultivars.

Keywords Sugarcane · Single bud germination · Nursery raising · Bagasse

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Introduction

There is always a high demand for the seeds of new developed promising sugarcane varieties, which cannot be fulfilled by routine varietal multiplication program in practice. Hence, it takes several years for a new variety to be multiplied in sufficient quantity as per demand for general cultivation. One of the major constraints to the fast multiplication of cane varieties, particularly in Northern India, is the poor rate of germination of the seed cane. The rate of germination is usually limited to 35–40 percent. However, if losses in germination can be checked and settlings are given better opportunities to establish themselves, the seed cane production ratio could be improved by several folds. Moreover, more than 60 percent of the sub-tropical sugarcane area practices sugarcane planting after wheat harvesting. A drastic reduction in sugarcane yield and juice quality is a common feature when sugarcane is planted late (April end–May) after the harvest of the wheat crop (Singh et al. 2019). To address these issues, techniques such as space transplanting and the poly tray/bag method of settling raising have proven to be effective in ensuring rapid seed cane multiplication and timely cane planting (Anonymous 2011). One of the major principles of the sustainable sugarcane initiative (SSI) also advocates for 'more with less'. The nursery raised planting of settlings increases the seed cane multiplication rate and reduces the total cost of seed cane required for planting. These techniques consist of raising a nursery, just a month before the normal planting time and the sprouted settlings are transplanted directly into the field after 3–4 weeks. Thus, instead of using 6–7 tons of seed cane for planting in one hectare, this technique requires only 2–2.5 tons of seed cane/ha, which saves 66 percent of seed cane. Additionally, this technique supports sugarcane production using less seed cane, less water, and optimum utilization of fertilizers and land to achieve more yields with a better quality cane. Despite these tremendous advantages, this method of planting is not common and readily adopted by the growers. In this method, a single bud sett is planted in a medium consisting of soil, sand, and compost; however, it needs utmost caring for successful germination and establishment of the setts. Post-transplanting mortality of the settlings is found to be high because of a jerk to roots during the uprooting of settlings from the nursery bed. However, poor germination and low survival of the settlings, whose roots are exposed when transplanted in the field, are the reasons for the lack of adoption by the growers. Sugarcane bagasse, a by-product of the sugar processing, consists of diverse chemical compositions such as cellulose, fiber, lignin, pentosans, sugar, ash and waxes (Singh 2020). This extremely homogeneous material also needs continuous proper disposal and careful handling in an eco-friendly manner. Although, bagasse is typically used to produce heat and electricity in sugar mills (cogeneration), paper making, as cattle feed, and for manufacturing disposable food containers (Singh and Singh 2020). But at the same time, it is a rich source of several chemicals that include major elements like aluminum, calcium, iron, magnesium, phosphorous, silicon, titanium, and minor elements like cobalt, copper, lead, molybdenum, nickel, zinc, etc. (Anonymous 2008). Sugarcane bagasse can increase the organic carbon content and the availability of nutrients to the plant and in the soils (Tanwar et al. 2013). In this study, sugarcane bagasse as a new cost-effective medium was used to see its effect on raising the single bud sugarcane settling in the poly trays and its successful transplanting in fields.

Materials and Methods

The experiment was commenced in the year 2021 at the Uttar Pradesh Council of Sugarcane Research, Shahjahanpur, India. The single eye-bud planting was done in the poly trays with three replications during the month of March. The size of the poly tray was 36 cm × 54 cm size having 50 rectangular cups each with 5.5 cm length, 4.5 cm width, and 5 cm depth.

Sugarcane Variety and Treatments.

Two early maturing sugarcane varieties (CoS 13235, CoLk 14201) and one mid-late maturing sugarcane variety (CoSe 13452) were used for this study. Seven different treatments combination of medium for settling raising comprised of T1 = sugarcane bagasse alone, T2 = sugarcane bagasse + compost (3:1), T3 = sugarcane bagasse + press mud (3:1), T4 = sugarcane bagasse + soil (3:1), T5 = soil alone, T6 = soil, sand, and compost (1:1:1), and T7 = coco peat alone. Sugarcane bagasse was collected from the sugar chemistry division of the institute which is generated as waste after fiber analysis of the sugarcane samples. Bagasse was dried in the shade and ground into fine particles in a grinder (Fig. 1). The fine bagasse particles were then mixed with water before placing them in the poly tray alone (T1) and with other treatments (T2-T4). Treatment T2, T3, and T4 were prepared by mixing three portions of sugarcane bagasse particles and one portion of compost, press mud, and soil, respectively (3:1). In the treatment T5, soil from sugarcane farm was used. Treatment T6 consisted of mixing an equal amount of farm soil, compost, and sand (1:1:1). Coco peat was procured from a local nursery for the treatment T7 (Table 1).

Preparation of poly tray and planting of seed cane for settling production

Single bud setts of all the three sugarcane varieties were cut with the help of a sugarcane cutter machine. The length of the seed cane used was 5 cm and the weight ranged from 18.6 to 31.8 g with a mean of 25 g/ sett. Cane setts were soaked in carbendazim (0.1 percent) for five minutes before planting. The seven different treatments as mentioned in Table 1 were placed in separate poly trays in three replication in such a way that the cups were half-filled (2.5 cm), the treated single cane bud sett was placed on top of the treatments. The bud was again covered with the respective treatments (Fig. 2). Almost 400 g of treatment was required for a single poly tray preparation. The

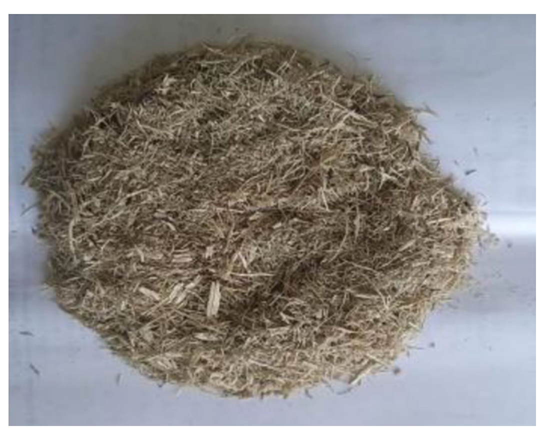


Fig. 1 Sugarcane bagasse

Table 1 Description of treatment combinations (%/w)

Treatment	Treatment combination	Description
T1	Sugarcane bagasse alone (T1)	100% bagasse without soil
T2	Sugarcane bagasse + compost (T2)	75% bagasse with 25% compost
T3	Sugarcane bagasse + pressmud (T3)	75% bagasse with 25% pressmud
T4	Sugarcane bagasse + soil (T4)	75% bagasse with 25% soil
T5	Soil alone (T5)	100% soil without bagasse
T6	Soil, sand and compost (T6)	33% soil with 33% sand and 33% compost
T7	Coco peat alone (T7)	100% coco peat

Fig. 2 Preparation of poly tray with sugarcane bagasse for raising settlings

moisture was maintained by irrigating the poly tray regularly with a watering can.

Observations recorded

The germination percent in the poly tray was recorded after 21 days of planting in all the seven treatments. The length of the roots and height of the settling were observed after 21 days of planting.

Transplanting of the raised settlings to the main field

Settlings raised through poly tray method when attained 3–4 green leaves (21–28 DAP) are transplanted to the main planting field. For this, the poly trays are transported to the planting site where settlings are uprooted carefully along with the earth content/medium without exposing and disturbing the roots from the cups of the tray and are planted in the furrows in the main field. The leaf blades of the settlings are cut before transplanting to reduce the transpiration loss. Soil treatment was given in the furrow after placement of settlings to check termite and shoot borer damage. The furrows were covered with soil by using a spade and the field was given light irrigation followed by the repeated light irrigations for better survival of the transplanted settlings.

Statistical analysis

The experimental data were subjected to analysis of variance (ANOVA) and means were separated with least significant difference test.

Results and Discussion

Germination percent

The data observed in all the treatments in the poly tray clearly indicate significant variations among the treatments. T1 (sugarcane bagasse alone) had the higher germination rate ranging between 96 and 98 percent with a mean of 97 percent in all cane varieties, followed by T2 (sugarcane bagasse + compost, 3:1) with a germination rate ranging between 92 and 98 percent with a mean of 95 percent in all cane varieties (Table 2, Fig. 3). Moisture retains in the bagasse may be an important factor that influences germination to a greater extent by affecting aeration and soil temperature (Waheed et al. 2015). Bagasse being fibrous and porous in nature has the tendency to retain the moisture for a longer duration, and this increase in soil moisture plays a major role in keeping the buds moist and favors early sprouting (Waheed et al. 2015). The percentage of the germination increases with an increase in the soil moisture was already reported earlier (Moreira and Victor 1998). The higher germination percent in the T1 and T2 treatments may be due to the high amount of soil moisture and aeration maintained by sugarcane bagasse. Also, the chemical constituents, sugar content, and water holding capacity of sugarcane bagasse are able to provide moisture and nourishment to the seed cane as well as prevent the growth of any bacterial or fungal contaminant (Tanwar et al. 2010). Studies carried out by Chacha et al. (2019) on Chinese cabbage also state that the

Table 2 Comparative analysis of germination percentage of varieties in different treatment after 21 days after planting in polytray raised settlings

S.No	Treatments	Germination percentage			
		CoLk 14201	CoS 13235	CoSe 13452	Mean
1	Sugarcane bagasse alone (T1)	98	96	98	97
2	Sugarcane bagasse + compost (T2)	97	92	97	95
3	Sugarcane bagasse + pressmud (T3)	72	74	68	71
4	Sugarcane bagasse + soil (T4)	82	76	72	77
5	Soil alone (T5)	70	64	68	67
6	Soil, sand and compost (T6)	72	67	69	69
7	Cocopeat alone (T7)	85	81	79	81

CV = 3.95, SE = 2.63, CD = 6.07

Fig. 3 Germination of variety CoS 13,235 on sugarcane bagasse in polytray

sugarcane bagasse increases the plant growth components significantly because of the high amount of humic acid. Similarly, Yusuf et al. (2018) claimed that the composition of 75 percent sugarcane bagasse compost and N fertilizer (from 25 percent urea) significantly increased the yield of soybean. The study carried out by Kameyama et al. (2010) found that the increase in the available water content of soil by using sugarcane bagasse could be an important instrumental factor for the growth and multiplication of AM fungi.

Root Length and Settling Height (cm)

The average values of root length and settling height after 21 days of planting were found to be highest in treatment T2 (sugarcane bagasse + compost), followed by treatment T1 (sugarcane bagasse alone) (Tables 3 and 4) in poly tray produced settlings. However, it was found to be lowest in treatment T5 (soil alone) as compared to other treatments. Roots are plant organs that develop under the soil surface and have the primary purpose of absorbing water and nutrients. The root acts as a vegetative organ to promote plant growth in addition to consuming water and nutrients, making it a crucial organ for the plant growth. The average root length and settling height in different treatments are presented in Tables 3 and 4. However, among the treatments, sugarcane bagasse alone (T1) and along with compost (T2) showed a significant difference compared to other treatments after 21 days of planting with regard to vigor, better root length and settling height. Moreover, the stalk roots were also found to be well developed in these two treatments (Fig. 4a and b). Studies carried out by Yusuf et al. (2018), also confirmed similar results by using different compositions of sugarcane bagasse and nitrogen fertilizer on the growth of soybean. The study suggested that any nutrient composition of sugarcane bagasse compost and N fertilizer from urea can support the better growth of root length. Similarly, studies carried out by Chacha et al. (2019), on Chinese cabbage states that the increase in the percentage of sugarcane bagasse in the soil increases the growth of the plant. This might be due to an increase in the amount of humic acid and organic carbon in the soil after amendment with bagasse. The soil amended with sugarcane bagasse improves the physical properties of the soil and causes an increase in root development which helps the uptake of more water and nutrients (Robert and Ronny 2012) However, the significant increase might be from soil properties that support the root growth due to enough oxygen diffusion to the root tip and supply of enough water for root growth and settling height (Chacha et al. 2019). Composting with sugarcane bagasse is considered to be one of the most suitable ways of converting organic wastes into simpler products that are beneficial for the plant growth (Stantiford 1987; Linderman and Davis 2001).

The main reason behind the lack of adoption of nursery raised settlings planting among the growers is its' high post-transplanting mortality. This is because of the jerk to roots during the uprooting of settlings from the poly tray. However, apart from better germination, the sugarcane

Table 3 Average root length (cm) after 21 DAP in polytray produced settlings

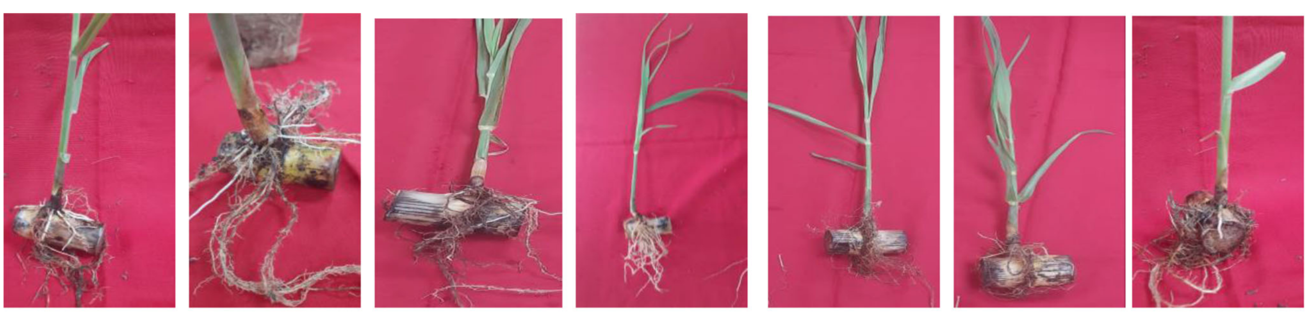
S.No	Treatments	Average root length (cm)			
		CoLk 14201	CoS 13235	CoSe 13452	Mean
1	Sugarcane bagasse alone (T1)	10.00	9.80	11.40	10.40
2	Sugarcane bagasse + compost (T2)	12.00	11.80	12.60	12.13
3	Sugarcane bagasse + pressmud (T3)	9.10	8.20	10.00	09.10
4	Sugarcane bagasse + soil (T4)	9.40	7.90	9.80	09.00
5	Soil alone (T5)	7.20	6.60	7.80	07.20
6	Soil, sand and compost (T6)	9.30	8.20	10.10	09.20
7	Coco peat alone (T7)	10.00	9.60	10.40	10.00

CV = 3.31, SE = 0.26, CD = 0.56

Table 4 Average settling height (cm) after 21 DAP in polytray raised settlings

S.No	Treatments	Average settling height (cm)			
		CoLk 14201	CoS 13235	CoSe 13452	Mean
1	Sugarcane bagasse alone (T1)	12.60	13.40	13.60	13.2
2	Sugarcane bagasse + compost (T2)	13.60	14.00	14.40	14.0
3	Sugarcane bagasse + pressmud (T3)	11.00	11.10	11.50	11.2
4	Sugarcane bagasse + soil (T4)	10.50	11.10	11.40	11.0
5	Soil alone (T5)	9.00	10.40	10.60	10.3
6	Soil, sand and compost (T6)	11.20	11.30	11.60	11.4
7	Coco peat alone (T7)	12.00	12.30	12.40	12.2

CV = 2.20, SE = 0.21, CD = 0.46



(a) (b) (c) (d) (e) (f) (g)

Fig. 4 Sett and shoot root development in different treatments **a** sugarcane bagasse alone **b** sugarcane bagasse + compost **c** sugarcane bagasse + press mud, **d** sugarcane bagasse + soil,**e** soil alone **f** soil, sand and compost and **g** coco peat alone

bagasse medium was also found to be useful in transplanting the settlings without any damage to the roots as compared to other treatments, particularly soil (Fig. 5). Damage of the root is quite common at the time of transplanting of the settling into fields when only soil is used in polybags and the survival percentage of the plantlets is also quite low. Bagasse being fibrous found to adhere and entangled more around the root zone and provides sufficient moisture to the settlings and was easily removed from the poly trays without exposure and damage to the roots during transplantation in fields (Fig. 5). The survival of the transplanted settlings in the field from treatment T1 and T2 was found to be around 98 percent for all the sugarcane varieties used. In the present study, bagasse proved to be more suitable for germination, multiplication, and plant growth as compared to other substrates (Tables 2,

Fig. 5 Settlings grown in sugarcane bagasse alone (T1) and sugarcane bagasse + compost (T2) were easily removed from the polytray without exposure and damage of the roots

3 and 4). Microbial decomposition and mineralization of cellulose, hemicellulose, lignin, and proteins present in bagasse (Singh 2020) increase soil nutrient content, especially N, P, Ca, and Mg required for plant growth (Meunchang et al. 2005; Waheed et al., 2015). However, increased germination and successful survival of the transplanted settlings might also be related to increased root biomass of the plant due to the increase in the available moisture and nutrients in the soil by using bagasse (Hayman 1970). Besides, the appropriate agricultural use of these residues can become advantageous for the farmers and mankind. It allows nutrients recycling, improves crop production, fewer pollution problems and improves the physical, chemical, and biotic conditions of the soil.

Conclusion

The results of the present study suggest that the application of sugarcane bagasse could be a better natural medium for raising the sugarcane nursery with a high percentage of germination and survival of settlings for field transplanting. Sugarcane bagasse is cost-effective medium for raising sugarcane nursery; however, the cost could be still reduced by replacing the poly tray with nursery bed depending upon the availability of the space. More information is needed to determine the relative profitability of both (poly tray and nursery bed) methods for raising the settlings to farmers and growers. The bagasse medium will lead to sustainable sugarcane cropping and improvement in physical and organic soil health conditions.

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