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Assessment of growing media and growth promoters in bud chip propagation for establishment and productivity of sugarcane

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Abstract
Sugarcane (*Saccharum* spp. hybrid) is a vital commercial crop with high seed cane requirements in conventional propagation. The bud chip method offers a sustainable alternative by reducing seed material and improving propagation efficiency. This study evaluated the impact of two growing media—vermicompost + coir pith and vermicompost + solid cow dung—and four growth promoters—cow dung extract, humic acid, ethrel, and control—on the establishment, growth, yield, juice quality, and economics of sugarcane variety CoP-12226 under Pantnagar conditions. Results revealed that seedlings raised in vermicompost combined with solid cow dung significantly enhanced tiller production, growth, cane yield, and juice quality traits compared to coir pith media. Application of humic acid and ethrel further improved these parameters and resulted in higher net returns. This integrated approach demonstrates a viable low-cost, organic propagation strategy for improved sugarcane productivity. The study supports adoption of bud chip propagation with optimized media and growth promoters to enhance sustainable sugarcane cultivation.

Keywords: Sugarcane, Bud chip propagation, Growing media, Humic acid, Ethrel, Yield, Juice quality, Economics

Introduction

Sugarcane (*Saccharum spp.* hybrid) is a crucial commercial crop, cultivated across 5.9 million hectares with an annual production of 468.7 million tonnes in India (ICAR-SBI, 2024) [4]. Traditionally propagated using setts or seed canes which has become increasingly unsustainable with seed cane now constitutes over 20% of production costs and requiring approximately 8 tonnes per hectare.

To address these issues, the bud chip method has emerged as a sustainable and cost-effective alternative to conventional propagation. This innovative approach involves excising sugarcane buds with a small portion of the root band and nurturing them in nurseries. Settlings are raised in small plastic cups or pro-trays, before transplanting them into the main field. However, the smaller size of the buds necessitates a specialized growing medium, as their limited food reserves can hinder sprouting and seedling survival. The quality and vigor of bud-chip-raised seedlings are critical and depend significantly on the choice of growing media (Annadurai *et al.*, 2024) [1].

While coir pith is commonly used medium, its high cost and poor availability in North India limit its use, prompting the search for sustainable alternatives like solid cow dung. Moreover, post transplanting, minimising transplant shock and ensuring seedling establishment are major challenges. Thus, to promote successful establishment and robust growth, plant growth regulators and biostimulants are widely utilized. Among the cost-effective options, cow dung liquid extract has shown promise due to its rich nutrient profile and growth-enhancing enzymes. Identifying low-cost, locally available alternatives is essential to enhance the adoption of this technology.

In this context, an experiment was conducted to evaluate the effectiveness of alternatives growing media and growth-promoting substances on the Sugarcane establishment, growth, yield and economics under the bud chip method.

2. Materials and Methods

2.1 Location, weather and soil properties

The experiment was conducted during the spring season of 2024 at the sugarcane block of N.E.B. Crop Research Centre, G.B.P.U.A&T, Pantnagar, Uttarakhand (29.0222° N, 79.4908° E, 243.83 m above sea level). The area experiences a sub-humid, sub-tropical climate with hot summers (temperatures exceeding 40°C), cold winters (occasionally near 0°C) and annual rainfall of 1433 mm predominantly from June-September.

The experimental soil, a sandy loam Mollisol, is moderately fertile with medium organic carbon (0.68%), neutral pH (7.3), and normal conductivity, but low nitrogen and medium phosphorus and potassium.

2.2 Experimental design and treatments

The field experiment was conducted in a factorial randomized block design with eight treatments and three replications. It included two growth media: T1 (1:1 mixture of vermicompost and coir pith) and T2 (1:1 mixture of vermicompost and solid cow dung), and four plant growth promoters: S1 (cow dung extract @50 mL/seedling); S2 (0.3% humic acid solution @ 50 mL/seedling); S3(ethephon/ethrel 200 ppm @ 50 mL/seedling); and S4 (tap water), resulting in eight treatment combinations (Table 2).

Table 1: Experimental design

Crop	Sugarcane (*Saccharum officinarum* L.)
Variety	CoP-12226
Season and year	Spring season of 2024-2025
Design	Factorial Randomized Block design
Number of treatments	2(growing medium) X 4(growth promoting substances) =8
Number of replications	3
Total number of plots	24
Gross plot size	2.7× 2.4 = 6.48 m^2
Planting method	Bud chip planting in furrows/ trenches
Spacing	120/60 cm paired row and 40 cm plant to plant

Table 2: Treatment details

T1S1	Vermicompost + Coir peat (1:1) + cow dung extract (1: 3) @ 50 ml/seedling
T1S2	Vermicompost + Coir peat (1:1) + Humic acid @ 0.3% 50ml/seedling
T1S3	Vermicompost + Coir peat (1:1) +Ethrel @ 200ppm 50 ml/seedling
T1S4	Vermicompost + Coir peat (1:1) + Control/ tap water
T2S1	Vermicompost + dry cow dung (1:1) + cow dung extract (1: 3) @ 50ml/seedling
T2S2	Vermicompost + dry cow dung (1:1) + Humic acid @ 0.3% 50 ml/seedling
T2S3	Vermicompost + dry cow dung (1:1) + seedling Ethrel @ 200ppm 50ml/seedling
T2S4	Vermicompost + dry cow dung (1:1) + Control/ tap water

2.3 Experimental details

The Healthy bud chips were excised from 7-9-month-old sugarcane stalks (variety CoP-12226) using a bud chipper machine. The chips were treated with 1% *Trichoderma* solution for 10-20 minutes, dried in the shade for two hours, and planted in trays with 50 cones per tray. As per the given treatment, the trays were filled with either of the growing medium (1:1vermicompost+coir pith or cow dung solid). The chips were planted at a slanting angle, and trays were covered with inverted trays, then wrapped in dry leaves to create a warm, humid incubation environment. After one-week, dry leaves were removed, and trays were watered daily for 15 days in the evening hours. After 48-50 days healthy seedlings were ready and selected for transplanting in the main field.

Bud chip planting in Pro-trays

Watering of bud chip pro-trays

Table 3: Material required for raising settlings per hectare

No. of pro-trays	560
No. of cones per tray	50
Per cone volume	50.24 cm^3
No. of canes required	30quintals
No. of bud chip required	28000
Cow dung solid	25 g per cavity/cone, total = 750 kg
Coir pith	10 g per cavity/cone, total = 300 kg
vermicomposting	25 g per cavity/cone, total = 750 kg

The experimental field was brought to fine tilth by one ploughing and two cross harrowing, followed by planking. The healthy seedlings were planted on 1st week of March 2024, in the deep trenches. Furrows were opened by tractor-drawn trench maker with paired row spacing of 120cm, inter-row spacing of 60 cm and plant to plant spacing 45 cm. Fertilizer application was made as per the recommendation of150:60:40 kg/ha (N: P_2O_5: K_2O), where 7 g of NPK and 10g of urea was spot applied to each settling. The entire dose of phosphorus and potassium were applied at the time of planting through NPK, while nitrogen was applied in two equal splits at 45 days after planting (DAP) and 90 DAP in the form of urea. Irrigation was done immediately post-transplant with growth stimulant solutions (S1, S2, S3, or S4) according to the treatment to avoid transplanting shock therefore, enhance establishment and productivity. The remaining activities were executed as per the region's recommended practice package of sugarcane. The incidence of disease and pests was kept below the economic threshold by spraying recommended pesticides for sugarcane.

2.4 Observations recorded
Observations included the number of tillers at 45,60 and 75 DAP, yield-contributing characters, yield with juice quality parameters.

The total number of tillers per row of 100 cm was counted at 45, 60 and 75 DAP and represented in per metre square. At harvest, ten plants were randomly selected in each plot of each replication. They were tagged to record observations on growth parameters number of millable cane, cane height, cane diameter and per cane weight. Weight of millable canes was recorded separately from each net plot with the help of platform balance. The cane yield per hectare was computed on the basis of net plot area and expressed as t ha^{-1}.

For juice quality parameters, same ten tagged sugarcane from each treatment were harvested and weighed. After recording weight of the canes, they were crushed to extract juice. The juice weight was recorded to work out juice extraction per cent calculated as (Weight of juice /weight of canes). Followed with this, the brix value was recorded for each sample using Brix hydrometer dipped in measuring cylinder filled with cane juice. Temperature corrections were done to correct observed brix value as described by Spencer and Meade (1995) [6]. After clarifying the juice using lead-sub-acetate (Meade and Chen 1977) [5], the pol (juice sucrose concentration) was determined using a polarimeter. The percentage of sucrose in the juice was computed using a formula developed from sucrose tables. The purity of cane juice was calculated as (sucrose%/brix) × 100 and cane available sugar calculate as Available Sugar (%) in Cane = [S-{(B-S) x0.4}] 0.73, where, S= sucrose percent in juice, B= corrected brix of cane juice and 0.4 and 0.73 are constant (Meade and Chen 1977) [5].

Economic analysis of sugarcane cultivation (cost of cultivation, gross return, net returns and benefit cost ratio) in the nursery and main field was also performed. Data were statistically analysed using Microsoft Excel and R Studio, with significant differences compared using Fisher's critical difference at a 5% probability level.

3. Results and Discussion
3.1 Effect of Growing Media and Growth Promoting Substances on Early Growth
At 45, 60, and 75 DAP, tiller count varied among treatments, though differences were non-significant among growing media (Table 4). Dung solid + vermicompost (VC) recorded higher tiller numbers (7.17, 9.16, 10.29) compared to coir pith + vermicompost (6.53, 8.87, 10.05). Among growth promoting substances, Ethrel significantly enhanced tiller number at 60 and 75 DAP, registering 10.28 and 11.22 tillers, respectively. This may be attributed to enhanced ethylene-mediated cell division and tiller initiation hormonal pathways, consistent with findings from earlier studies (Patil *et al.*, 2019) [2]. The control consistently recorded the lowest tiller count, indicating the potential benefit of growth regulators in early crop establishment.

Table 4: Number of tillers at 45, 60 and 75 DAP under different treatments

Treatments	45 DAP	60 DAP	75 DAP
Growing media			
Coir pith + VC	6.53	8.87	10.05
Dung solid+VC	7.17	9.16	10.29
SEd (±)	0.367	0.24	0.17
CD (0.05)	NS	NS	NS
Growth promoting substances			
Dung extract	7.39	9.46	10.34
Humic acid	7.03	8.96	10.11
Ethrel	7.19	10.28	11.22
Control	5.78	7.36	9.01
SEd (±)	0.52	0.34	0.25
CD (0.05)	1.12	0.75	0.53

3.2 Yield and Yield Attributes
Application of different growing media and growth promoters had a variable effect on sugarcane yield attributes (Table 5). Though the number of millable canes (NMC) and girth were statistically at par among growing media, dung solid + vermicompost exhibited higher cane height (240.6 cm) and yield (152.8 t/ha) than coir pith + vermicompost (229.5 cm, 151.2 t/ha). Among growth promoters, humic acid resulted in significantly greater cane height (251.5 cm), per cane weight (1.31 kg), and cane yield (158.7 t/ha). Ethrel and dung extract also outperformed the control in terms of NMC, girth, cane height, per cane weight and yield, which may be due to improved nutrient uptake, hormonal regulation, and increased photosynthetic efficiency.

Table 5: Number of millable canes, cane height and cane girth under different treatments

Treatments	NMC ('000/ha)	Cane height (cm)	Girth (cm)	Per cane weight (kg)	Yield (t/ha)
Growing media					
Coir pith + VC	119.6	229.5	7.98	1.26	151.2
Dung solid+VC	116.2	240.6	7.96	1.31	152.8
SEd (±)	2.8	4.5	0.17	0.03	5.58
CD (0.05)	NS	9.8	NS	NS	NS
Growth promoting substances					
Dung extract	121.6	226.9	8.18	1.28	156.1
Humic acid	120.9	251.5	7.89	1.31	158.7
Ethrel	119.8	234.2	8.15	1.31	157.8
Control	109.3	225.0	7.55	1.23	135.5
SEd (±)	3.9	6.4	0.26	0.05	7.9
CD (0.05)	8.4	13.9	0.56	0.11	17.1

1. Healthy canes under coir pith and vermicompost treatment

2. Healthy canes under cow dung solid and vermicompost treatment

3.3 Juice Quality Parameters

Juice quality parameters did not differ significantly between the growing media. However, growth promoter treatments, particularly Ethrel and cow dung extract, showed improved performance (Table 6). Ethrel recorded the highest values for brix (20.88%), sucrose (14.74%), and cane available sugar (12.84%), with statistically significant increases over control. These results suggest that Ethrel enhances sugar translocation and ripening by stimulating ethylene biosynthesis pathways, which aligns with other studies (Kumar *et al.*, 2021) [3]. Dung extract also significantly improved juice extraction and sucrose content, which may be due to the presence of readily available micronutrients and bioactive compounds.

Table 6: Juice extraction, Brix, Sucrose, Purity and Cane available sugarcane under different treatments

Treatments	Juice extraction%	Brix (%)	Sucrose (%)	Purity (%)	Cane available sugar
Growing media					
Coir pith + VC	27.50	20.23	14.25	69.17	12.40
Dung solid+VC	28.17	20.46	14.43	69.25	12.56
SEd(±)	0.40	0.13	0.13	0.42	0.15
CD(0.05)	N/S	NS	NS	NS	NS
Growth promoting substances					
Cow Dung Extract	29.17	20.44	14.54	69.33	12.70
Humic Acid	28.00	20.22	14.21	69.00	12.35
Ethrel	29.17	20.88	14.74	69.83	12.84
Water	25.00	19.85	13.89	68.67	12.04
SEd (±)	0.57	0.18	0.19	0.59	0.21
CD(0.05)	1.24	0.39	0.41	NS	0.45

3.4 Economic Analysis
Economic evaluation revealed that dung solid + vermicompost provided higher net returns (₹ 5,88,846/ha) and B:C ratio (3.37) compared to coir pith + vermicompost (₹ 5,75,989/ha; B:C 3.20) despite a slightly lower gross return (Table 6). Among growth promoters, humic acid was most profitable with net returns of ₹ 6,15,278/ha and B:C ratio of 3.46, followed by Ethrel and water treatments. This suggests humic acid not only enhances yield but also offers economic advantage under integrated nutrient management systems.

Table 7: Cost of cultivation, Gross Return, Net Returns and B:C ration under different treatments

Treatments	Cost of Cultivation ₹ /ha)	Gross Returns (₹ /ha)	Net Returns (₹/ha)	B:C ratio
Growing media				
Coir pith + VC	180145	756134	575989	3.20
Dung solid+VC	174895	763742	588846	3.37
SEd(±)	6676	27902	21244	-
CD (0.05)	NS	NS	NS	-
Growth promoting substances				
Cow Dung Extract	178666	677244	501202	2.85
Humic Acid	180677	793331	615278	3.46
Ethrel	181476	788894	610043	3.41
Water	179761	780283	603147	3.41
SEd (±)	9441	39459	30044	-
CD (0.05)	NS	85451	65063	-

4. Conclusion
The integration of organic growing media and growth promoter significantly influenced early growth, yield, and economic returns in sugarcane. Cow dung-based media combined with humic acid or Ethrel exhibited superior performance in terms of both biological and economic traits. These findings highlight the potential of combining low-cost organic substrates with hormonal and natural growth promoters for improving sugarcane productivity and profitability under sustainable cultivation systems.

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