Assessing Feasibility of Growing Sugarcane by a Polythene Bag Culture System for Rapid Multiplication of Seed Cane in Sub-Tropical Climatic Conditions of India

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Abstract: The conventional system of sugarcane (Saccharum species complex) planting is inefficient for rapidly multiplying the seed cane of newly released varieties due to a higher seed rate (6.0 t ha⁻¹) and low germination rate (35−40%). We examined the effect of planting methods on the multiplication rate of seed cane in a field experiment conducted at Lucknow (India) during the 2005−06 and 2006−07 cropping season. Forty-day-old plantlets grown in polythene bags in the nursery using 28,000 single-bud cane pieces per ha area, were transplanted at 45 cm spacing in furrows 90 cm apart and the results were compared with those obtained by the conventional practice of planting three- two- and one-bud cane pieces at the rate of 37,000, 55,500 and 111,000 setts per ha, respectively. The polythene bag culture produced a significantly higher number of shoots and millable canes and a higher seed cane yield as compared with the conventional planting method, which is an advantage for seed cane multiplication. The results further indicated that with almost equal cost of cultivation, the rate of seed cane multiplication was about 35 times by the polythene bag culture method and 8−11 times by the conventional planting method.

Key words: Planting system/method, Polythene bag culture, Seed cane, Sugarcane.

One of the major items of expenditure in sugarcane (Saccharum species complex) cultivation is the huge planting material which ranges from 22 to 25-% of the total production cost (Srivastava et al., 1981). The cane growers may have to pay even more for the newly released varieties due to scarcity of high quality seed cane. Therefore, it becomes imperative to develop an efficient agro-technique for producing a sufficient quantity coupled with optimum quality of healthy seed cane for planting sugarcane under such conditions. Several techniques have been developed for multiplication of seed cane of promising varieties at a faster rate (Panje, 1965; Srivastava et al., 1981), but could not be applied due to several problems. To solve of these problems, Singh et al. (1995) proposed a method of raising polythene bag nursery from young buds in the spindle region of sugarcane plants and transplanted the plantlets into the field. However, when planting material is lacking, buds from the upper 2/3⁴th portion of sugarcane stalk having a higher reducing sugar content and even those from the whole cane stalk may also be used. Planting single bud setts in polythene bags provides an opportunity for faster multiplication of newly released varieties of sugarcane since the conventional system with the average germination rate of 35−40-% from 37,000 three-bud cane setts (6 t ha⁻¹) wastes the precious seed material used in bulk for planting.

Materials and Methods

1. The experimental site and soil

A field experiment was conducted for two crop cycles of sugarcane plant crop during 2005−06 and 2006−07 at the Indian Institute of Sugarcane Research, Lucknow, India located at 26°56’ N, 80°52’ E and 111m above the mean sea level with semi-arid sub-tropical climate having a dry hot summer and cold winter. The soil of the experimental field was sandy loam (15.7, 24.6 and 62.5% clay, silt and sand respectively) of Indo-Gangetic alluvial origin, very deep (>2 m), well drained, flat and classified as non-calcareous mixed hyperthermic udic ustochrept. The initial organic carbon, available N, P and K of the experimental soil were 14.3 Mg ha⁻¹ and 177 kg ha⁻¹, 12.3 kg ha⁻¹ and 197.2 kg ha⁻¹, respectively.
2. Crop Culture

(1) Conventional planting

The sugarcane crop (cv. CoSe 92423) was planted using 37,000, 55,500 and 111,000 three, two and one-bud cane setts ha\(^{-1}\) (each at 6.0 t ha\(^{-1}\)) in the first week of March at 90 cm row spacing. Before planting the setts in the furrows, half the dose of required nitrogen (i.e. 75 kg N ha\(^{-1}\)) and full doses of P (60 kg ha\(^{-1}\)) and K (40 kg ha\(^{-1}\)) were applied in furrows at the time of planting, while the remaining 75 kg N ha\(^{-1}\) was top-dressed uniformly in the second week of June. The plot size for each treatment was 10 m × 5.4 m (54 m\(^2\)). Later on, recommended package of practices were followed to raise the crop.

(2) Agro-technique for raising polythene bag nursery

1) Preparation of soil mixture

Field soil, compost and sand were taken in equal proportions, mixed thoroughly and sieved through a 4 mm sieve. It was treated with insecticide, chlorpyriphos 20 EC @ 100 ml tonne\(^{-1}\) of soil mixture to manage the incidence of termite and early shoot borer in sugarcane crop. The mixture was filled in perforated polythene bags (size 12.5 cm × 12.5 cm).

2) Seed preparation

About 6.0 cm long single-bud cane pieces, each containing one healthy undamaged bud, were cut from the freshly harvested sugarcane cv. CoSe 92423 for raising the nursery. The pieces were cut so that the upper region of the bud was smaller than the lower region (Fig. 1). The pieces were taken from cane stalks using a sharp cutter. A total of 28,000 single cane bud pieces, weighing 1.5 tonnes, were required for raising the nursery to transplant in one ha area. The pieces were soaked in water for 6-8 hrs before planting in polythene bags.

3) Seed treatment

The single-bud pieces were soaked for 6-8 hrs in water and then treated with a solution -100 g of fungicide bavistin (0.2%) and 2.5 g gibberallic acid (GA\(_3\), 50 ppm) and 2.5 g naphthalene acetic acid (NAA, 50 ppm) in 50 liters of water.

4) Planting in polythene bags

After treatment, the pieces were planted vertically facing the buds upwards (Fig. 1) in polythene bags containing the soil mixture on the date scheduled for conventional sett planting, with the buds remaining about 2.5 cm below the surface of the soil mixture. These polythene bags, 2080 in total, were kept in a nursery plot 20 m × 10.0 m. The plots were irrigated lightly, so that the water absorbed by the soil mixture through the perforations reached the cane buds. The nursery was covered with the dry leaves of sugarcane to maintain the humidity. Every 4-5 days, water was sprinkled over the nursery plots to maintain the proper moisture level until the completion of germination. After a week, the buds began sprouting, and the dry leaves were removed to facilitate plant-growth.

5) Field transplantation

About forty-day-old plantlets (Fig. 1) each bearing 4-5 leaves and with a height of 20-25 cm were transplanted into the field after proper nipping of leaves (2-3 cm from tips). They were transplanted one month from the scheduled date of conventional planting in a well-prepared field at a distance of about 45 cm between the plants in 20-22 cm deep furrows 90 cm apart. During transplanting the polythene bags were removed, the plants were placed in furrows and the root zone along with the
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The same amount of fertilizers as in the conventional method was applied at the base of each transplant in the furrows. The field was immediately irrigated after transplanting. The other agronomic practices were the same as those in the conventional planting. The experiment with a plot size of 10.0 m × 5.4 m was laid out in a randomized block design with six replications. The data were recorded on germination percent, number of shoots and millable canes and seed cane yield under different treatments at appropriate stages. At harvest, ten canes were randomly selected from each plot for estimation of juice quality parameters according to the standard methods. Sucrose (%) in juice was determined according to the method described by Meade and Chen (1977).

| Treatments                          | Germination of buds (%) | No. of buds used for planting (ha⁻¹) (a) | Total no. of buds obtained (@ 10 viable buds per cane) (b) | Multiplication ratio (b/a) | No. of millable canes (000 ha⁻¹) | Seed cane yield (t ha⁻¹) | CCS (%) |
|------------------------------------|-------------------------|------------------------------------------|------------------------------------------------------------|-----------------------------|---------------------------------|--------------------------|--------|
| T₁: Conventional 3-bud sett planting | 0 18.40 30.62 36.44 186 111000 | 1213440 10.93 120 70.74 11.48 |
| T₂: Conventional 2-bud sett planting | 0 10.56 22.38 30.47 146 111000 | 1014660 9.14 112 63.74 11.45 | |
| T₃: Conventional 1-bud sett planting | 0 5.45 14.57 26.22 131 111000 | 873120 7.87 101 54.47 11.37 | |
| T₄: Poly-bag culture planting      | 26.41 54.80 75.16 86.34 198 111000 | 3833480 34.54 154 78.42 11.55 | |
| CD (P<0.05)                        | - 5.09 7.14 4.86 8.58 - - - 6.48 7.28 NS |

DAP: Days after planting.
NS: Non-significant (among treatments at 5% level of significance).
CD: Critical Difference i.e. statistically significant treatment differences at 5% level of significance.
CCS: Commercial cane sugar.
3. Statistical analysis of data
The data in each crop season were statistically analyzed separately. The homogeneity of error variance was tested using Bartlett’s χ² test. As the error variance was homogenous, pooled analysis was done according to Cochran and Cox (1957). Since the variation between the two seasons was not significant, the mean data of two crop seasons were considered for results and discussion. Same treatments were compared under a randomized block design. The critical difference (CD) was computed to determine statistically significant treatment differences at the 5% level of significance.

4. Cost of cultivation
Different inputs required for seed cane cultivation as shown in Table 2 were arranged and purchased on the basis of prevailing market prices. The cost of cultivation by the two methods was computed accordingly.

Results and Discussion
1. Germination of cane buds
As shown in Table 1, the mean rate of germination of cane buds, at 10, 20, 30 and 40 days after planting (DAP) was significantly higher by the polythene bag culture method than that by conventional planting with 3-, 2- and 1-bud sets. Under the polythene bag system, it was 26.41, 54.80, 75.16 and 86.34%, respectively, at 10, 20, 30 and 40 DAP. At 10 DAP, no sprouting was observed in the plants cultured by the conventional method. At 20 and 40 DAP, the germination rate was 18.40 and 36.44%, respectively in the 3-bud sets by the conventional planting. However, the average germination rate of 35–40% for cane buds in the tropical climatic conditions of India was not attained with the conventional method using 3-, 2- and 1-bud setts, respectively, by the conventional planting method. At 10 DAP, no sprouting was observed in the plants cultured by the conventional method. At 20 and 40 DAP, the germination rate was 18.40 and 36.44%, respectively in the 3-bud sets by the conventional planting. However, the average germination rate of 35–40% for cane buds in the tropical climatic conditions of India was not attained with either the 2- or 1-bud sets by the conventional planting due to desiccation of the plant (Kakde, 1985). In the polythene bag culture system, the setts were pre-soaked in water to dilute the growth retarding substances followed by treatment with NAA for root development and GA₃ to induce precocious bud break which promoted early germination. The rate of germination by the polythene bag culture method was significantly higher than that by the conventional method.

2. Growth, multiplication ratio and yield of seed cane
As Table 1 shows the polythene bag culture method (T₃) produced significantly more shoots and millable canes and a higher seed cane yield than the conventional method (T₀, T₂ and T₄). Moreover, the polythene bag culture also saved precious seed material by requiring only 1.5 t ha⁻¹ seed cane for planting as compared with 6.0 t ha⁻¹ by the conventional method. However, there was no significant difference in the yield of commercial cane sugar (CCS, %). The higher number of shoots and millable canes by the polythene bag culture method resulted in a higher seed cane yield and was primarily due to ample and equal space provided to the transplanted setts, which is necessary for penetration of sufficient light to the plants. In the conventional system, the plants were grown in rows at 90 cm spacing and were arranged in a series which resulted in uncontrolled germination and gaps. This lowered the number of shoots and millable canes and also seed cane yield per unit area and for each sett planted. The polythene bag culture gave a seed cane multiplication rate of about 35 times as compared with that of 11, 9 and 8 times obtained with 3-, 2- and 1-bud setts, respectively, by the conventional method (Table 1). A higher multiplication rate of seed cane was obtained by the polythene bag culture possibly due to higher rate of germination (86.34%) in cane buds and more millable canes compared with the corresponding values of germination (36.44, 30.47 and 26.22% at 40 DAP) and millable canes under the conventional method (Table 1).

3. Cost of cultivation and economic efficiency
As shown in Table 2, the quantity and cost of planting material for rapid multiplication of seed cane yield was reduced 75% by the polythene bag culture technique as compared with the conventional method. The cost of seed material was evidently lowered by the polythene bag method, which required only 1.5 t ha⁻¹ of seed material as compared with 6.0 t ha⁻¹ by the conventional method. The cost of cultivation was lowered and net return increased by the polythene bag culture method with a cost ratio of 1.50 and economic efficiency of 161.06. By the conventional method using 3-, 2- and 1-bud setts, the cost ratio was 1.27, 1.01 and 0.69 and economic efficiency 135.63, 109.68 and 75.93, respectively. Thus, it can be concluded that the polythene bag culture offers an economical and innovative approach for multiplying newly released varieties of sugarcane.

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