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## RESEARCH ARTICLE

# QUALITY SEED ASSURANCE IN SUGARCANE (*SACCHARUM* SPP.) FOR REJUVENATION OF VARIETAL YIELD DECLINE USING RAPID MULTIPLICATION TECHNIQUES (RMTS)

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**ABSTRACT**

Sugarcane, being a vegetatively propagated crop, has a low seed cane multiplication rate. Besides, huge quantity of cane seed used for planting may have infested with number of pest and diseases cause decrease in cane yield and quality significantly over the years of its cultivation. A number of cane seed propagation techniques have been adopted successfully by farmers and industry in different sugarcane growing countries. *In vitro* propagation is the best alternative to overcome such limitations to produce disease free and sufficient amount of planting material. It is however a very sensitive technique, which requires aseptic condition in different stages viz. mother plant establishment, initiation and establishment of aseptic culture, multiplication, rooting, and acclimatization. In different seed cane programmes, breeder, foundation and certified classes of sugarcane seed are not being maintained by the different agencies or organisations associated with sugarcane agriculture across different states. Further, accounting of different classes of sugarcane seed i.e. breeder, foundation and certified are not being maintained by the different sugarcane growing States therefore the exact quantum of sugarcane certified seed distributed by different agencies in major sugarcane growing state could not be assessed and resulted in failure of assessment of seed replacement rate (SRR) in sugarcane. Sugarcane varieties selected for micro-propagation should have accompanying morphological description to enable verification of varietal characteristics during different stages of seed production. The nursery crop meant for harvesting of shoots for culture is raised from heat-treated setts in a field where sugarcane crop has not been grown during the previous season. The nursery should be inspected and certified by breeders, pathologists from research institutes and accredited laboratories for freedom from diseases such as grassy shoot, phytoplasma, sugarcane mosaic virus, sugarcane yellow leaf virus, ratoon stunting disease, leaf scald, smut and red rot by using recent techniques/methods. Further, shoot tip explants can be obtained from three sources: (a) tops of actively growing canes, (b) elongating axillary shoots from the decapitated shoots, and (c) dormant axillary buds. In our experience, the best explants is the shoot tips from actively growing sugarcane tops. For best results, harvesting of shoot tips is done 120 and 180 days after planting and one to two days after a good irrigation of the nursery. This paper add information on testing and certification seed cane material for supporting the propagation within a short period of time and cost effective manner to have rapid multiplication of disease-free seed of new, improved varieties of sugarcane; and to safeguard the interests of cane growers and the sugar industry.



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## INTRODUCTION

Sugarcane is one of the most efficient converters of solar energy into sugars and other renewable forms of energy. The plant was domesticated by the Polynesians (Artschwager and Brandes, 1958) for its sweet stem, but presently it has emerged as a multipurpose crop providing not only sugar but also a series of value added products such as paper, ethanol and other alcohol derived chemicals, animal feed, antibiotics, particle board, bio-fertilizer and raw material for generating electricity (Sanghera *et al.* 2018a). Sugarcane cultivation and the development of a sugar production industry run in parallel to the growth of human civilisation and are as old as agriculture. The production of sugar is the second largest agro-processing industry in the country, after cotton and textiles. About 4 million sugarcane farmers and a large number of agricultural labourers are involved in sugarcane cultivation and ancillary activities, constituting 7.5% of the rural labour force.

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In addition, the industry provides employment to 500,000 skilled and semi-skilled workers in rural areas (Sanghera and Sharma 2015). The sugar industry thus is a focal point for socio-economic development in rural areas, mobilizing rural resources, generating employment and higher incomes, and supporting the development of transport and communication facilities. Sugarcane, thus, plays a major role in the economy of sugarcane growing areas and, hence, improving sugarcane production will greatly help in economic prosperity of the farmers and other stakeholders associated with sugarcane cultivation (Sanghera and Kumar 2018a). Sugarcane yields are deteriorating day by day because of lack of good quality seed (Mall *et al*. 2018 and Yadav 2009) Recovery of sugar also come down because of poor quality canes due to lack of availability of optimum climates required for cane development (Binbol *et al*. 2006, Gawander 2007). It is also strongly influenced by the impacts of long-term climatic change as well as local weather and seasonal variations. The climate affects the growth and development ofplants and may harm the crops (Sanghera and Kumar 2018a). It also affects severely on the microorganisms related directly or indirectly for better growth and yield ofthe crop (Sanghera and Sharma 2011). Potential direct/indirect effects ofclimate change on the agricultural systems have been identified which include: seasonal changes in rainfall and temperature could impact agro-climatic conditions, altering growing seasons, planting and harvesting calendars, water availability, pest, weed and disease populations, transpiration, photosynthesis and biomass production is altered along with land suitability (Rosegrant *et al*. 2008 and Sanghera *et al*. 2018a and 2018b).

Inadequate availability of quality seed of new sugarcane varieties and poor seed replacement rate adversely affect the realization of potential cane yield of varieties. Seed replacement with fresh commercial seed is done only after 4 years (Sundara, 2000). Diseases are one of the major constraints in the profitable cultivation of sugarcane. Sugarcane is vegetatively propagated and it favours accumulation of pathogens of most of the diseases. Hence along with seed canes disease causing pathogens are also introduced into new areas. Slow accumulation of different pathogens over a period of time makes minor diseases into major one. Several epidemics due to red rot, smut, wilt, grassy shoot, ratoon stunting, yellow leaf and leaf scald occurred in the past indicated that disease infected seed can played significantly in their creation and further spread (Vishvanathan and Rao 2011 & Sanghera and Kumar, 2018b). Affected planting material poses a major problem in propagation and exchange of germplasm, and eventually in breeding and distribution of superior genotypes (Pathak 2009). In order to achieve the demand for sugar in 2020, sugarcane production has to be increased. For increasing sugarcane production availability good quality seed material of high yielding varieties is very essential. High yielding sugarcane varieties are developed and released by various sugarcane research stations. But seed of these varieties is not available for large scale cultivation (Karuppaiyan and Ram, 2012).

Sugarcane, being a vegetatively propagated crop, has a low 1:6 to 1:10 seed multiplication rate. Hence, non-availability of quality seed material is one of the major problems faced by farmers in developing countries. Further, the bulky cane cuttings used for planting as seed harbor many pests and diseases thereby decreasing cane yield and quality drastically (Sanghera and Kumar 2018b).

Accumulation of diseases over vegetative cycles leads to further yield and quality decline over the years. In fact, poor quality seed is a major constraint in sugarcane production (Sundara 1995). There is normal practice in sugarcane growing States to use commercial crop ofsugarcane for seed purposes. Since, it is vegetatively propagated crop and requires huge quantity of seed. The accounting of different classes of sugarcane seed i.e. breeder, foundation and certified are not being maintained by the different sugarcane growing States therefore the exact quantum of sugarcane certified seed distributed by different agencies in major sugarcane growing state could not be assessed and resulted in failure of assessment of seed replacement rate (SRR) in sugarcane (Trivedi and Gunasekaran 2013). To increase output and profitability in the sector, there is need to increase on farm production and productivity of cane and to increase the recovery rate of sugar in mills. Also, there is need to improve the efficiency and to reduce the costs of cultivation by adopting the latest technologies; to have rapid multiplication of disease-free seed of new, improved varieties ofsugarcane; and to safeguard the interests of cane growers and the sugar industry by saving cane that could be used for seed purposes. A number of cane seed propagation techniques have been adopted successfully by farmers and industry in some sugarcane growing countries. This chapter provides a comprehensive review of the important cane seed production advanced technologies for seed quality assurance through community based systems to harness better cane and sugar yields for sustaining sugar industry.

**Specification for sugarcane seed material:** The successful cultivation of sugarcane crop mainly depends upon the use of disease free good quality seed material, adequate fertilizers and irrigation. The cultivators usually raise their own crop for seed material but the Government and the sugar factories are making an attempt to supply good quality seed material, through proper agencies, to the cultivators/ growers. Many states have introduced production schemes for quality seeds. In order to ensure the quality ofthe seed material, it is desirable that the cultivators/ growers obtain the seed material from the Government or other recognized agency at least once in 5 years. Moreover, taking into consideration the volume oftrade existing in the sugarcane seed material, it is considered necessary to prescribe a specification for the sugarcane seed material. The first Indian Standard for sugarcane seed material was adopted by the Indian Standards Institution on 5th December 1966, after the draft finalized by the propagation materials sectional committee had been approved by the Agricultural and Food products division council and issued as ISI 3866-1966 (Sinha 2006).

Some of the standards and practices for quality seed proposed here are empirical. But these have been arrived at on the basis of consensus of several technical experts who were members of a committee constituted by Indian Council of Agricultural Research under the aegis of All India Coordinated Research Project on Sugarcane. It is expected that this specification would help all those engaged in production and distribution of sugarcane seed material in making available good quality seed to the cultivators thereby helping in increasing the yield of sugarcane per hectare. Sugarcane seed material is traded in different forms in the country. In the northern region, it is generally in the form of seed canes whereas in the southern region it is generally in the form of sugarcane setts. This standard covers the requirement for both these types of seed

materials and prescribes the requirements and the methods of test for sugarcane seed materials, seed cane as well as sugarcane setts.

**Traditional three-tier seed production:** The normal practice in many parts of the world is to use sugarcane produced for commercial purposes also for seed purposes. Characteristics for good seed qualities are seldom taken into consideration. Many growers do not consider seed quality, and many of those who do, select the seed cane only at the sett cutting and planting stage. This is not enough. If a grower wants to be sure of getting good, disease-free seed cane, he should raise the seed crop separately. This crop should be kept completely free from pests and diseases by constant field scouting through the whole season. Moreover, seed quality is not just a matter of being free from pests and diseases. Seed has to have high water content and good nutritional status. Neglect in raising a good seed crop is one of the major defects in sugarcane cultivation all over the world. Deriving sugarcane seed from the commercial crop has been responsible for rapid multiplication of a large number of diseases like red rot, wilt, smut, ratoon stunting, and grassy shoot. These adversely affect the cane yield and quality. Raising healthy and vigorous sugarcane crops for seed purposes is essential and recommended.

Some of the methods applied for elimination of viruses in sugarcane crop for developing good quality seed are thermotherapy and meristem tip culture technology. Apical meristem culture was used by Coleman (1970) and Hendre *et al*. (1975) to obtain sugarcane mosaic virus free plants. Hendre *et al*. (1983) standardized an apical meristem culture technique for rapid multiplication of mosaic virus-free plants of variety Co 740. Heat therapy has been used to successfully eliminate many viruses from a variety of plant species and is the proven approach to eliminate the pathogen from seed canes but there are some disadvantages of this therapy. Techniques involving thermotherapy or tissue culture and frequently a combination of both have been successfully used to eradicate viruses from infected plants (Walkey, 1980).When disease-free material is used as the source of explant or the explants are heat-treated to eliminate diseases, the resultant micropropagated plants are disease free and healthy (Jalaja et *al*. 2008). A seed production system comprising breeder seed, foundation seed and commercial seed production as detailed below is ideally followed.

**Breeder Seed:** Primary seed production is done in scientifically supervised farms of research stations, state seed farms or research and development (R&D) farms of sugar industry. Setts from well maintained seed nurseries are given heat treatment by any one of the above detailed methods. After treatment, the setts are soaked in a fungicide solution (0.1 per cent MBC) for 5 to 10 minutes and planted in a well-prepared field, where sugarcane was not grown during the previous year. All recommended agronomical practices are followed. The field should be well-prepared and organic manure such as farm yard manure or cured press mud should be applied at the rate of 25 to 30 t/ha 15 days before planting. A spacing of 75 cm to 90 cm between rows is recommended. A slightly higher seed rate of 75,000 two-bud setts is recommended for raising breeder seed (primary seed) to compensate for germination loss due to heat therapy. For foundation and certified seed nurseries, a seed rate of 60,000 two-bud setts is adequate for obtaining a good stand.

Monitoring of the seed nursery is done at least three times during the crop growth. First inspection is done at 45 to 60 days after planting to detect off-types and to remove plants infected with designated diseases and pests. The second inspection is done at 120-130 days after planting to check for off-types, designated diseases and pests. The third inspection is done 15 days prior to harvesting of canes to check the general condition of the canes as seed (Sinha 2006). The crop is harvested at 7 to 10 months and used for planting foundation seed (secondary seed) nursery. The multiplication rate is around 1:6 to 1:7, lower than the normal multiplication rate of 1:7 to 1:8 due to slightly lower germination as a result of heat treatment of setts.

**Foundation Seed:** Setts from primary seed nursery are used for planting secondary seed nursery. All the required agronomic practices are followed and the seed plots are inspected at regular intervals for prescribed standards (Annexure I). The crop is harvested at 7 to 10 month age and setts are used for planting commercial seed nurseries.

**Commercial Seed:** Setts obtained from foundation seed crop are used for planting commercial seed nurseries. Commercial seed plots are laid in farmers' fields identified for the purpose and distributed throughout the operational area of the sugar mill. This practice avoids transport of bulky seed to long distances. The seed plots are inspected as per seed certification standard (described in later section of chapter). The crop is harvested at 7 to 10 month age and the cane is supplied as commercial seed. Care is taken to ensure that the buds are intact during transportation. The commercial seed thus produced can be propagated for about 4 to 5 years. Seed replacement with fresh commercial seed is done only after 4 years (Sundara, 2000). The setts from commercial seed plots are supplied to the sugarcane farmers generally by the cane development department of the sugar mills. While the system of seed production and distribution works satisfactorily at some places, at several others one or more stages of the system are impaired and the seed production is affected. Thus, a large proportion of the farmers in most of the developing countries still use traditional, poor quality seeds resulting in poor yields.

**Rapid Multiplication Techniques (RMTs) for Strengthening Quality Sugarcane Planting Material:** Sugarcane yields are deteriorating day by day because of lack of good quality seed. Inadequate availability of quality seed of new sugarcane varieties and poor seed replacement rate adversely affect the realization of potential cane yield of varieties. Availability of disease and pest free, true to type planting material is an important prerequisite for achieving the desired yield improvement in sugarcane. During last two and half decades, some innovative techniques have been developed by different research organisations that needs to be integrated for strengthening and Rapid Multiplication of quality sugarcane planting material. A gist of such techniques and their integration with advance biotechnological tools vis a-vis traditional system are elaborated below in subsequent sections of this chapter.

**Sustainable Sugarcane Intensification (SSI):** The normal practice in many parts of the world is to use sugarcane produced for commercial purposes also for seed purposes. Characteristics for good seed qualities are seldom taken into consideration. Many growers do not consider seed quality, and many of those who do, select the seed cane only at the sett

cutting and planting stage. This is not enough. If a grower wants to be sure of getting good, disease-free seed cane, he should raise the seed crop separately. This crop should be kept completely free from pests and diseases by constant field scouting through the whole season. The Sustainable Sugarcane Initiative (SSI) being supported by the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) and the Worldwide Fund for Nature (WWF) is one such approach that offers some solutions to these mounting problems through a set of principles and practices that 'produce more with less,' getting more output with reduced inputs. The management practices proposed in this approach could help farmers by reducing their costs of cultivation while enhancing their crop productivity in a sustainable manner. We would like to bring to everyone's attention to the groundbreaking insights for sugarcane cultivation with farm-based approaches that pursue a strategy for getting 'more with less' in agriculture. Such approaches are also showing good results with others crops, applying the concepts and principles of the System of Rice Intensification (SRI). The constituent elements of SSI are:

- Raising young cane plants in a nursery using small chips taken from the cane, each with a single bud, and growing them out individually in cups. This allows the cane itself to be used for sugar extraction, rather than being put into the soil to sprout as is the practice now.
- Transplanting these seedlings while still young (25-35 days old) once they have emerged and stabilized.
- Maintaining wide spacing between plants (4 x 2 feet) in the main field when doing the transplanting.
- Providing sufficient moisture to the crop, but avoiding inundation of water.
- Encouraging soil health and fertility by adding organic material to the soil for nutrient enhancement, plant protection, and other intercultural practices.
- Practicing intercropping with other crops, such as onion, garlic, cabbage and lady fingers, for more effective utilization of land, which also enhances the health and fertility of the soil.

This method of better management practices in sugarcane cultivation involves use of **less seeds** and **less water**, and reduced by optimizing utilization of fertilizers and land. It can achieve more yields and profits for farmers and millers alike. SSI is an alternative to the conventional seed, water and space-intensive sugarcane cultivation that is presently practiced by millions of farmers across the country.

**Micro-propagation:** It is another alternative technique to solve the chronic problem of low multiplication of seed. It is the clonal propagation of sugarcane where planting material is multiplied rapidly without impairing the genetic purity. Lee (1987) showed that a better way of micro propagation is shoot tip culture as plant obtained from mother plants has similar phenotypic character. Besides, studies have illustrated that there are many other benefits of using such a technique for development of cane by this method such as increase multiplication rate of new released varieties (Sreenivasan 1995), better cane stalk health, diseases free plants, application of this technique especially for storing the germplasm of canes (Ali *et al*. 2008 and Mamun *et al*. 2004). Micro-propogation is not only a popular mean of clonal propagation but also the most viable and successful method for the production of pathogen free seed material (Sugiyarta and Winarsih 2008).

This technique can be used for large scale production of newly released sugarcane varieties in order to speed up the sugarcane breeding process and for rejuvenation of outstanding old varieties (Belete 2017). A number of micropropagation techniques suitable for commercial seed production in sugarcane have been reported. Apical meristem culture was used by Coleman (1970) and Hendre *et al.* (1975) to obtain sugarcane mosaic virus free plants. Axillary bud culture was applied successfully by Sauvaire and Galzy (1978) to produce true to type clones in many sugarcane varieties. Hendre *et al.* (1983) standardized an apical meristem culture technique for rapid multiplication of mosaic virus-free plants of variety Co 740. Sreenivasan and Jalaja (1981) standardized micro-propagation technique based on the use of apical meristem with two or three leaf primodia (meristem tip) as the explants. In general, following steps are followed for this technique.

Step 1 Initial culture of shoot tip or meristem
Step 2 Auxiliary bud proliferation stage (can be repeated 6-8 times)
Step 3 Root initiation stage
Step 4 Acclimatization or hardening stage
Step 5 Transplanting and field establishment

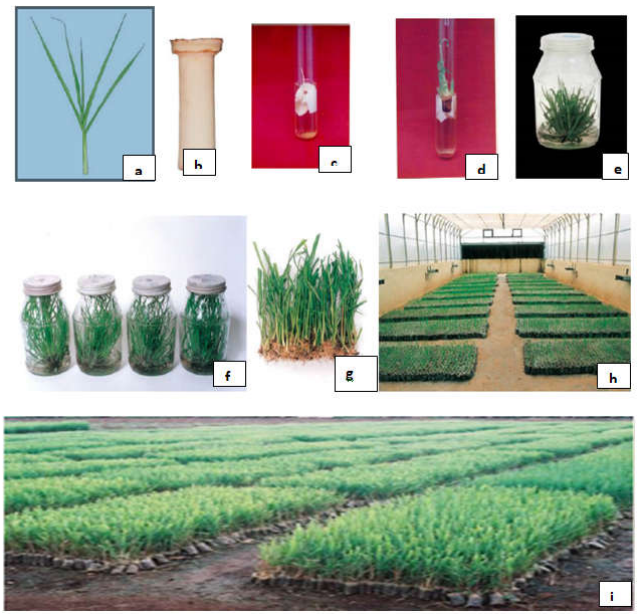


**Fig 1. Schematic steps for micro propagation of sugarcane plantlets: a) Sugarcane top ; b) Inner portion; c ) Meristem culture; d) Shoot Formation; e) Shoot multiplication; f) Rooting; g) In vitro plantlets with root and shoot, h) Hardening in greenhouse and i) Hardening outside the greenhouse (Source: Salokhe 2016)**

**Quality Control Consideration for Micro-propagation:** The tissue culture technique in sugarcane can be used for rapid multiplication of newly developed high yielding, high sugar, disease resistant varieties and rejuvenation of outstanding varieties under cultivation. The micro propagation technique used in this technology with the advantages of (i) Production of true to type plantlets, rapid multiplication (ii) independent of seasonal constraints (iii) maintaining and improving the productivity of outstanding varieties in the field (iv) production of disease free planting material from apical meristem. Quality control is essential to ensure that appropriate initial material is used for micro-propagation, culture conditions are satisfactory and the identity of cultivar is maintained during the culture process.

**Table 1. Performa for field inspection of seed cane that needs to signed by officials of certification team CLASS OF SEED: Breeder/ Foundation/Certified Seed**

| Sr. | Description | I Inspection | II inspection |
|---|---|---|---|
| 1. | Name of the seed centre/mill farm | | |
| 2. | Date of inspection | | |
| 3. | Previous crop | | |
| 4. | Location of field No. | | |
| 5. | Source of Seed | | |
| 6. | Variety | | |
| 7. | Date of planting | | |
| 8. | Area Planted (ha) | | |
| 9. | Area Inspected (ha) | | |
| 10 | Observations | | |
| | (i) Age (Months) | | |
| | (ii) Genetic Purity (%) | | |
| | (iii) Bud Viability (%) | | |
| | (iv) Lodging (%) | | |
| | (v) Diseases(% incidence) | | |
| | a.Red Rot | | |
| | b.Wilt | | |
| | c.Smut | | |
| | d.GSD (grassy shoot disease) | | |
| | e.RSD (ratoon stunting disease) | | |
| | f.Top Rot | | |
| | (vi) Insect Pests(% incidence) | | |
| | g.Top Borer | | |
| | h.Gurdaspur Borer | | |
| | ı.Stalk Borer | | |
| | j.Scale Insect | | |
| | k.Pyrilla | | |
| 11 | Crop growth | | |
| 12 | Expected Yield | | |
| 13 | Remark: | | |
| Inspecting Officials: | | | |

Testing and certification of tissue culture raised quality planting material is required for seed quality assurance and needs to be carried out at accredited test laboratories for the purpose. The following aspects have been emphasized for maintaining the quality of tissue culture raised sugarcane plants (Sinha, 2006).

***Genetic purity of source material****:* The genetic purity of the variety to be micro-propagated should be certified by the breeder/research organization identified for the maintenance of the variety.

***Source material:*** The explant should be taken from vigorously growing healthy plants raised from heat-treated setts and grown under optimum moisture and nutritional conditions. The crop raised from micropropagated seedlings should not be used as source material.

***Accreditation of micro-propagation laboratory****:* Micropropagation laboratory should be accredited by an appropriate authority to ensure technical competence and satisfactory infrastructure.

***Micro-propagation protocol:*** Micropropagation protocol should ensure only minimal genetic changes. Shoot multiplication cycles should be restricted to avoid morphological variation.

***Seedling establishment****:* The seedlings should be well-established in soil mixture with good root system and with 4 to 5 green leaves at the time of supply to user agencies.

***Disease indexing:*** The micropropagation-raised plants should be indexed for freedom from viruses and virus-like diseases through ELISA, and molecular methods. Standard molecular techniques may be used to assess the genetic purity of plants.

***Seed production:*** The micro-propagation-raised seedling should be treated as breeders' (primary) seed. This seed should be further propagated through vegetative cuttings to produce foundation (secondary) seed and then commercial seed. Inspection of the field at the breeders' seed production stage must be done to remove any offtypes.

***Commercial seed:*** Commercial seed thus produced should be used up to four years.

**Spaced transplanting or Polythene bag Technology:** Cane setts with roots and shoots are known as settlings. Settlings can be raised either in nursery beds or in polythene bags. Single node settlings are used as a planting material in spaced transplanting technique of raising sugarcane crop. Indian Institute of Sugarcane Research, Lucknow evolved a planting method namely, Spaced transplanting technique (STP) (Anonymous 1976 and Shrivastava *et al.* 2006).

Settlings are raised by planting single bud setts in nursery about a month before transplanting in the main field. For transplanting one hectare of field, approx. 50 m2 area of land and 2 tons of seed cane are required. This technique ensures higher stalk population (>1.2 Lakh canes ha-1) with uniform crop stand and higher average cane weight. Lower incidence of pests and diseases and reduced crop lodging. It improves the ratio of seed cane to output from 1:10 to 1:40. This technique saves seed cane to the tune of 4t/ha. Raising seedlings through bud chip/ single bud technique is now the major frontier seed multiplication technique in sugarcane (Singh *et al*. 2011).

**Scope for Community-Based Seed cane Production (CBSS) Approach:** Seed production and distribution are notorious bottlenecks to the dissemination of new varieties within the sub-regions of any country. National seed systems are market-oriented and are based on the production of certified seeds according to national standards that are non-efficient for small farmers. In addition, they are all often under-resourced in terms of staff, equipment and funding, and therefore unable to meet production needs. The consequence is that the use of improved seed cane and seed replacement rate is low (Pathak 2009). Further, certified seeds are more destined to cash crops with the use of diverse inputs such as fertilizers, pesticides, and where there a good water control. For subsistence sugarcane production, the situation is different.

**Farmers Produce Seed cane of Acceptable Quality for Farming community:** Farmers work in low-potential and heterogeneous agro-ecological areas where soils are mainly exposed to erosion as a result of primitive techniques and the fallow period short. Farmers do not have access to credit. Potential markets are too distant and practically do not exist. Sustainable sugarcane production relies, on the management of natural processes, such as rotation, crop combinations, natural predation, and so on. Subsistence agriculture is very complex and requires the management of a greater ecological and economic diversity. Farmers exploit their own technologies and local indigenous knowledge to face production needs (Vijay *et al.* 2018).

**Tips to Improve Farmer's Seed cane Production through the CBSS approach:** The Community-Based Seed cane production System (CBSS) is suited to the different social cultures, because farmers have been growing and supplying seeds to other farmers for centuries. Rather than bringing a new system, the CBSS builds on the seed cane production

**Table 2. Specific standards for the sugarcane seed production fields**

| S.No. | Factors | Stage of field inspection | Maximum permissible limits (%) | |
|---|---|---|---|---|
| | | | Foundation | Certified |
| i. | Off-types | I, II, III | None | None |
| ii. | | Plants affected with designated diseases | | |
| | Red rot | I, II, III | None | None |
| | | I | 0.02* | 0.10* |
| | Smut | II | 0.01* | 0.10* |
| | | III | None | None |
| | Grassy shoot | II | 0.05* | 0.50* |
| | | III | None | None |
| | Wilt | III | 0.01* | 0.01* |
| | Leaf scald | II | 0.01* | 0.05* |
| | | III | None | None |
| iii. | | Plants affected by designated insect-pests | | |
| | Top borer | II & III | 5.0 | 5.0 |
| | Internode borer | III | 10.0# | 10.0 |
| | | | None** | None** |
| | Stalk borer | III | 20.0+ | 20.0 |
| | | | None** | None** |
| | Plassey borer, Gurdaspur borer, Scale insect, Mealybug | III | 5.0 | 5.0 |
| | | | None** | None** |

*Subject to immediate rouging of the whole clump. **In areas where the presence of the pest has not been recorded. #It gives around 10% affected buds. +It gives around 0.5% affected buds.

practices that farmers have passed down, generation to generation, for centuries. The program was initially developed by Senegalese Agricultural Research Institute (ISRA) and WARDA in rice crop. Community-Based Seed cane production System teaches farmers how to produce better seeds for their own uses, and to exchange or to sell excess to other farmers. It shortens the time for seed to reach to farmers.

**Working model of CBSS approach:** The CBSS is normally initiated when a variety is released. But Extension and Research institutions may sometimes decide to initiate CBSS after Participatory Varietal Selection trials (PVS), if large seed requests of a variety, by making small quantities of foundation seeds available to various sugar mills and informal basic seed-multipliers. Basic seed cane growers/ sugar mills, in turn, produce seed cane for acceptable quality producers who produce for their communities. At the community level, seed cane should be multiplied and distributed by using local practices. It is very important to respect local customs because in contrary of what we usually think, farmers buy seeds only if there is any more solution.

In general, they opt often for seed exchange, for gift or for loan. Some simple guidance is given to help farmers maintain the seed cane purity at the community level during a period of 3 to 5 years. This advice covers the areas of purification of seed cane, by the removal of off-types; choosing the best clumps with thick and healthy canes and fully developed immature canes will be tagged before harvesting for careful handling of seed cane during harvesting process to ensure storing for shorter transit/ transport and germination test of buds. Since sugarcane is vegetatively propagated crop, farmers do not have to replace their seed cane stocks every season. The major concerns of deterioration of seed quality over time reduced germination ability and purity (mechanical mixture) are monitored at the farm level by the officials of sugar mills and cane department extension services.

**Tools for implementing CBSS:**

**Different tools are used to implement CBSS which includes:**

- Rapid rural appraisals to identify the major constraints and opportunities by region and by community;
- Development of a national/ state seed cane program;
- Organization of farmers field workshops focussing on improvement of the seed
- quality;
- Increasing awareness of the need to produce seed cane of acceptable quality;
- Increasing awareness of the need to preserve local and improved varieties
- Feedback on seed cane nurseries and seed cane demands by community.

**Benefits of quality seed cane:** Increase in the area under sugarcane crop seems difficult, because of severe competition from food crops. Good quality seed and/or planting material is needed to establish the perennial nature of sugarcane crop identified for diverse and harsh climatic situations of tropical and semi- tropical conditions. It has been observed that there is need for 25–30% quantity of quality Seed cane in country and <10% is available in different states. Production of high volume seed cane for vegetative propagation and repeated harvesting of under developed non-uniform canes and latent infection of various diseases and pests in seed crop owing to poor crop stand and and maturity makes it highly labour-intensive for grading and separation of healthy canes. The seed canes so produced also show poor germination due to bud damage and hidden infections mosaic (Vishvanathan and Rao 2011). These factors lead to lesser interest among seed cane growers in producing seed cane nurseries. Sugarcane seed production is greatly hampered because of indeterminate growth, lack of uniform maturity, damaged buds and small period of seed cane storage and transport. These otherwise required traits in ecological perspective, become major bottlenecks in large-scale seed cane production (Yadav 2009). Various benefits of quality seed cane production are described below:

**Reduced pest and disease risk:** Planting good quality seed cane significantly reduces the risk of serious pest or disease outbreaks in commercial fields. This includes ratoon stunt (RSD), smut and.

**Improved germination:** Another advantage of good quality seed cane is good germination and the improved likelihood of high yields. Well-grown seed cane not yet mature is most likely to germinate quickly and evenly. Good germination leads to rapid growth of a uniform stand, and allows the variety to realise its full potential.

Problems of gap filling after planting are therefore minimised and weed control is aided by a full leaf canopy. Having the plant crop start off on such a strong footing and subsequent good management will lead to prolonged ratooning before replanting, thereby significantly reducing production costs.

**Varietal purity:** A further benefit of good quality seedcane produced in a well-managed nursery is varietal purity. Seedcane taken from commercial fields is often contaminated with off-type varieties, including unwanted varieties infected with disease. The production of seedcane under nursery conditions allows for regular inspections and effective eradication (roguing) of unwanted stools. Where the grower has his own seedcane nursery, he is guaranteed seedcane of the right variety at the right time and of the right quantity for the replant programme. A well-managed certified nursery expedites the introduction of new varieties by ensuring purity and providing a controlled environment for rapid bulking.

**Seed cane certification standards:** Age of the seed cane crop at harvest for seed purpose shall be 6 to 8 months and 8 to 10 months for the sowing in tropics and sub-tropics, respectively, seed cane material undamaged and reasonably clean. Each node of seed cane shall bear one sound bud. The number of nodes without sound bud shall not exceed 5.0% (by number) of the total number of buds per seed cane. The number of buds, which have swollen up or have projected beyond one centimeter from the rind surface, shall not exceed 5.0% (by number) of the total number of buds.

**Application and Amplification of General Seed Cane Certification Standards:** The General Seed Cane Certification Standards are basic and together with the following specific standards constitute the standards for certification of sugarcane seed cane (Trivedi and Gunasekaran 2013). The certified classes shall be produced from seed canes and/or meri-clones whose sources and identity may be assured and approved by the Certification Agency.

**Land Requirements:** A seed crop of sugarcane shall not be eligible for certification if planted on land on which sugarcane was grown in the previous season. Land/seed crop shall be kept free from sugarcane residues and drainage from other sugarcane fields.

**Heat Treatment:** Foundation Stage (I) shall be raised from heat-treated seed cane. Sugarcane setts may harbor a host of diseases such as sugarcane smut, red rot, grassy shoot, ratoon stunting, sugarcane mosaic and yellow leaf. Also, scale insects and borers present on the setts can cause heavy damage to the new crop. Heat treatment of setts helps in getting rid of several diseases and pests. There are four types of heat therapies: (1) Hot water: setts are immersed in water maintained at 50°C for two to two and a half hours. Often, fungicides are mixed in hot water to eliminate smut disease. (2) Hot air: dry heat produced by electric heaters placed at different points in the heating chamber is circulated with a fan. Temperature is maintained at 56°C and the seed is treated for eight hours. (3) Moist hot air: steam is injected into the treatment chamber for four hours maintaining the temperature at 54°C. (4) Aerated steam: steam is mixed with air in 1:4 proportion and forced into the treatment chamber through small holes. The treatment is given for one hour at 50°C. When applied properly, heat therapy eliminates ratoon stunting disease, grassy shoot disease, sugarcane smut disease, and also seed borne insect pests and mosaic (Vishvanathan and Rao 2011 and Sanghera and Kumar 2018b).

**Field Inspection**

**A minimum of three inspections shall be made as under:**

- The first inspection shall be made at 45-60 days after planting in order to verify isolation and detect volunteer plants, designated diseases and pests and other relevant factors.
- The second inspections shall be made at 120-130 days after planting to verify Off-types, designated diseases and pests and other relevant factors.
- The third inspection shall be made 15 days prior to the harvesting of seed canes to verify the age of cane, off-types, designated diseases and pests and other relevant factors.

**Seed-cane inspection report:** The performa for field inspection of seed cane is presented below that needs to signed by officials of certification team during field inspection.

**Field Standards**

***General requirements***

**Isolation**: The sugarcane seed production fields shall be isolated from other fields with a minimum distance of 5 m to avoid mechanical mixture of other varieties.

**Designated Diseases and their keys for identification are given below:**

**Red rot (*Glomerella tucumanensis* (Speg.) Arx & Muller)**

Red rot is one of the major diseases of sugarcane found in many areas of the world. In India it has caused extensive damage in recent past and remains endemic in severe form in some parts.

**Fig. 2. Key symptoms for field identification of red rot disease of sugarcane**

- The first symptom of red rot in the field is discolouration of the young leaves. The margins and tips of the leaves wither and the leaves droop.
- The discolouration and withering continues from the tip to the leaf base until the whole crown withers and the plant dies, within 4 to 8 days.
- Since reddening is a common symptom of other diseases of sugarcane, the white patch symptom is an important diagnostic characteristic of red rot.

- When a diseased plant is open, a characteristic odour becomes evident.

**Smut (*Ustilago scitaminea* (Sydow)**

The disease is known as culmicolous, which describes the outgrowth of fungus of the stalk on the cane. It attacks several sugarcane species and has been reported to occur on a few other grass species as well, but not to a critical amount. The most recognizable characteristic of this disease is a black or gray growth that is referred to as a "smut whip".

**Fig. 3. Key symptoms for field identification of smut disease of with sugarcane**

- Two to four months after the fungus has infected the plant, black whip-like structures, instead of a spindle leaf, emerge from the meristem, or growing point, of the plant.
- The developing whip is a mixture of plant tissue and fungal tissue. The whip reaches maturity between the sixth and the seventh month.
- When spores that are contained inside the whip are released, the core of the whip remains behind and is a straw-like color.
- Plants infected with the fungus usually appear to have thin stalks and are often stunted.
- They end up tillering much more than normal and this results in leaves that are more slender and much weaker.

**Wilt (*Cephalosporium sacchari* Butler)**

This is one of the early known diseases of sugarcane in India. It was first reported by Butler and Khan in 1913, from North India. It has been reported to cause severe damage to sugarcane crops in many parts of India.

**Fig 4. Key symptoms for field identification of grassy shoot disease (GSD) of sugarcane**

- The first symptoms of the disease become apparent only when the plant has grown for about 4-5 months.
- The canes show gradual withering.
- On examination of affected clumps , the pith will be seen discoloured purple or dirty reef, with longitudinal streaks
- The leaves of affected clumps gradually turn yellow and dry up.
- A characteristic disagreeable odour is also associated with such diseased canes.
- A cottony white mycelium can also be seen in the pith region.

**Grassy shoot disease (Mycopplasma-Like-Organism)**

**Fig. 5. Key symptoms for field identification of grassy shoot disease (GSD) of sugarcane**

- Initial symptom appears in the young crop of 3 – 4 months age as thin papery white young leaves at the top of the cane.
- The disease is characterized by proliferation of vegetative buds from the base of the cane giving rise to crowded bunch of tillers bearing narrow leaves.
- The tillers bear pale yellow to completely chlorotic leaves.
- Cane formation rarely takes place in affected clumps and if formed the canes are thin with short internodes.
- Later, white or yellow tillers appear in large number below these leaves (profuse tillering).
- The cane becomes stunted with reduced internodal length with axillary bud sprouting.
- This disease appears in isolated clumps

**Leaf scald (*Xanthomonas albilineans* (Ashby) Dowson**

It is a bacterial disease, widely spread in many countries. Disease is favoured by wet seasons, water stress due to drought, water logging and low temperatures.

- Disease symptoms appear in two phases, the chronic and acute phases.
- In the chronic phase, "white pencil line" extending entire length of lamina reaching the margin of young leaves and stripes diffuse later resulting in leaf etiolation.
- Drying from tip onwards presents a scalded appearance. Different degrees of chlorosis from total albinism to inter veinal chlorosis in young leaves during summer, germination of buds in acropetal manner with bushy appearance in standing cane, cut open stalks showing dark red vascular strands, prominent streaks at node invariably in the side shoots, are other prominent symptoms of chronic phase.
- In the acute phase the symptoms appear suddenly and die without any major leaf symptoms. The masking of symptoms is more common during monsoon and symptoms may appear suddenly any time during crop growth.

**Designated Insect-Pests considered in seed nursery plots:** According to rough estimates, insect pests cause almost 20 to 40 per cent reduction in yield of the crop resulting in huge

losses to growers (Satyagopal et al. 2014). Amongst sugar cane pests, borers cause more damage to the crop. Moths of sugar cane borers lay their eggs underside the leaves. They keep feeding inside the cane and render it unfit for consumption and milling. Weight of cane and sucrose percentage is drastically reduced.

**Fig. 6. Key symptoms for field identification of leaf scald disease of sugarcane**

**Designated Insect-Pests that need significant attention in cane seed crop and their keys for are listed below**

- Top borer (*Scirpophaga excerptalis* Wlk.)
- Internode borer (*Chilo sacchariphagus indicus* Kapur)
- Stalk borer (*Chilo auricilius* Ddgn.)
- Plassey borer (*Chilo tumidicostalis* Hmpsn.)
- Gurdaspur borer (*Acigona steniellus* Hmpsn.)
- Scale insect (*Melanaspis glomerata* Green)
- Mealy bug (*Sacchariphagus sacchari* Cockerell)

**Special Note**

- All off-types and diseased plants shall be rouged out along with roots and destroyed.
- -.Maximum permissible limits for the stripping of dry foliage shall be 2.0%
- The crop should not have more than 10% lodged canes.
- Seed canes should not have nodal roots. In waterlogged areas, relaxation may be given upto a maximum of 5%.
- Moisture in seed cane should not be less than 65% on wet weight basis.
- Germinability of buds should not be less than 85%
- Physical purity of seed should be 98%.
- Genetic purity of seed should be 100% based on DUS characteristics.

**Conclusion**

Sugarcane yields and recovery are deteriorating day by day because of lack of good quality seed. Since, it plays a pivotal role in the economy of sugarcane growing areas and, hence, improving sugarcane production will greatly help in economic prosperity of the farmers and other stakeholders associated with sugarcane cultivation. Seed production in sugarcane is important for high cane yield and production. Generally farmers practice normal convention means and planting material without realizing the importance of right practice and usage of good quality seed. There is a need to aware the farmers for use of right methods and procedures for seed production. With the application of RMTs elaborated above along with augmentation of seed certification standards in quality assurance and right practice adoption and use of good quality seed cane not only help the farmers but the sugar millers too as good seed cane will give good cane yield with improved recovery. Healthy and good quality seed cane provide assured germination of disease free canes that helps the farmers to rejuvenate and retain high yielding sugarcane varieties for longer duration.

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