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Bud Chip Seedling-A New Propagating Technique in Sugarcane Production: An Overview

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ABSTRACT

Chip bud technology is the most promising technique of sugarcane production, where chip bud seedlings raised in controlled environment are transplanted in main field. Generally, in this technology, seedlings are transplanted at a particular age, with a definite spacing and proper management practices. This technology is found to be beneficial in terms of growth, cane yield over conventional and other method of planting. However, depending upon the edaphic and climatic variation, researchers are working on evaluation of proper nursery management, spacing and other production technology of chip bud seedlings related to its growth, yield and economical return. In this article an attempt has been made to reveal some of the research finding srelated to this technology for further research with an objective to maximum the economical return by curtailing the cost of production.

Key words: Bud chip, Conventional, Economic, Planting material, Sugarcane.

Sugarcane (*Saccharum officinarum* L.) is one of the most important commercial crops in India and is used mainly in the production of sugar next to sugar beet. India occupies the second position in terms of area and production of sugarcane after Brazil. The crop occupies almost 2.67% of total cultivated land area contributing about 7.5% of total agricultural production in the country (DAC, 2020).

In sugarcane production, seed cane used for planting is the prime factor to establish a good initial crop stand and it accounts 20% of the total production cost (Galal, 2016). Traditionally in India, sugarcane is grown using stem cuttings called setts which are short cane stalks with one or more buds. As per variety used in this system, a very high sugarcane seed rate of 7-10 t ha^{-1} are used as planting material, which comprises of about 40,000 stalk pieces having 2-3 buds (Sarala, 2017).

The use of large number of three eyed setts per furrow resulted a very strong competition among the main shoots, which in turn reduced the number of tillers per planting material used (Verma, 2004). Moreover, in conventional sugarcane cultivation, the requirement of large mass of planting material poses a great problem in transport, handling and storage of seed cane and undergoes rapid deterioration thus reducing the viability of buds and subsequently their germination. Van Dillewijn (1952) stated that for propagation of sugarcane a small volume of tissue with a single root primordium adhering to the bud are enough to ensure germination. He also stated that cutting of one bud is sufficient as seed material under favorable growing conditions. Moreover, Narasimha and Satyanarayana (1974) and Ramaiah *et al*., (1977) also showed the feasibility of eliminating the internode part of the seed piece and using only buds for commercial planting. This alternative method of planting using bud chip (Fig 1) instead of planting 2/3 budded setts reduces the quantity of planting material apart from improving the quality of seed cane. These bud chips are less bulky, easily transportable and more economical (Sarala, 2017). After extraction of bud chip from the cane the left over portion can be sent for milling (Fig 1).

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What is bud chip technology of sugarcane

The bud chip technology as a principle in the Sustainable Sugarcane Initiative (SSI) involves use of less seed, less water and optimum utilization of land to achieve more yields (Biksham, 2011). The bud chip technology involves excision of sugarcane bud with small material of the root band, growing them in plant media and finally transplanting the raised seedlings (Fig 2) into the main field at definite inter and intra-row plant spacing as sown in Fig 3. The single eyed raised seedlings considerably reduced 70% of seed requirements because only 1 ton ha^{-1} of seed cane is required in this method and benefited the farmer by facilitating the left over cane for milling (Nyati, 1998). This technology was found to increase cane yield by 11 per cent over traditional method (Hunsigi, 2001). According to Rajula and Ramanjaneyulu (2014), the bud chip technology could be one of the most viable and economical alternatives in reducing the cost of sugarcane production. In this method, bud chip seedlings are raised in nursery preferably in small plastic cups or trays or nursery and transplanting is done in

the field. Depending on the season, it might take 35-70 days (Clowes and Breakwell, 1998) for transplanting the seedlings into the main field. In this method, only 13,500 buds/ha of single buds are sufficient to attain 122500-137500 millable cane ha^{-1} (Goud, 2011).

Advantages of bud chip technology over conventional method

Saving in seed material

The bud chip technology was three times more cost effective than the normal planting technique (Narendranath 1992). Generally, eight tons of sugarcane setts is required to plant a hectare of land, if 30,000 three budded setts are used. But, in bud chip technology only two to three quintals (200-300 kg) of planting material is required which saved about 96% of cane by weight (Narasimha, 1977). It was also reported that planting of sugarcane bud chips seedling saved about 97% of stalk material by weight (Galal, 2016). He also stated that seedling raised in trays recorded higher field survival (95%) as compared to those arising on mini plot (82.5%) under field conditions. The saving of large quantities of planting material under SSI (Parajuli *et al*., 2019) is due to higher germination% that leads to better crop establishment (Mishra, 2019; Jamuna, 2019).

Easy transportation

Prasad and Sreenivasan (1996) used the bud chip method as a technology for easy transport of cane seed material. In this method, very less sugarcane seed material *i.e*. $1/10^{th}$ of conventional method is used which also reduced the transportation cost. The "chip bud technology", involved removal of buds from cane and raising them in nurseries that drastically reduced the seed cane requirement of about 4-6 t ha^{-1} as compared to conventional method (Biksham and Natarajan, 2013). In addition, this technology provides high productivity with saving in irrigation water, reduction in seed cane cost and increase in farm income through intercrops and facilitates mechanized cane harvesting due to wider spacing (Kathiresan, 2014).

More growth

The propagation through bud chip method recorded better expression of growth attributes *viz*., cane girth, tiller number, NMC, photosynthetic rate and dry matter production. The stool weight (22.37 kg), leaf area index (6.82 cm^2), cane height (340 cm), cane girth (3.36 cm) and single cane weight (2.36kg) were higher in the bud chip method as compared to traditional method (Kumar and Suresh, 2011). The number of tillers $plant^{-1}$ (17.3) and number of millable canes $clump^{-1}$ (14.2) also significantly increased under bud chip of method of sugarcane cultivation over traditional method (Samant, 2017). The system of transplanting seedlings also increased the weight of cane by 34% (Tianco 1995). The more tillering capacity in bud chip technology resulted in higher cane productivity as compared to conventional method. Begum *et al*. (2018) also found profuse tillers in case of bud seedling (Fig 4).

Facilitates intercropping

The wider row to row spacing in case of sugarcane bud chip seedling facilitates the inclusion of second crop which helped in earning more economic return. Gujja *et al*. (2009) stated that the selection of intercrop are location specific, however, crop like cowpea, chickpea, potato, green gram, water melon and wheat were successfully grown with this technology. In case of autumn planted sugarcane bud chip technology, the crop like potato, cabbage, frenchbean performed better, while in case of summer planting crop like okra can be easily grown (Fig 5).

Besides this, crop like onion can also be successfully grown without any detrimental effect on growth of main sugarcane (Chandrakar *et al*., 2019). While, in sub tropical India, pulses like gram/lentil/summer moong/summer mash has immense scope as intercrop in autumn planted sugarcane (Saini *et al*., 2012).

Yield advantageous

The bud chip technology produced higher number of tillers $plant^{-1}$ (17.3) and millable canes $clump^{-1}$ (14.2) that resulted more cane yield (129.2 t ha^{-1}) as compared to farmer's practice of conventional method (Samant, 2017). The yield advantage of sugarcane bud chip technology over conventional method was also reported by Mishra (2019). He reported a cane yield of 122.6 t ha^{-1} due to adoption of sugarcane bud chip technology which was 37.3% higher than the conventional 3 budded method. Similarly, Mohanty



Fig 1: Bud chip and cane stalk after scooping the bud chip.

et al. (2015) reported almost 18% higher yield over conventional method. Several Scientist reported about yield advantage of SSI method than the conventional (Sugeerthi *et al*., 2018; Mishra, 2019).

Maximum economic return

Planting of chip bud seedlings registered the maximum economic returns by producing higher net income (Rs. 1, 83,040 ha^{-1}) and B: C ratio of 2.63 as compared to other planting method (Sugeerthi *et al*., 2018). They stated that although the input cost on chip bud seedlings involves high cost, the beneficial aspects of chip budded seedling on establishment and productivity in terms of seed cane yield are much higher and it could have ultimately reflected on high economic income in terms of net monetary returns and B:C ratio. The monetary benefit of sugarcane bud chip technology over traditional method of planting was also reported by Mishra (2019). In earlier research, Mohanty *et al*., (2015) also reported more economical return *i.e*. gross as well net return of Rs. 2, 36,250 and 84,300, respectively under bud chip technology as compared to conventional 3 budded planting. The wider spacing facilitates the scope of inclusion of intercrops in between rows which gives additional income to the sugarcane growers. This method of sugarcane production was found to be economically viable than traditional method of planting using two to three budded setts. In the bud chip technology, the return from crop is relatively higher and substantial saving in the seed material could be possible. The left over cane could be utilized for crushing since it remains a full cane except for the scooped up bud portion.



Fig 2: Raising of bud chip seedling in nursery.

Performance of sugarcane bud chip seed technology as compared to other method of planting

When different method of planting was compared, the planting of chip bud seedlings technique recorded higher plant height (229.46 cm), tiller population (113.01, '000 ha^{-1})



Fig 3: Transplanting of seedling in main field.



Fig 4: Profuse tillering in case of bud chip seedling.



Fig 5: Intercropping of okra in between 2 rows of sugarcane.

and dry matter production (85.87 t ha^{-1}) followed by double budded setts (Sugeerthi *et al*., 2018). This might be due to abundant light interception, aeration and lesser plant competition prevailed with interplant spacing that would have offered congenial environment for each seedling for effective utilization of above resources for metabolic activities of sugarcane as compared to conventional method. Moreover, with appreciable increments in the values of both plant height and tiller numbers would have contributed increased values of crop biomass in terms of dry matter production (Loganandhan *et al*., 2012). Besides this, chip budded seedlings also recorded significantly higher yield parameter *viz*., single cane weight (1.80 kg/cane) and seed cane yield (98.32 t ha^{-1}) as compared to other types of seed cane planting. The appropriate spacing maintained within the acquainted seedling rows might have intercepted solar radiation at its potential for enhanced photosynthate productivity at the source region *i.e*. enlarged leaf area of increased individual leaves and its effective translocation and subsequent storage in the cane stalk and sink (Sugeerthi *et al*., 2018). The cane yield in conventional planting ranged from 38 to 96 t ha^{-1}, whereas under SSI planting, cane yield ranged from 58 to190 t ha^{-1} (Shanthy and Ramanjaneyulu, 2014). Although the bud chip technology has many advantages, however many research works have been going on this technology for the refinement and modification of chip bud technology. Some of the research findings related to chip seedlings are reviewed below.

Effect of different growing media on germination/ establishment of bud chip seedlings

The growing media plays an important role on growth of bud chip seedlings. While studying the effect of different growing media on growth of sugarcane bud chip seedling in Zimbabwe, composted filter cake was reported as most suitable plant media which can be used for raising sugarcane bud chips (Masukume, 2016). Moreover, treating the bud chip settling with growth promoting chemicals *viz*. ethephon (2-chloroethyl phosphonic acid) @ 100 mg l^{-1} and calcium chloride @ 0.1% improved the sprouting of bud chip seed stocks which ranged from 32-36 per cent over control (Jain *et al*., 2010). Soaking of bud chips with 50-200 mg l^{-1} of ethephon also promotes better sprouting, rooting activity, plant growth, tillering and rate of photosynthesis by altering some of the key biochemical activities essential for their early growth and better establishment compared to untreated (Jain and Solomon, 2010). The beneficial effect of ethephon and calcium chloride on the enhancement of sprouting of sugarcane setts was also reported by Jain *et al*. (2009).

An experiment was also conducted at Sugarcane Research Station, Melalathur, Tamil Nadu by Indira *et al*., (2018) on growth and seedling vigour of bud chip seedling. They revealed that treating the chip buds with the combination of AM fungi 2 g+Azophos 2 g+Pseudomonas flurorescens 0.75 g/chip bud recorded the maximum values for germination percentage (88), root length (35.3 cm), shoot length (38.0 cm) and seedling vigour (6450) as compared to control which recorded lesser values for germination percentage (80), root length (21.0 cm), shoot length (25.0 cm) and seedling vigour (3680). Effect of different combinations of mediums on growth of the bud chip seedling was studied by Loganandhan *et al*., (2012). They revealed that the combination of coco pith and sawdust (1:1) resulted the highest germination (88%) followed by the combinations of coco pith+vermicompost (85%) and sawdust+press mud (84%).

Effect of age of seedling on growth and yield of sugarcane

In Philippines, Tianco (1995) reported 11% higher yield and 34% heavier individual canes but 17% lower millable cane as compared to normal method of cultivation by transplanting 40 days old seedlings grown in poly bags. On the other hand, Sarala (2017) reported that transplanting of 30-45 days old bud chip seedlings at a spacing of 60/120 cm × 60 cm with recommended dose of fertilizers recorded higher cane yield in sandy loamy soils of Andhra Pradesh. Moreover, Natarajan (2011) stated that both in tropics and subtropics, tillering capacity could be improved by transplanting 20 days old seedlings.

Growth and yield attributes of sugarcane influenced by different planting geometry of bud chip seedling

Planting geometry plays a significant role on growth of sugarcane. Planting of sugarcane bud chip seedling in wider row spacing of 120 cm gave higher leaf area index (7.90) followed by 90 cm row spacing (6.44) whereas minimum leaf area index (6.02) was recorded in row spacing of 60 cm (Khalid *et al*., 2015). Moreover, they also reported higher leaf area $tiller^{-1}$ (563.3 cm^{-2}) with 120 cm row spacing followed by 90 cm row spacing (591.7 cm^{-2}). The lowest was noted with 60 cm^{-2} row spacing with a leaf area $leaf^{-1}$ of 415.49 cm^{-2}. The findings are in line with Ahmad (2002) and he mentioned that wider row spacing also had

significant effect on leaf area tiller, LAI. Bhanupriya *et al*. (2014) also reported the production of more number of tillers and higher LAI due to planting of single chip bud seedlings as compared to conventional method. Similarly, the sugarcane bud chip seedling performed better with increase in inter row spacing under dry land situation (Wawan *et al*., 2017). They reported more crop growth parameters like leaf area, crop growth rate (CGR) and net assimilation rate (NAR) due to planting of sugarcane bud chip seedling at 75 cm × 100 cm and 60 cm ×100 cm as compared to other spacing. The planting of sugarcane bud chip settling at a spacing of 120 cm × 60 cm performed better than other spacing in terms of cane yield (Chandraka *et al*., 2019). However, the number of tillers, plant height and intermodal length greatly increased with increase in spacing and reached maximum with 150 cm × 120 cm, but can yield was greatly reduced due to reduction in single cane weight (kg) and girth of the cane. Begum (2018) also reported profuse tillering in case of bud chip technology of sugarcane (Fig 4).

Cane yield of sugarcane influenced by different planting geometry of bud chip seedling

Sugarcane yield is highly affected by planting geometry and improper row spacing is the most critical factor for reduction of sugarcane yield (Mahmood *et al*., 2007). The highest cane yield (80.9 t ha^{-1}) was obtained when sugarcane bud chip seedlings was planted at 120 cm apart followed by 90 cm (80.2 t ha^{-1}) whereas, the lower yield was recorded in plots where 60 cm row to row spacing was maintained (Khalid *et al*., 2015). However, Planting of sugarcane bud chip seedling in row spacing up to 120 cm had enhanced weeds density, fresh and dry weight as well as the individual weed density and weight as compared to planting at 90 cm. The panting of sugarcane bud chip seedling at a spacing of 120 cm also recorded 18% higher cane yield and net return of Rs. 84,300/ha than the conventional 3 budded setts planted at a row to row spacing of 75 cm (Mohanty *et al*., 2015).

Moreover, transplanting of single bud chip in different row spacing also plays a great impact on growth of sugarcane. Saini *et al*., (2012) stated that sugarcane yield could be obtained up to 117.8-120.8 tha^{-1} by transplanting seedling of bud chips in proper row spacing. The propagation technique through bud chip method had recorded higher cane yield (148.56 t ha^{-1}) compared to traditional method (139.3 t ha^{-1}) (Kumar and Suresh, 2011). In tropical condition, planting of sugarcane bud chip settling at spacing of 150 cm × 45 cm along with the application of composted coir pith @ 5 or 10 t/ha and 75% recommended level of irrigation performed better than planting at a spacing of 150 cm × 60 cm (Dhanapal *et al*., 2019). On the contrary, Swapna *et al*. (2020) reported that among the different planting geometry of bud chip method, 150 cm × 60 cm was found to be most suitable in terms of cane length, tiller numbers internode length as well as cane yield (162 t ha^{-1}) as compared to other planting geometry.

In another experiment, planting of sugarcane bud chip settling at 90 cm row spacing for three consecutive seasons at Sugarcane Research Institute, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar, showed the highest dry matter accumulation (30.6 and 28.1 t/ha), millable canes (102,000 and 116,300/ha), in plant and ratoon crops, respectively. Planting of bud chip settlings at 90 cm row spacing significantly increased the yield of plant and ratoon canes during all the years of experimentation (Kumar, 2019).

Juice quality of sugarcane influenced by different planting geometry of bud chip seedling

The commercial cane sugar (CCS) was not significantly influenced by the different row spacing, although higher CCS (15.3 and 15.5%) was recorded when bud chip seedlings were planted at 120 cm and 90 cm row spacing, respectively (Khalid *et al*., 2015). They also stated that the pol % in sugarcane was also not significantly affected by different row spacing although higher pol % (17.61) was recorded in 120 cm row spacing followed by 90 cm (17.55%). This might be due to the prime genetic trait of the cultivar and hence row spacing did not have any significant effect on POL% and CCS of sugarcane. Maqsood *et al*. (2005) and Ehsanullah *et al*. (2011) also stated that juice quality parameters like CCS and sucrose were not significantly affected by row spacing in sugarcane. On the other hand, improvement in sucrose content and commercial cane sugar percentage due to wider row spacing was reported also by Pawar *et al*. (2005).

Performance of sugarcane bud chip seedling under different nutrient management

The planting of bud chip seedlings along with 75 per cent recommended dose of NPK + *Azophos+ in situ* incorporation of sunnhemp + foliar spraying of sugarcane booster (S3N4) recorded higher establishment percentage (87.89), plant height (246.35 cm), tiller population (123.25, 000 ha^{-1}), dry matter production (92.21 t ha^{-1}), single cane weight (1.95 kg), seed cane yield (105.99t ha^{-1}) as compared to other planting materials and nutrient management (Sugeerthi *et al*., 2018). The performance of sugarcane in bud chip technology also depends upon the fertilizer dose and method of application like the conventional method of planting (Swapna *et al*., 2020). They reported that the yield attributing characters as well as yield increased with the application of 150% recommendation of dose of fertilizers (RDF) than the 100% RDF. In case of both the fertilizer levels, the yield increased with increase in number of splits of application of fertilizers. In a nutshell, the highest cane yield was obtained with application of 150% RDF in 4 splits. Row spacing and nutrient management have a key role in maximizing sugarcane yield and improving its quality as among the agronomic practices, reason for lower cane yield are due to improper nutrient management and planting geometry (Suggu, 2010).

Performance of sugarcane bud chip seedling under mechanization

To facilitate the easy transplanting of sugarcane bud chip seedling in main field a tractor mounted two row mechanical planter was developed by Central Institute of Agricultural Engineering Regional Centre, Coimbatore and Sugarcane Breeding Institute, Coimbatore (Naik *et al*., 2013) and no significant difference in yield attributing characters, yield as well as juice quality parameters was recorded due to planting of sugarcane settlings by manually and mechanically. However, the cost economic analysis of planting with mechanical planter showed 40 and 85% saving in cost and labour, respectively over manual bud chip settling planting. Sundara (2011) stated that mechanization in sugarcane would help to reduce dependence on manual labour, facilitate timely farm operations and help to improve the quality of various operations thereby improving yield.

Economics

It was reported that about 80% by weight of the sett-planting seed material can be saved by planting bud chips (Narendranath, 1992; Iqbal *et al*., 2002; Tamil Selvan, 2006) due to saving in seed material, the maximum net returns were obtained with bud chips raised seedlings. The improved practice of bud chip method of sugarcane planting recorded higher gross return (Rs. 271320 ha^{-1}) than traditional method of cultivation. The higher B: C ratio (3.86) obtained in improved practice due to higher net return as compared to local check (2.34) attributed to more cane production (Samant, 2017). The variation in net return and benefit-cost ratio may be attributed to the variation in the price of agri inputs and produce (Kapur, 2011). In another experiment, planting of sugarcane bud chip settling at 90 cm row spacing for three consecutive seasons on sugarcane at Sugarcane Research Institute, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar, showed net returns (Rs. 137,700 and 140,600/ha) and benefit/cost ratio (1.67 and 2.40). In addition to that planting of settling at 30 and 45 cm planting distance were not significant however the higher benefit/cost ratio was obtained at 45 cm planting distance (Kumar, 2019).

Conflict of interest

All authors declare that they have no conflict of interest.

REFERENCES

Ahmad, I. (2002). Bio-economic efficiency of spring planted sugarcane as influenced by spatial arrangement and nutrient management. Ph.D. Thesis, Dept. Agron. Uni, Agric. Faisalabad, Pakistan. pp. 155-158.

Begum, M. (2018). Comparative performance of sugarcane bud chip seedling with conventional method. Annual Report, Sugarcane Research Station, Assam Agricultural University, Jarhat, Assam India.

Bhanupriya, N., Durai, Singh., Ramessh C. (2014). Evaluation of planting materials and nutrient levels in chewing cane (*Saccharum officinarum*). Madras Agricultural Journal. 101(10-12): 361-364.

Biksham, G., (2011). A Methodology to improve cane productivity. In: Sustainable Sugarcane Initiative Draft (SSI). Sugarcane Breeding Institute and Natural Resources Management Centre. pp. 5-6.

Biksham, G. and Natarajan, U.S. (2013). Sustainable Sugarcane Initiative-Improving yields and reducing the ecological footprint. LEISA India. 3: 23-24.

Chandrakar, C.K., Prabha, N., Verma, O.N. and Pandey, K.K. (2019). Standardization of planting geometry of sugarcane with suitable intercropping under drip irrigation in Chattisgarh Plains. Int. J. Curr. Microbiol. App. Sci. 8(7): 2878-2884 doi: https://doi.org/10.20546/ijcmas.2019.807.358.

Clowes, M.S.J and Breakwell, W.L. (1998). Zimbabwe sugarcane production manual. ZimSug Assoc ExpSta, Chiredzi, Zimbabwe https://lib.ugent.be/catalog/rug01:000486147.

DAC, (2020). Pocket Book of Agricultural Statistics (2019). Directorate of Economics and Statistics, Government of India. New Delhi. pp. 122.

Dhanapal, R., Tayade, A., Bhaskaran, A. and Geetha, P. (2019). Efficient water management in sugarcane with composted coir pith and sugarcane trash under tropical Indian conditions, Sugar Tech. 21: 256-264, doi: 10.1007/s12355-018-0593-3.

Ehsanullah, K.J., Jamil, M. and Ghafar, A. (2011). Optimizing the row spacing and seedling density to improve yield and quality of sugarcane. Crop Envt. 2: 1-5.

Galal, M.O.A. (2016). A new technique for planting sugarcane in Egypt. IIOABJ 7. 4: 15-21.

Goud, V.V. (2011). Sustainable Sugarcane Initiative, SSI- A Methodology for improving yields, First National Seminar on, SSI TNAU, Coimbatore, India. pp: 9-12

Gujja, B., Loganandhan, N., Gound, V., Agarwal, M. and Dalai, S. (2009). Sustainable Sugarcane Initiative, Training Manual, an Initiative of ICRISAT-WWF Project: 1-36.

Hunsigi, G. (2001). Sugarcane in Agriculture and Industry. Bangalore: Prism Books Pvt Ltd. 70.

Indira, K., Saravanan, N.A. and Thirumurugan A. (2018). Effect of arbuscularmycorhizal fungi and bio inoculants to ssi chip buds on germination and seedling vigour in sugarcane. International Journal of Current Research in Life Sciences. 07: 2725-2726.

Iqbal, M.T., Eusufzal, S.U.K., Rukshana, F. (2002). Performance of sugarcane bud chip settlings. Indian J. Sugarcane Technol. 17: 88.

Jain, R., Solomon, S., Lal, P., Shrivastava, A.K. (2009). Nutrient application improves stubble bud sprouting under low temperature conditions in sugarcane. Sugar Tech. 11: 83-85.

Jain, R., Solomon, S., Shrivastava, A.K., Chandra, A. (2010). Sugarcane bud chips: A promising seed material. Sugar Tech. 12: 67-69.

Jain, R. and Solomon, S. (2010). Growth stimulating effect of ethephon on sprouting and early vigor of sugarcane bud chips. Sugar Cane International. 28: 114-118.

Jamuna, E. (2019). Combined effect of glucono acetobacter diazotrophicus AM fungi in rising Sugarcane seedlings under SSI Technology. Plant Archives. 19: 2929-2932.

Kathiresan, G. (2014). Cost Reducing Practices for Pruning, Mother Shoot in SSI and Controlling Twiner Weeds on grown up Sugarcane. Souvenir of National Seminar on Improved Technologies for Sustainable Sugarcane production, Kalavai, Tamil Nadu. p: 128-131.

Kapur, R., Duttamajumdar, S.K., Rao, K.A. (2011). A breeder's perspective on the tiller dynamics in sugarcane. Current Science. 100: 183-189.

Khalid, S., Munsif, F., Ali, A., Ismail, M., Haq, N. and Shahid, M. (2015). Evaluation of chip bud settling of sugarcane for enhancing yield to various row spacing. International J. Agricultural and Environmental Research. 1(2): 8-13.

Kumar, M.V. and Suresh, K. (2011). Studies on Physiological Aspects of Growth, Quality and Yield of Bud Chip Technology in Sugarcane, First National Seminar on, SSI, organized by TNAU, Coimbatore, Tamil Nadu, India. pp: 44-46.

Kumar, N. (2019). Enhancing Sugarcane Plant-Ratoon Productivity Through Bud Chip Transplanting Geometry. Sugar Tech. https://doi.org/10.1007/s12355-019-00772-3.

Loganandhan, N., Gujja, B., Vinod, V.G. and Natarajan, U.S. (2012). Sustainable Sugarcane Initiative (SSI): A Methodology of 'More with Less". Sugar Tech. doi: 10.1007/s12355-012-0180-y.

Mahmood, A., Ishfaq, M. Iqbal, J. and Nazir, M.S. (2007). Agronomic performance and juice quality of autumn planted sugarcane as affected by flat, ditch and pit planting under different spatial arrangements. Int. J. Agric. Biol. 9: 167-169.

Maqsood, M., Iqbal, M. and Tayyab, M. (2005). Comparative productivity performance of sugarcane sown in different planting patterns at farmer's field. Pak. J. Agric. Sci. 42: 25-28.

Masukume, S. (2016). A Research Project submitted in Partial fulfilment of requirements for a Bachelor of Science Agronomy Honours Degree "The effect of plant media and intra-row spacing using bud chip technology on growth and yield of sugarcane (*Saccharum officinarum* L.) varieties" Midlands State University, Zimbabwe.

Mishra, K. (2019). Evaluation of bud chip method for enhancing yield and economics of sugarcane, International Journal of Chemical Studies. 7: 1726-1729

Mohanty, M., Das, P.P. and Nanda, S.S. (2015). Introducing SSI (Sustainable Sugarcane Initiative) technology for enhanced cane production and economic returns in real farming Situations under east coast climatic conditions of India. Sugar Tech. 17: 116-120. doi: 10.1007/s12355-014-0311-8.

Naik, R., Annamalai, S.J.K. and Nair, N.V. (2013). Studies on mechanisation of planting of sugarcane bud chip settlings raised in protrays. Sugar Tech. 15: 27.

Narendranath, M. (1992). Cost-effectiveness of Transplanting Nursery -raised Sugarcane Bud Chip Plants on Commercial Sugar Plantations. Proc 11th Inter Soc Sugar cane Technol, Poster paper. p. 332.

Narasimha, R.G. (1977). Chip bud method. The Hindu, July 9.

Narasimha, R. and Satyanarayan, G. (1974). Studies in control of sett borne infection of red rot of sugarcane. J. Res. Andhra Pradesh Agric Univ. 1: 83-86.

Natarajan, U.S. (2011): Tillering in SSI-emergence, factors affecting, constraints and solutions. First National Seminar on Sustainable Sugarcane Initiative. pp: 21-23.

Nyati, C. (1998). Fertilization. In: Zimbabwe Sugarcane Production Manual. [Clowes, M.S.J. and Breakwell, W.L. (eds)]. Chiredzi: Cannon Press. pp. 110-113.

Prasad, R.N. and Sreenivasan, T.V. (1996). Developing technology for sugarcane varietal exchange through bud chips. Indian Journal of Sugarcane Technology. 11: 25-28.

Parajuli, T., Kurre, D.K, Jangde, S.K. (2019). Sustainable sugarcane initiative (SSI)-An approach to enhance sugarcane cultivation and input use efficiency and sustainable yield of sugarcane in India. International Journal of Agricultural Sciences. 15: 222-226.

Rajula, S.T. and Ramanjaneyulu, S. (2014). Socio economic performance analysis of sugarcane cultivation under sustainable sugarcane Initiative method. Indian Res. J. Ext. Edu. 14: 93-98.

Ramaiah, B.B., Narasimha, R., Prasad, G. (1977). Elimination of internodes in sugarcane seed Piece. Proc. Inter. Soc. Sugar Cane. Technol. pp. 1509-1513.

Pawar, M.W., More, D.B., Amodkar, V.T. and Joshi, S. (2005). Effect of intersettling spacing on sugarcane yield and quality. Ind. J. Sugar Tech. 7: 87-89.

Saini, S., Pal, S., Singh, A. and Singh, P. (2012). Crop yield, efficiency and economics of autumn and spring sown single bud sugarcane intercropped with pulse crops. Internat. J. Forestry and Crop Improv. 3: 60-65.

Sarala, N.V. (2017). Influence of planting methods, age of the seedlings and nutrient management on yield and quality of sugarcane raised from bud chip seedlings in sandy loam soils of Andhra Pradesh. International J. Clinical and Biological Sciences. 2: 44-49.

Samant, T.K. (2017). Bud chip method: A potential technology for sugarcane (*Saccharum officinarum*) cultivation. Journal of Medicinal Plants Studies. 5: 355-357.

Shanthy, T.R. and Ramanjaneyulu, S. (2014). Socio-economic performance analysis of sugarcane cultivation under sustainable sugarcane initiative method. Indian Res. J. Ext. Edu. 14: 93-98

Suggu, A.G., Ahmad, E., Himayatullah, H., Ayaz, M., Ahmad, H.K. and Aslam, M. (2010). Morphological responses of autumn planted sugarcane to planting geometry and nutrient management on different soils under arid conditions. Pakistan Sug. J. 25(01): 2-9.

Sugeerthi, S., Jayachandran, M. and Chinnusamy, C. (2018). Effect of planting materials and integrated nutrient management on yield of sugarcane seed crop. Madras Agric. J. 105: 141-146.

Sundara, B. (2011). Agro- technologies to enhance sugarcane productivity in India. Sugar Tech. 13: 281-298.

Swapna, N., Reddy, T.P., Rakesh, G., Reddy, G.E., Naik, P.J. and Venkataiah, M. (2020). Effect of plant density and nitrogen management for realizing higher cane yield under bud chip method of planting in sugarcane (*Saccharum officinarum*). Current Journal of Applied Science and Technology. 39: 124-129.

Tianco, A.P. (1995). Preliminary observations on using single eye transplants and hole planting to reduce cost of conventional planting. Proc. ISSCT. Bangkok. 21(2): 136-142.

Tamil Selvan, N. (2006). Sugar cane response to chip bud method of planting. Inter Soc Sugar Cane Technol, Agronomy Workshop, KhonKaen, Thailand. 23-26 May.

Van Dillewijn, C. (1952). The Chronica Botanica Co. Waltham, USA, p. 352.

Verma, R.S. (2004). Sugarcane Projection Technology in India. International Book Distributing Co. Lucknow.

Wawan, S., Taryono, P.Y., Irham, L. (2017). Growth analysis of transplanted sugarcane bud chips seedling in the dry land, Int. J. Scientific and Technology Research. 6: 87-91.