



Review Article

PRESENT MECHANIZATION STATUS IN SUGARCANE – A REVIEW

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Received: April 17, 2017; Revised: April 25, 2017; Accepted: April 26, 2017; Published: May 12, 2017

Abstract- The crops grown by the Indian farmers include different food crops, commercial crops, oil seeds etc.; sugarcane is one of the important commercial crops grown in India. The area under sugarcane is covering around 5.08 million hectares and with an average annual production of 350.02 million tonnes in the year 2013-14 and with an average productivity of 68 tonnes/ha. India is a second largest producer as well as consumer of the sugar in the world and during 2014-15; it produced 28 million tonnes of sugar, which was nearly 11.8 per cent of the total sugar production of the world. The major producing states are Uttar Pradesh, Maharashtra, Tamil Nadu, Karnataka, Gujarat and Andhra Pradesh. Though, the area under cultivation of sugarcane is more in the world as well as in the country, the extent of labour consuming is more and mechanization is less and also the energy consumption in sugarcane production is more as compared to other crops like paddy, wheat, potato, maize, etc. Since the cost of labour in country is increasing rapidly and the price of local sugar is uncompetitive with the product from mechanized international producers, India needs to change its sugarcane production methods from manual work to mechanization in order to catch up with international trends in this global industry. Use of mechanization helps in labour saving, timeliness of operations, human drudgery reduction, reduces cost of operation, helps in improving quality of work and ensures effective utilization of resources. The major operations in sugarcane cultivation right from land preparation, sugarcane planting, ratoon management, weeding, harvesting, detaching and trash management, respectively needs mechanization effectively. Almost all of the sugarcane grown in India is still harvested and detached the leaves by hand. In order to summarize past experience and promote the mechanization of sugarcane production in India, this paper reviews the whole process of developing mechanization since years and describes the current state of sugarcane mechanization in India. The mechanization used in all the operations is discussed in this study.

Keywords- Sugarcane mechanization, Sugarcane production, Harvesting, Detaching, Drudgery

Citation: Kishore N., et al., (2017) Present Mechanization Status in Sugarcane–A Review. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 9, Issue 22, pp.-4247-4253.

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Academic Editor / Reviewer: Sravan Thutturu, Apparao Chodiseti

Introduction

Sugarcane (*Saccharum officinarum*) is vegetative propagated crop, grown in more than 80 countries and it produces 11.8 million tonne of sugar [1]. The global annual production of sugarcane is 1794 million tonnes, occupies area of 25.4 million hectares [2]. Approximately 70% of the global sugar production is derived from sugarcane. India is the second largest global producer of sugarcane next to Brazil and the world's leading sugar consumer. India's total sugarcane cultivation area is 5.08 million ha and production is 350.02 million tonnes with productivity of 68 tonnes/ha [2]. Total 527 sugar factories are in operation produce 24.39 million tonnes of sugar [2]. Uttar Pradesh, Maharashtra, Karnataka, Gujarat, Andhra Pradesh and Tamil Nadu are the major sugarcane growing states contribute about 81% of the total production in India [2]. However, at present is being cultivated in all the states, except the hilly regions. About 45million farmers are engaged in sugarcane cultivation in India [1]. Sugarcane is one of the important cash crops plays a vital role in Indian economy. The sugar industry is the second largest agro-based industry, next only to textiles [3]. For optimization of the variables of the mechanical cleaner, the mill trash should not exceed 3% and maximum acceptable cane loss should be 2% [3]. This was based on the fact that, even in the manual cleaning of sugarcane, the trash percentage was more than 2%. The same was accepted by the mills in the country. The status of sugarcane production in India is shown in the [Fig-1].

Sugarcane crop is very labour consuming cultivation and requires about 3300 man

working hours for different operations for its duration [5].

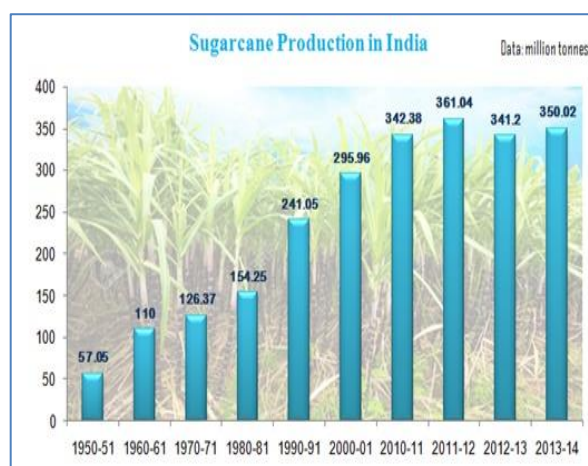


Fig-1 Sugarcane production in India

Use of machinery helps in labour saving, ensures timeliness of operations, reduces human drudgery, helps in improving quality of work, reduces cost of operation and ensures effective utilization of resources. Various harvesting

practices are used in sugarcane production, each requiring different harvesting technologies to ensure effective and efficient field operations. Based on how the sugarcane is presented to the harvester. Though, some machinery has been developed for sugarcane crop in the world wide, however the adoption of these machinery have not been the up to the mark in India. Thus, the considerable gap was found in usage of machinery especially in sugarcane planting, intercultural (weeding), harvesting, detrashing and ratoon management. Therefore, the efforts are to be made in adoption, development and popularization of sugarcane machinery for various cultural operations. In this study, the present mechanization status in sugarcane cultivation is discussed.

Different Stages in Sugarcane Mechanization



Fig-2 Operations need to be mechanized in sugarcane production

Mechanized land preparation

A well and fine preparation of seed bed is required for sugarcane cultivation. The main achievement in sugarcane mechanization in India to date is in land preparation with the mechanization level of that operation now around 80%. The equipment mainly used includes primary tillage implements like indigenous plough, mould board plough, disc plough, rotavator, duck foot tiller, sub soiler, clod crusher, trencher, ridger, bund former and other local available implements and tools. Tillage equipment developed and produced in India has been widely used

The following are the various stages where mechanization is required in sugarcane cultivation. Mechanization of sugarcane production means adopting mechanized operations in the sugarcane production system, which includes mechanized soil preparation, furrowing, planting, cultivation with fertilizer application, plant protection, harvesting, loading and transportation and shown in [Fig-2]. These mechanical operations may be continued at ratooning with shredding leaves to leave them in the field as mulch, stubble shaving to keep the ridge flat for ratoon sugarcane, or deep ripping of the row interspaces to apply fertilizer, as typical operations. Mechanization of sugarcane production is the inevitable choice in order to reduce production costs, improve labour productivity, and reduce the intense demands for farmers' labour. It is the most important measure to promote development of the sugar industry in India.

for ploughing, rotary hoeing, harrowing, furrow preparation, sugarcane leaf shredding and ratooning operations. Land preparation is normally designed to reduce soil strength, cover plant materials and rearrange aggregates. These are also performed to develop a desirable soil structure for a seedbed, to provide optimum environmental conditions for plant growth, to allow rapid infiltration and good retention of rainfall, to provide adequate air capacity and exchange with in the soil, to minimize resistance to root penetration, to minimize soil erosion by following such practices as contour tillage, listing and proper placement of trash,

to establish specific surface configurations for planting, irrigating, drainage, harvest operations and to incorporate fertilizers, pesticides, etc. A study analysis showed that minimum tillage with mechanical stool removal and machine planting accounted the best economic returns being 29.3% and 39.4%, respectively more profitable than the conventional and no tillage treatments [1]. The process of land preparation is shown in the [Fig-3].



Fig-3 Land preparations by using primary and secondary tillage implements

Mechanized sugarcane planting

The first mechanised operation in the sugarcane cultivation after land preparation is sugarcane planting. The farmers have been following different planting methods viz., flat planting, trench planting, pit planting, staggered row planting, spaced transplanting and dual row planting, sugarcane cutter cum planter, etc [1]. The row to row space maintained by the farmers is mostly ranging from 60-70 to 90-150, but 75 cm is being the most common by the Indian farmers. Still in many places of India, the farmers are planting the sugarcane buds manually even though some mechanization is available for placing the sugarcane buds in the soil. Different types of animal drawn and tractor drawn sugarcane planters have been developed, tested in laboratory conditions and demonstrated at the farmer's field. The various planters available are drop type planters where whole cane is cut separately into the bud sets either manually or by a power operated cutting machine. These bud sets have to be fed manually and the rest of operations like furrow opening, dropping of bud sets, fertiliser, pesticide and insecticide application, providing a soil cover over the bud sets and compaction of the soil cover are carried out automatically with the help of planter itself.

In case of automatic planters, dropping of the bud is also automatic besides other operations. But with the development of sugarcane cutter cum planter, where cutting of whole cane into sets is also done simultaneously, planting through machine has become a viable hypothesis. The first sugarcane cutter cum planter was developed by Indian Institute of Sugarcane Research (IISR), Lucknow and was demonstrated successfully at farmer's field there by a number of manufacturers have come forward for manufacturing IISR design on commercial scale. The cost of sugarcane planting with mechanical planter may be reduced by about 60 % and 85 % labour as compared to the conventional system of cane planting [4]. The average field capacity is about 0.2 ha/h, the depth of placement of bud set is in the range of 160-180 mm. Still some research is going on in development of sugarcane planter and these seem to play a major role in

managing sustainable sugarcane production. The process of planting the sugarcane by manually and mechanically is shown in [Fig-4 & 5].



Fig-4 Manual planting of sugarcane bud sett



Fig-5 IISR Sugarcane cutter cum planter in operation

Mechanized intercultural operations

Mechanical cultivation or tillage is still the most important method for controlling weeds and is generally the most economical method where it can be used. The weeds may be uprooted, covered or cut off. In ancient days, the Indian farmers have been used hoes, spades, khurpa, etc. for uprooting the weeds but now a day many mechanical weeders like tractor and animal drawn cultivators, wheel hoe and power weeders are available. The mechanical intercultural operations required in sugarcane crop are weed control, moisture conservation and creation of better environment for overall growth of plant. After emergence, weeding is done with the help of tractor drawn or animal drawn cultivators. Tractor drawn cultivators can effectively be used by adjusting the spacing between the tines as per the row to row spacing of the crop, use of wheel hoe, use of dry land power weeder, use of self-propelled rotary weeder and light weight power tiller. A low hp tractor drawn earthing up cum fertilizer unit is available for intercultural operations in sugarcane crop which covers 0.33 ha/h with weeding efficiency of 94% and field efficiency of 82.70% developed by the Department of the Farm Machinery and Power, Dr. A S College of Engineering MPKV, Rahuri [8] and IISR multipurpose planter can also be used for intercultural operations. The mechanization used for intercultural operations is shown in the [Fig-6 & 7].



Fig-6 Tractor drawn tiller in operation



Fig-7 IISR multipurpose planter in operation

Mechanized fertilizer and pesticide application

In sugarcane weeds have been estimated to cause 12 to 72 % reduction in cane yield depending upon the severity of infestation. The nature of weed problem in sugarcane cultivation is quite different from other field crops because of the reasons sugarcane is planted with relatively wider row spacing, the sugarcane growth is very slow in the initial stages. It takes about 30–45 days to complete germination and another 60–75 days for developing full canopy cover, the crop is grown under abundant water and nutrient supply conditions and in ratoon crop very little preparatory tillage is taken up hence weeds that have established in the plant crop tend to flourish well. Tractor mounted fertilizer distributor is used to spread the fertilizer in the band form. It is a semi-mounted implement attached to the tractor hitch system. The application rate can be controlled by the lever thereby opening and closing the aperture. The application rate varies from 500–700 kg per hectare. Its capacity may be 0.35 m³. Fertilizer spreader can also be used for spreading of fertilizer and granular insecticides. It is attached to the tractor 3-point linkage system and is powered by the PTO of tractor. The power is transmitted to the disc which accelerates the fertilizer along the oscillating spout. Even distribution of fertilizer is achieved with the spreader. Many types of sprayers like power sprayer, hydraulic sprayer, knapsack sprayer, bucket sprayer, hand compression sprayer, rocker sprayer, and foot operated sprayer and dusters like plunger type, knapsack type, rotary type and power operated dusters are available in different sizes for plant protection work. The fertilizer and pesticide application by mechanical means is shown in [Fig-8 & 9].



Fig-8 Application of fertilizer



Fig-9 Application of pesticide

Mechanized sugarcane harvesting

Though sugarcane harvesters are available in some regions of India, manual harvesting of sugarcane by using harvesting knives is most common. Sugarcane is a labour intensive crop and huge requirement of labour is major concern in sugarcane harvesting. Keeping all these in view, mechanization for harvesting should be adopted in sugarcane cultivation. The manual harvesting of sugarcane by using tools is highly labour consuming process and costly too. About 850–1000 man working hours per hectare is required for harvesting of sugarcane manually [5]. The process involved in sugarcane harvesting is base cutting of sugarcane, detopping, detrashing, bundle making and transporting the harvested cane to sugar mills. Delayed harvesting affects the quality of sugarcane, yield, juice quality and sugar recovery. So, keeping all these disadvantages of manual harvesting in view, sugar industries are looking for mechanical harvesting of sugarcane crop at a reasonable wage rate. Many researchers and research stations like IISR, Lucknow have made efforts in developing the mechanical means for harvesting of sugarcane crop so as to improve the quality of cutting and reduced energy input. The present available mechanization in sugarcane harvesting is whole stalk linear windrowing, whole stalk traverse windrowing, whole stalk bundling machine, hand controlled self-propelled harvester and chopper type cane harvester. In ancient days, burnt cane harvesting was the more popular. The states like Tamil Nadu and Maharashtra, the imported models of sugarcane chopper harvesters have been tried and the output was found to be 25–30 tonnes/field/hour but the trash percentage in the billets was found to be 7–8%, high initial cost of the machine, wider row spacing (1.5 m) required (but Indian farmers maintain 75 cm row to row spacing) and advanced systems are the major problems in successful adoption of these imported machine in Indian conditions [7]. In sugarcane combine chopper harvester, all the operations like cutting, conveying, billeting can be done within the machine. Different tools and machines used for harvesting of sugarcane crop is shown in [Fig-10, 11, 12 & 13]. The process flow chart of cane flow in whole stalk harvester and chopper harvester is shown in [Fig-14].



Fig-10 Manual harvesting tool



Fig-11 Whole stalk linear windrowing



Fig-12 Whole stalk bundling machine



Fig-13 Sugarcane chopper harvester

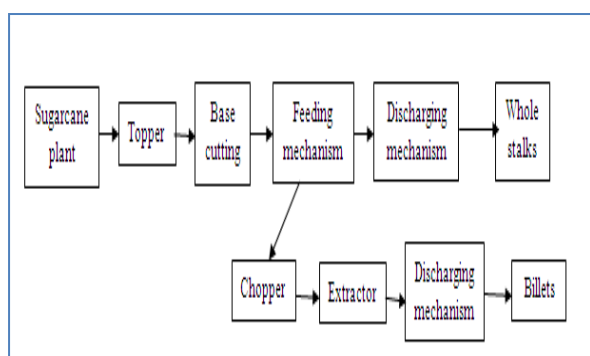


Fig-14 Process flow chart of cane flow in whole stalk harvester and chopper harvester

the [Table-1]. Different available detrasers developed b different institutions are shown in [Fig-15 & 16].

Table-1 Comparison of stripping efficiency and damage caused to the stalk of various available detrasers

Detrasher	Stripping efficiency, kg/h	Damage caused to stalk, %
IISR developed sugarcane detrasher	119.75	6.1
TNAU developed sugarcane detrasher	123.25	3.5
OUAT developed sugarcane detrasher	117.50	4.3
Hand detrashing	110.60	0.0
IISR mechanical detrasher	2400	0.0
IIT Kharagpur mechanical detrasher	1210	0.0

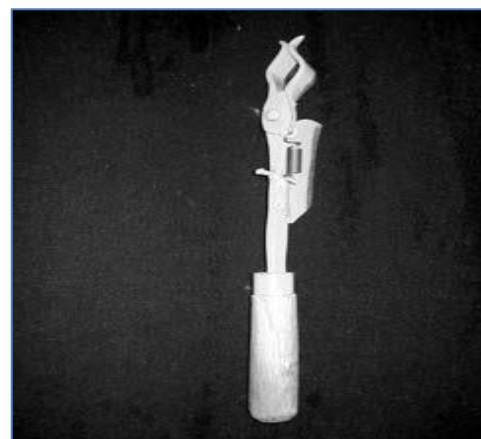


Fig-15 Hand tools for detashing of sugarcane developed by TNAU and IISR

Mechanized detashing of sugarcane leaves

Development of mechanical detrasher is the area for the researchers now a day. Sugarcane stalk has a large number of leaves (30-35) which requires labour for manual cleaning (removing tops, dry and green leaves) of about 400 man-h and cost of operation is Rs. 7500/- per hectare [7]. It is the most labour consuming operation in the post-harvest of sugarcane cultivation. In India, tops and green leaves are removed by hand tools. The institutions like IISR, TNAU and OUAT are developed some hand tools for detashing and successfully tested in the field level and are available in the market also. Human drudgery was found to be the major problem while using these hand tools. In order to avoid difficulties of this detashing operation, a power operated whole stalk sugarcane detrasher was developed by some research institutes to remove dry trash from the harvested sugarcane stalks. It consisted of mechanisms for cane feeding and detashing. 0.5 hp power was required for smooth operation of developed detrasher. Rubber canvass belt was mounted on the rollers to reduce the damage to the stalks while detashing. Stripping efficiency and damage caused to the stalk of IISR, TNAU, OUAT, IISR mechanical detrasher and IIT KGP developed detrasher are given in

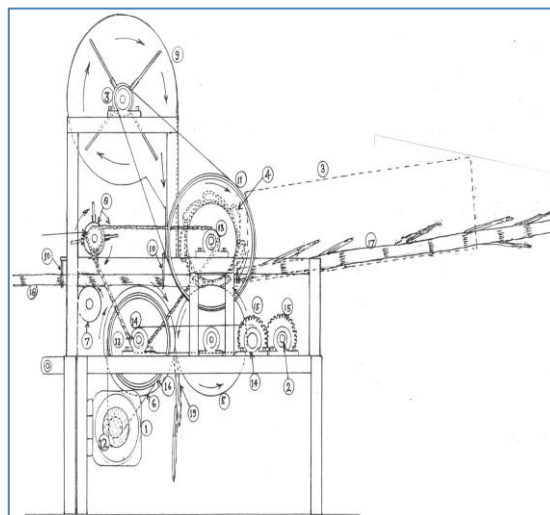




Fig-16 Mechanical detrashers developed by IISR and IIT Kharagpur

Mechanized ratoon management

Ratooning is a method where the lower parts of the plants along with the roots are left uncut at the time of harvesting gives sprouting of ratoon. In ratoon crops, there is a saving in cost of cultivation in terms of land preparation, seed canes, etc. If ratoons are well maintained, they give high yields. But, for a better ratoon crop, a better plant crop is necessary [6]. After harvesting the crop, ratoon management practices like stubble shaving and burying and fertigation etc., should be initiated. IISR has been developed ratoon management device and is shown in [Fig-17].



Fig-17 IISR ratoon management device in the field and IISR multipurpose equipment for sugarcane ratoon in operation

Mechanized loading and transporting

Mechanical sugar cane loaders can be used to load the harvested and detrashed sugarcane stalks into the trucks. Sugarcane grabber cum loader can handle 600-800 kg in one go and its maximum output is 300-350 quintals per hour. Trucks and other vehicles can also be used for transporting the sugarcane stalks or billets to sugar industries. Loading and transporting machines used for sugarcane crop are shown in [Fig-18 & 19].



Fig-18 Sugarcane loader



Fig-19 Transporting sugarcane stalks

Mechanized trash shredder

With the trend of increased mechanical harvesting of sugarcane without burning, the trash emerges as a likely residue to be used as a fuel. This practice results in a large amount of material remaining in the field. As an alternative it has been used for gathering is the adoption and operation of windrowing and baling the trash after harvest [2]. Tractor operated and power tiller operated shredders are available which handle both dry and fresh sugarcane trash to incorporate the trash remained in the after harvest with the soil thereby the fertility of the soil is increased. The sugarcane trash shredder in operation is shown in [Fig-20].



Fig-20 Sugarcane trash shredder in operation

Conclusion

From this study, it is concluded that since the area under sugarcane cultivation is very high in India, the mechanization will play an important role. Farmers are still using traditional tools and equipment in sugarcane cultivation. The lack of usage of mechanization in India is due to small land holdings, improper crop spacing, less skill about planters and harvesters. The major areas which require mechanization in sugarcane cultivation are planting, harvesting and detrashing because these are the high labour consuming operations. Many researchers and institutions have developed prototype models and machines but those are still under development stage and need to be tried at different locations for testing. Some machines are worthy and farmers are not affording to purchase but introduction of costly machines through custom hiring centers can help the farmers to get the benefits of machinery. IISR developed some machinery and demonstrated on a large scale at different places. There is no doubt that this equipment is labour saving, cost saving, reduce human drudgery and make sugarcane cultivation more profitable than compared to traditional cultivation. There should be a serious effort by industries, State and Central Agricultural Universities, Research Organizations, Cane Departments, etc., for popularizing the sugarcane equipment [4]. The next revolution in Indian agriculture is bound to come through the use of agricultural machinery only [1]. All the researchers, state and central government have to create some awareness programs to adopt mechanization in sugarcane cultivation and make it so profitable.

Acknowledgement: Author are thankful to Department of Agricultural Engineering, Aditya Engineering College, Surampalem, 533 437, Andhra Pradesh, India

Author Contributions: All author equally contributed

Abbreviations

%	=	Percentage
tones/ha	=	tones per hectare
IISR	=	Indian Institute of Sugarcane Research
TNAU	=	Tamil Nadu Agricultural University
ha/h	=	hectare per hour
MPKV	=	Mahatma Phule Krishi Vidyapeeth
m ³	=	cubic meter
PTO	=	Power Take Off
IIT KGP	=	Indian Institute of Technology, Kharagpur
man-h	=	man hours
OUAT	=	Orissa University of Agriculture and Technology
hp	=	horse power
kg/h	=	kilogram per hour
kg	=	kilogram

Conflict of Interest: None declared

References

- [1] Javed Ali. (2015) Mechanization on Sugarcane Cultivation. <https://www.researchgate.net/publication/282978399>.
- [2] Anon. (2013) *Indian Sugar*, 63 (3), 48-49.
- [3] Shukla L.N., Singh I. and Sandhar N.S. (1995) *Journal of Agricultural Mechanization in Asia, Africa and Latin America*, 22 (3), 55-58.
- [4] Singh A.K., Singh P.R. and Gupta R. (2012) *Journal of Sugarcane Research*, 2 (2), 9-14.
- [5] Yadav R.N.S. and Chaudhuri D. (2000) *Sugar Tech*, 4 (3), 59-64.
- [6] Yadav R.N.S., Yadav S. and Teja R.K. (2003) *Sugar Tech*, 5 (1), 7-10.
- [7] Singh A.K. and Solomon S. (2014) *Journal of sugarcane research*, 17(2), 189-194.
- [8] Navale S.A., Landage R.S., Sable H.P., Kadu V.M., Lende A.B. and Garte L.V. (2009) *International Journal of Agriculture, Environment and Biotechnology* 2 (4), 471-475.