

RESEARCH ARTICLE

FROM MANUAL TO MECHANICAL HARVESTING IN SUGARCANE: SOCIAL IMPLICATIONS

T. Rajula Shanthi^{1*}, P. William Antony² and C. Karpagam¹

Abstract

In the changing scenario of agriculture, labour availability poses a major threat, more so in sugarcane farming as it is a labour, drudgery and energy intensive crop. Optimizing the harvesting system at the proper time is crucial to the profitability of both the cane grower and the miller. Many times, harvesting is not done at the appropriate period due to labour unavailability. The aim of this paper is to evaluate the current sugarcane manual and mechanical harvesting systems in Tamil Nadu State, India, with regard to the economics involved and constraints faced by farmers, and to draw suitable suggestions for implementation. Accordingly, the study was conducted in Thiru Arooran Sugars predominant with mechanical harvesters and Kallakurichi Cooperative Sugar mill mainly with manual harvesting. Mechanized harvesting provides improved resilience in cane productivity with reduced cost of cultivation; harvesting can be done in time on a large scale which paves the way for uniform ratoon growth. However, non-availability of sufficient number of mechanical harvesters and wide spaced sugarcane limit mechanized harvesting.

Key words: Sugarcane, mechanical harvesting, manual harvesting, advantages, economics

Introduction

Indian sugarcane and sugar production system finds itself entwined in a complex web of problems that contribute to declining productivity and reduced profitability. While sugarcane growers face resource crunch in terms of labour, fertilizers, irrigation potential and power shortage, sugar industry faces financial crisis due to reduced sugar recovery, higher cane price, surplus or inadequate production and poor market realization for sugar. Among these, inadequacy of agricultural labor, more than the cost, particularly for sugarcane harvest, has become the single most important constraint in cane cultivation. The present day labourers either demand very high

wages or decline to undertake cane cutting activities due to the availability of more lucrative alternatives (Nagendran 2012). Due to such labour intensive nature of the crop, growers too prefer less labour intensive crops or demand hike in cane procurement price. Under these conditions, the only alternative is to mechanize the farming operations. With the majority of holdings being small to medium, large scale mechanization in the country poses innumerable challenges compared to other developed countries (Singh et al. 2011).

Some of the recent modifications that have been brought into sugarcane cultivation are wider spacing of sugarcane planting, mechanization of harvest and

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intercultural operations, sustainable sugarcane initiative or bud chip planting, drip fertigation and tissue culture seedlings. In order to mechanize harvesting, farmers had to switch their spacing from 90 cm to 150 cm. Though the first harvester was introduced in the state in 1996, less than 50% of the cultivated area is under wide row planting till date. In this context, it was felt appropriate to conduct a study on the apprehensions of cane growers about manual and mechanical harvesting.

The primary objectives of the study were to study the profile of farmers practicing mechanical and manual harvesting, the advantages of mechanical harvesting, analyze the constraints in sugarcane harvesting, assess the economics of manual harvesting compared to mechanical harvesting and propose suggestions for resolving the problems in harvesting.

Materials and methods

Descriptive type of research design and ex-post facto approach were followed for the present study. The respondents were selected among farmers adopting manual and mechanical harvesting operations in Kallakurichi Cooperative Sugar Mill (KCSM) located at Kachirayapalayam in Villupuram district and Thiru Arooran Sugars (TAS) in Chittoor village in Cuddalore district respectively. The distinct feature of a high number of harvesters (12) in operation in TAS against the complete dependence on manual labor in KCSM was the main reason for choosing these mills. Moreover, the soil type, topography and climate in these two districts were almost identical as they are situated close to each other. Sixty cane growers, six each from five divisions in each of the two sugar factories, were selected randomly for the study. A questionnaire was developed for this purpose and pilot tested with non-sample farmers. Detailed survey was undertaken by personal interview using the pre-tested interview schedule during 2012-13. Ten socio-economic and demographic factors were considered to assess the

profile of the respondents. The yield data of the plots were recorded from the individual farms and the sociological appraisal was done through personal interview. Their responses were tabulated and the data were analyzed using mean, simple percentage and rank analysis as the statistical tools.

Results and discussion

The present study focused on the profile of sugarcane farmers practicing manual and mechanical harvesting, advantages of mechanical harvesting, constraints in harvesting sugarcane, economics of manual harvesting compared to mechanical harvesting and suggestions for resolving the problems in harvesting. The details are discussed below:

Demographic profile of sugarcane growers practicing manual and mechanical harvesting

Age

According to age, 63% of the respondents in TAS and 46% in KCSM were middle aged (35 - 50 years) whereas, 16% each in both the areas were below 35 years. So age was not a constraint in adopting new technologies.

Education

Educational statistics indicated that 19.9% and 3.3% were graduates and above, 73.3% and 83.2% had primary or secondary education in TAS and KCSM respectively; the rest were illiterates or could just read and write. Thus, high levels of education in TAS appeared to act as a motivating factor in the adoption of mechanization.

Occupation

In KCSM, at least 70% of the respondents had farming as their main occupation, 20% worked as agricultural labourers as well and a small 10% had some business along with farming. In TAS, however,

40% of the respondents had agriculture as their sole occupation, 54% did farming and business, and a meager 6% worked as agricultural labourers apart from farming. It is possible that people involved in other business activities receive greater exposure and information from many sources and are cosmopolites.

Farm size

Preference for mechanical cane harvester was found among both small and big farmers alike, despite its greater feasibility in large farms. It was seen that 63% of the farmers in KCSM and 70% in TAS were large farmers and the rest were small or marginal farmers.

Farming experience

Nearly 40% of the farmers in both the sugar factory areas had more than 15 years of farming experience and almost 50% had a farming experience of 10-15 years. This implies that increase in farming experience leads to increase in adoption of latest technologies *viz.*, wider row spacing, drip fertigation and mechanical harvesters.

Experience in sugarcane cultivation

The experience in sugarcane cultivation ranged from less than five years to more than 25 years. At least 20% of the farmers in TAS and 17% in KCSM had less than five years experience in sugarcane and 39% in TAS and 17% in KCSM had 5-15 years experience. The farmers with less than five years of experience also adopted latest technologies indicating the involvement of young farmers in cane cultivation due to mechanization.

Implement possession

In both the mills, the small and marginal farmers possessed small implements such as spade, pick axe, crow bar, country plough, etc. and medium farmers had rotavator, ridger, disc plough, etc. Nearly 20%

of the big farmers possessed farm implements like minitractor, trash shredder, etc. Small and marginal farmers utilize the implements on hired basis. Possession of implements permits the farmers to carry out the agricultural operations in time with saving in cost as well.

Source of information

The study revealed that more than 75% of the cane growers contacted sugar factory personnel for getting information on cane cultivation and the rest sought other sources like neighbours, friends, relatives, family members and input dealers.

Social participation

Social participation in the study includes membership / office bearers in sugar mill, village panchayats, agricultural credit society, farmers association under National Agricultural Development Programme, farmers' discussion group and self-help group. The medium and large farmers had higher social participation than small and marginal farmers. Higher social participation results in better awareness about rural development initiatives and other social happenings.

Mass media participation

The respondents utilized mass media channels namely television, radio (mainly FM), newspaper and farm magazines. All the respondents had access to television while 48% in TAS and 53% in KCSM had access to selected mass media channels. Mass media channels help in creating awareness about the new technologies. Farmers get to know about the news related to agriculture, development programs, farmers' fair, etc. through these channels.

Advantages of mechanical harvesting in sugarcane

In the present context, the sugar mills need to stabilize their cane area and production and

ultimately attain a viable and sustainable operation besides up-keeping farmer's enthusiasm in cane cultivation (Panghal 2010). This can be achieved only through viable technologies that can reduce the cost of cultivation with no compromise on cane yield.

Any new innovation has its own advantages and disadvantages during and after adoption. If the

planting systems with mechanized cultivation. In the present study also, reduced cost of cultivation and thereby increased profit was perceived as major advantages.

With mechanical harvesters, the cutting charge is maintained uniform throughout the season and there is considerable reduction in cost of cultivation. Cane

Table 1. Growers' perception on the advantages of mechanical harvesting in sugarcane

S. No.	Advantage	No. of respondents	%	Rank
1	Reduced cost of cultivation	29	96.67	I
2	Short time required for harvesting in large areas	28	93.33	II
3	Increase in profit/returns	27	90.00	III
4	Possibility of timely harvest	26	86.67	IV
5	Possibility of good ratoon crop	26	86.67	IV
6	Stubble shaving need not be done	25	83.33	V
7	Dependency on human labour reduced	24	80.00	VI
8	Uniform cutting charges throughout the season	23	76.67	VII
9	Possibility of additional yield	23	76.67	VII
10	Can harvest all types of canes	21	70.00	VI

(N=30)

farmers perceived that the advantages of the new technology are more than its disadvantages, then it leads to adoption of that technology. In this study, the respondents were asked to enlist the advantages of mechanical harvesting with an open ended schedule (Table 1).

In areas where mechanized cultivation is practiced, the row spacing is wider (> 1.2 m) whereas in countries where human labour is extensively used narrower row spacing (0.6 m - 1.2 m) is adopted. It is therefore logical to assume that wider spacing was necessitated by mechanized cultivation (Hunsigi 1993). Farmers feel that mechanical harvest in wider rows reduced the harvesting charge and avoided trash burning. Salunkhe et al (2001) and Khandagave (2010) reported that total production costs incurred were lower in dual row planting and wider row

cutting can be done in larger areas in a single day and the cut cane is delivered within few hours to the sugar mill. This would reduce post harvest deterioration leading to high sugar recovery.

Mechanical harvesting by choppers eliminates stubble shaving operation in the ratoon crop due to cutting of cane close to ground level. There will be early and uniform sprouting of stubbles and all the inter cultural operations could be easily done with mini-tractor. The trash blanket can be thoroughly incorporated into the soil after 60 days with rotavator.

The mechanical harvester cuts the standing crop at one inch below the ground level, thus sending sugar rich bottom nodes to factory which are otherwise left uncut in the field under manual harvesting. This

gives an additional yield of 1-1.2 tons per acre besides saving in cost of ratoon crop due to exclusion of stubble shaving.

Through mechanical harvesting, cane supply can be regulated by the sugar mill to maintain the targeted requirement for crushing and the dependence on human labour can be reduced for cane harvesting operation.

The mechanical harvesters can cut all types of cane including fresh unburnt canes even with coarse spiny leaves and infestation of sucking pests. Canes are slightly burnt before harvest under manual harvesting in areas with infestation of wild boar and where detrashing is not done.

The cumulative effects of wider row planting, mechanized cane operations including harvesting and multi-ratooning facility will boost up profit margin to the cane growers (Nagendran 2009).

Economics of manual harvesting compared to mechanical harvesting

Good harvest management is crucial to the profitability of both the cane grower and the miller. The grower invests significant time and money to

25–35%) of the overall cost of cane production and must be minimized. Very careful consideration must therefore be given to both the selection and the management of the harvesting system (David 2004).

The use of mechanical harvesters / manual harvesting is directly influenced by factors like labour availability and inter row spacing in the field.

Influence of spacing in mechanization

Crop production aims at efficient harvest of solar energy through crop plants, which in turn depends upon the efficiency of light interception and its utilization. Cane yield is a function of the stalk population per unit area (number of millable canes) and single cane weight (Gopalasundaram 2011). This is mainly influenced by the inter row spacing in sugarcane. Farmers in the study area opted either 75 cm, 120 cm or 150 cm spacing (Table 2).

It is evident from Table 2 that 73% of the respondents in KCSM are still following the conventional type of row spacing i.e. 75 cm and rest of the respondents adopted wider spacing of planting. Wider row spacing is a basic and important pre-requisite for using any implements particularly mechanical cane harvesters (Colete 1987; Scandaliaris et al. 1989;

Table 2. Spacing adoption pattern among respondents in the two study mills

S. No.	Sugar mill	Adoption of spacing					
		75 cm		120 cm		150 cm	
		No. of respondents	%	No. of respondents	%	No. of respondents	%
1	KCSM	22	73	5	17	3	10
2	TAS	10	33	12	40	8	27

produce his crop but poor harvesting and transport operations can result in dramatic losses of recoverable sugar both from physical losses of cane in field and deterioration in cane quality before milling. Ongoing ratoon yields can also be depressed by poor harvesting practices. The harvesting and transport costs form a large proportion (normally

Patel et al. 2006; Nagendran 2009; Rajula Shanthi and Muthuswamy 2012). Wider row plantings in tropical areas have been found to produce higher cane yields, facilitate mechanization of field operations and thereby reduce production costs (Sundara 2003). Sixty seven percent of the farmers in TAS have grown sugarcane under wide row

spacing and they have realized that wider spaced crop gives good yield apart from making mechanical cane harvesters feasible and accessible in their fields.

In spite of acute labour shortage especially during peak harvest seasons, farmers in some areas are still reluctant to go for wider spacing. This is due to the misconception that under wider row spacing, plant population is less and yields are low.

As such, only few sugar factories own harvesters, be it small ones or the bigger models. The private entrepreneurs are reluctant to purchase cane harvesters as they demand a minimum acreage of wider spaced sugarcane crop in the area to operate the harvester in an economically viable manner. On the other hand, when encouraged to adopt wider spacing, the cane growers respond that they would follow it only after the introduction of mechanical

to a hard and unattractive job. This difficulty may then be overcome by either importing transient labour from lower cost areas or by mechanizing part or all of the harvesting process.

From Table 3, we infer that in KCSM 50% of harvesting labourers are locally available and the rest are from nearby villages; whereas, in TAS, 30% of the labourers are locally available and 53% of them are from nearby villages. Non availability of local manual labourers for cane harvesting has necessitated TAS mill to hire transient labourers from other states like Bihar and Andhra Pradesh. They have also introduced mechanical cane harvesters to tide over labour scarcity problem. On the other hand, the availability of local labourers for harvesting in KCSM has neither helped to optimize the harvesting charges nor solved the problems in harvesting.

Table 3. Availability of cane cutting laborers

S. No.	Mill	Type of Harvest					
		Local labor		Nearby village		Contract labor	
		No.	%	No.	%	No.	%
1	KCSM	15	50	15	50	-	
2	TAS	9	30	16	53	5	17

cane harvesters in their area. Thus there is a haul between the cane growers and private entrepreneurs in taking the initiative.

Availability of laborers for cane cutting

Cutting cane by hand is a hard physical work carried out under hot and unpleasant conditions. It is not normally regarded as an ideal job if alternative work is available, and in many countries cane cutters have low social status.

As the local economy strengthens, growers may be unable to pay enough to attract sufficient personnel

Labour availability poses a major threat for carrying out timely agricultural operations, more so in a labour intensive long duration crop like sugarcane. More often it is labour scarcity and thereby high cost that drives farmers to seek options of mechanized farming.

Expenditures involved in manual and mechanical harvesting

The details of manual and mechanical harvesting charges incurred by the respondents are given in Table 4.

Table 4. Expenditure involved in manual and mechanical harvesting

Parameter	Manual Harvesting	Mechanical Harvesting
Total area harvested in acres	163.35	99.30
Total cane produced (tonnes)	5151	3775
Total charge paid (Rs.)	29,99,415 582 /ton	16,98,750 Rs.450/ ton
Other related expenses (Rs.)	1,96,020 38 per ton	97,390/ Rs.26 / ton
Total charges for harvesting in Rs.	31,95,435	17,96,140
Harvesting charge per ton in Rs.	620.35	476
% in cane price	28.5	21.10

Expenditure involved in manual harvesting

It is seen that a total area of 163.35 acres of sugarcane owned by the respondents are manually harvested amounting to 5151 tonnes. The average productivity here is 31.53 tonnes per acre. The average harvesting charge paid is Rs 582 per tonne of cane. It is to be noted that Rs. 38 per tonne of cane is spent on other related expenditure that includes charges for conveyance of harvesting laborers from the villages / nearby villages to the field, and giving 'karikkasu'. The practice of giving 'karikkasu' or 'kallakkasu' or 'quarterkasu' on the last day of harvest for laborers is a new practice which has become an additional burden to the cane grower. It is being demanded by the labourers and the farmers say that this practice makes the labourers to continue to work for the same farmer during the next season also. Another concern is that the harvesting charge will be increasing over a period of time and normally it is less in the early season and increases in the later part of the crushing season.

In manual harvesting, the cane growers spend 29% of the cane price for engaging labourers. Higher harvesting charge will result in less net profit for

the cane grower. The exorbitant harvesting charge and non-payment by sugar factories have frustrated many cane growers and this problem is assuming an increasingly dangerous proportion every year.

Expenditures involved in mechanical harvesting

A total area of 99.30 acres of the respondents with a cane production of 3775 tonnes was harvested by mechanical harvesters. The average productivity here is 33.98 tonnes per acre. On an average, farmers spend Rs 450 per tonne for mechanical harvesting which is far less than Rs 582 under manual harvesting. The respondents incur Rs.26 per tonne towards food allowance to the operators of harvesters and wages to the scrap / cut cane collectors in the field. A significant aspect in paying harvesting charge for mechanical cane harvester is that there is no fluctuation in charges and it remains the same throughout the crushing season unlike manual harvesting which starts at an optimum level in the early part of the season and reaches exorbitant rates during the later months. The cane growers pay 21% of the cane proceed for the purpose of cane harvesting while engaging mechanical cane harvesters which is 7% lesser than in manual harvesting.

Comparison between manual and mechanical harvesting on cost basis

Based on the data obtained from the respondents of both the sugar mills, a comparison has been made between manual and mechanical harvesting (Table 5).

Table 5. Comparative economics of manual and mechanical harvesting

Parameter	Cost in Rupees		
	Manual	Mechanical	Deviation
Harvesting charge/ton	582.00	450.00	132.00
Other charges/ton	38.05	25.95	12.10
Total charge/ton	620.35	476.00	144.35
Total harvesting charge/acre	19561.90	18088.00	1473.90

Table 5 indicates that by all means, manual harvesting is always of higher cost than mechanical harvesting. A cane grower who engages manual labour for harvesting has to spend about Rs.144.35 per tonne more than his counterpart who does it by mechanical cane harvesters. The additional cost per acre in manual harvesting is approximately Rs 1475 higher compared to mechanical harvesters. The extra charge for harvesting is also Rs 12 higher in manual harvesting. As such, both the harvesting charge and the other charges are higher for manual harvesting than the mechanical harvesting. This leads to direct monetary loss to the cane growers and increases the cost of cultivation thereby reducing the net profit and benefit cost ratio. This apart, there are additional benefits like quickness and uniform harvesting. Even though there is sufficient number of cutting labourers available in KCSM, availability has not reduced the harvesting charge.

Constraints in sugarcane harvesting

The harvesting operation in sugarcane comprises burning (if applicable), cutting, loading, and transporting the cane to the mill. Adequate planning of the harvesting process is essential if sugar

production is to be maximized. It is necessary for the cane to be cut at the correct age, as losses in growth potential and sucrose content will be incurred if the cane is cut too young or too old. Be it manual or mechanical harvesting, farmers face certain constraints in harvesting.

Constraints in manual harvesting

The response obtained from the farmers of Kallakurichi Cooperative Sugar Mills on the constraints faced by them in manual harvesting is given in Table 6.

Competition from private brokers

According to 83% of the respondents, the main cause for the exorbitant harvesting charge is attributed to the competition from the private brokers. The private cane brokers who transport cane to the needy sugar mills from sugarcane rich pockets normally are in possession of own vehicles and harvesting labourers. Although it is not an authorized business, too many brokers are earning huge profits from this type of cane transport. The private sugar mills are in constant touch with these brokers and they support these brokers to a greater extent by offering huge finance along with incentives. The private sugar mills resort to this option not only to draw cane for their requirement, but also to retain a good number of cutting labourers under their fold.

The brokers offer huge money to the cane cutting labourers as “advances” besides paying commission for each tonne they harvest. It is common that there are broker sets and mill sets of cane cutting labourers

Table 6. Constraints in manual sugarcane harvesting

S. No.	Constraint	No.	%	Rank
1	Competition from private brokers	25	83.33	I
2	High cane cutting charges	24	80.00	II
3	Diversion of labourers to other agricultural works	23	76.67	III
4	Migration of workers to other parts	19	63.33	IV
5	No incentive to cane cutting labourers	15	50.00	V
6	Untimely cutting orders	14	46.67	VI
7	Cane harvesting is laborious	12	40.00	VII
8	Non availability of cane cutting labourers	11	36.67	VIII
9	Cane harvesting causes irritation	11	36.67	VIII
10	Poor support by sugar mills	8	26.67	IX

(N=30)

in every village and each has its own boundaries. The broker sets are normally engaged for harvesting the unregistered cane mainly for the unauthorized transport of cane to private sugar mills. Optimum harvesting charge is fixed for this operation. In situations when one has to approach these broker sets for harvesting registered cane, they demand high harvesting charge, for the simple reason that they are registered to mills. To run the business and to survive among the competitors, the brokers go to the extent of offering festival gifts to the members of the cutting gang and they are enjoying a strange loyalty. When sugar mills fail to attract the cutting labourers by such tactics, it will reflect in the cane cutting operation particularly in cane cutting charge.

High cane cutting charges

Majority of the respondents (80%) have expressed that the harvesting charges are higher. When the cane cutting labourers are available in sufficient numbers, one will expect that the cane cutting charge would be optimum if at all not less. But the availability of labourers has neither helped to keep the harvesting charge optimum nor reduced the burden of the growers.

Diversion of labourers to other agricultural works

Another major constraint (76.67%) in cane harvesting is diversion of agricultural labourers to other competitive forms of work. The popular Mahatma Gandhi National Rural Employment Guarantee Programme has taken away a substantial number of farm labourers. The pinch is strongly felt during peak labour demand period. As the cane harvesting operation is physically demanding, many people do not prefer this work. Besides, many labourers engaged in cane harvesting have their own crops and they have to allot time to attend to important operations in their fields. As such, they simply disappear when they are badly needed.

Migration of workers to other parts

Migration of labourers to other parts is also one of the major constraints in cane harvesting according to 63.33% of the respondents. Karnataka and Kerala are the states that draw a major portion of the agricultural labourers by giving attractive remuneration. There is also another category of harvesting labourers in this area who regularly move to other cane intensive and labour demanding mills.

No incentive to cane cutting labourers

Incentives refer to the additional benefits rendered by the sugar mills to encourage the cane cutting labourers. These benefits may be of kind and cash. As long as the cane is supplied in sufficient quantity for the mills to crush, the sugar mills will never bother for cane cutting operation. The sugar mills will realize the importance of cutting labour and harvesting operation only when the mill has to stop crushing for want of cane due to the absence or inadequate availability of labourers. This point has been equally counteracted by the respondents in KCSM Ltd, which allows the reader to interpret for his own.

Untimely cutting orders

Untimely issue of cutting orders results in high harvesting charge as the cutting labourers always try to capitalize such situations. The absence of staggered planting system in sugar mills and unsynchronized crushing programme according to the planting pattern are the main causes for this condition. Due to these reasons, most of the times cutting orders are issued to the growers either in the immature or over matured stage of sugarcane. However, more than half of the respondents have expressed that such untimely issue of cutting orders is not the cause for the increased harvesting charge in KCSM Ltd.

Cane harvesting is laborious

When the sugarcane crop is planted with an inter row spacing of 90 cm or less, the labourers find it difficult to enter into the field for harvesting. This is more felt when the crop lodges for varied reasons like nature of the variety, improper earthing up, loose soil or heavy winds.

Cane harvesting causes irritation

This is true when the sugarcane variety has spines or coarse hairs on the leaf surface or when the crop is infested with sucking pests like white woolly aphid or mealy bugs.

Non-availability of cane cutting labourers

The human labour engagement for sugarcane is higher in tropical India than sub-tropical states. Presently, it is the highest in Tamil Nadu (289 labour days) followed by Andhra Pradesh (288 labour days), Karnataka (276 labour days) and Maharashtra (266 labour days).

In KCSM, around 37% of the respondents reported non availability of labourers as a constraint and the rest 63% of the respondents reported that availability of labourers is not an issue. Sugarcane is the major crop of this area, being grown in more than 15,000 to 16,000 acres. Sugarcane has also been traditionally grown for more than 40 years i.e. from the inception of Kallakurichi coop sugar mills, Moongilthuraipattu and the availability of cane cutting labourers is also high. The availability of laborers has prevented the mill to find alternatives viz. hiring labourers from outside and resorting to mechanical cane harvesting. The complacency with regard to labour availability has also prevented the cane growers to follow wider row spacing.

Sharma and Prakash (2011) stated that the unavailability of labour for sugarcane production is because of the non-participation of family members in agricultural activities.

Poor support by sugar mills

About 73% of the sample respondents reported that the sugar mills support the cane growers in doing cane cutting operation. The field workers maintain good rapport with the cane cutting labourers and they play a key role in arranging labourers for a cane grower. They perform a mediating function between the cane grower and the cane cutting labourers in finalizing the cane cutting charges also. They also help the cane cutting labourers to get their harvesting charges from the grower. Any dispute between the grower and labour is finally settled only in the presence of the field staff. Hardly 27% of them reported poor support by the sugar mill as a constraint.

Constraints in mechanical harvesting

Mechanized cultivation, specifically for cane harvesting is the need of the hour. However, there are certain practical difficulties in using the same and the technical hitches as expressed by the respondents are listed in Table 7.

harvesters is its higher cost. The harvesting machine along with the infielders and the cane transporting vehicles cost more than 1.25 crore which is not affordable by individuals. Even though many private entrepreneurs wish to own a harvester, they don't dare procuring them because of the huge investment it requires.

Table 7. Constraints in sugarcane mechanical harvesting

S. No.	Constraint	No.	%	Rank
1	Non availability of mechanical harvester	26	86.67	I
2	Requires huge initial investment	25	83.33	II
3	Requires specialized people	25	83.33	II
4	Deduction of more tops	24	80.00	III
5	Non availability of cluster planting	21	70.00	IV
6	Non availability of wider spaced crops	20	66.67	V
7	Cane damage in the field	10	33.33	VI
8	Impact on establishment of ratoon crop	10	33.33	VII
9	Infield losses are more than manual harvesting	4	13.33	VIII
10	Transport difficulties	3	10.00	IX
11	Higher harvesting charge	3	10.00	IX
12	Involvement and support of sugar mills	2	6.67	X

(N=30)

Non- availability of mechanical harvester

According to 87% of the respondents, the major constraint is the non availability of mechanical harvesters itself. Due to the higher cost of the machines and lesser business scope, the harvesters are available only in lesser numbers which is always short to the requirement. Many growers wish to use harvesters in their fields but due to the non availability of machines, they have to employ manual labourers. Unless the harvesters are made available to the needy growers in time, the usage will be very much limited.

Requires huge initial investment

The data reveals that 83% of the respondents have stated that the constraint in using mechanical

Requires specialized people

According to 83% of the respondents in TAS, another major constraint in using cane harvesters is that cane harvesters require specialized people for operating the machines. Lack of specialized people for optimum wages and lack of technicians capable of handling the practical problems are other related issues that make the private entrepreneurs to reconsider their plan of procuring cane harvesters.

Deduction of more tops

The cane harvested by machines is not as clean as the manually harvested cane and these pelleted cane pieces are found with more green trash bits. The bottom cane is also found more with mud and unshaved roots. Due to this uncleanness, the sugar

mills normally deduct up to 5-10% towards extraneous matter, about 4-8% above the normal deduction done for manually harvested crop. The survey reveals that 80% of the respondents feel that such deduction is a constraint in using harvester as it inflicts direct monetary loss to the growers.

For mechanical harvesting, the trash percent was found to be 10.04% (ranged between 5.84 to 16.86%) and 3.66% (ranged 2.76-8.5%) for manual harvesting. Every 1% increase in trash or extraneous matter causes a reduction of 0.1% in sugar recovery (Adam and Amna 2013).

Non-availability of cluster planting

About 70% of the respondents have expressed that non availability of cluster planting is also a constraint in using harvesters. As the cane harvesters are large in size, they cannot be moved to different places like a tractor. Hence it requires prior planning like wider spacing and cluster planting for using the machines efficiently and economically. This would also reduce the needless transport leading to decrease in the fuel cost and as such it will increase the net profit.

Non-availability of wider spaced crops

Non availability of wider spaced crops has been mentioned as a constraint by 66.67% of the respondents. The basic requirement for using cane harvesters is wider row spacing ranging from 4' to 6' with cane planted in single row or in paired row within an inner spacing of 1- 1.5' spacing. Harvesters cannot be used in the conventional type of planting taken in 2.5' row spacing. Hence, invariably all sugar mills are trying to popularize the wider row spacing of cane planting in order to introduce harvesters at least on hire basis. Cane development wings in private sugar mills do concerted extension efforts to educate farmers about this new planting system and they have methodically demonstrated that wider spacing will not result in lower yields - as such a myth still prevailing among the growers.

Cane damage in the field

The survey reveals that damage caused by harvester is not a constraint in using the same. Cane harvesters require enough space to turn around at the end of the fields. During operation, the movement of heavy harvesters in the fully grown cane may cause damage to the cane planted closer in rows. It also uproots the crop when the moisture condition of the field is not optimum. The heavy nature of the machines may spoil the stubbles of ratoon crop. But the respondents view that all these issues are not so threatening as the fields harvested by machines are coming up well and giving good yield as well.

Impact on establishment of ratoon crop

According to 67% of the respondents, usage of mechanical harvesters does not cause any damage to the crop and this is not a constraint in using harvesters. The cane harvesters are not only larger in size but also weigh up to 7 – 10 tonnes. Owing to the heavy nature of the machines, one may fear that the movement of such heavy machines will damage the ratoon crop, resulting in poor yield. Rather the cane grower who uses cane harvester enjoys additional benefits like stubble shaving and trash mulching that helps to manage ratoon crop effectively.

Greater infield losses

Compared to manual harvesting, infield losses in terms of fallen cane losses, attached cane losses (long canes left attached to the root system) and cut cane losses were more in mechanical harvesting; Manual harvesting leads to higher low topping cane losses than mechanical harvesting.

Transport difficulties

According to 90% of the respondents, transport of harvesters and transport of harvested cane are not at all a constraint in using cane harvesters in the field. If at all there are some problems like absence

of cluster type planting, that will result in frequent movement of machines to different places, and insufficient number of cane carrying vehicles with hydraulic facility that can be used in tippler type unloaders, such problems are considered only as petty issues. The cane growers are prepared to compromise such minor difficulties while using harvesters since they are completely free from the unnecessary strains they have been experiencing earlier in manual harvesting.

Involvement and support of sugar mills

According to 93% of the respondents, the TAS mill is rendering good support and their involvement in operating harvester is satisfactory. The sugar mills have procured machines, incurring huge amount for the benefit of the cane growers and successfully operating in the fields though it is not economical many times. Diesel price is also increasing day by day. Specialized persons are required to operate the machines. Spares for the imported machines and competent technicians are also hardly available. Wider row spaced planting in a cluster pattern is also not taken up to the required level. The machines require lengthier fields without barriers and obstructing structures. Moreover, the machines can be operated only in the non-monsoon period. It cannot be used in clay or heavy soils. In spite of all these adversities, the sugar mill is able to run and maintain the machine successfully as reflected in the study.

Higher harvesting charge

It could be inferred from the survey that using cane harvester does not incur higher cost and it is also not a constraint in using harvesters. Also, the charge for using cane harvester is uniform throughout the season unlike the charges paid to the manual labourers which normally starts at a low level during the early part of the season and surges to unusual rate at the later part of the season. Harvesting charge for mechanical harvesting is always lesser to manual harvesting and is stable.

Measures to resolve harvest constraints

Harvesting has become a hurdle in sugarcane cultivation with no concrete solutions. With an intention of getting some tangible solutions for this problem, focus group discussions involving cane growers, factory personnel and researchers were conducted in the study area. The myriad outcomes of such deliberations are discussed below:

Cane growers' perspective

Sugarcane farmers after investing capital and labour can realize profit only after 12 months provided the cane is harvested in time and payment is made promptly. Quite often, the crop remains in the field even after 12 months for want of cutting order or unavailability of labourers. Harvest as such is an important link between the field and mills, which is mainly accomplished by the cane cutting laborers. The cane growers can resort to the following ways to get their crop harvested in time by manual or mechanical means.

- The cane grower has to understand the reality prevailing in his location and after negotiation he should settle for a reasonable cutting charge to be paid for harvesting without delay, failing which the cutting labor may find another field for harvest.
- Proper arrangement should be made for making the cane harvest charge payment to the labourers in time either with the support of the mills or by himself.
- Vehicles for transporting the harvested cane shall be arranged promptly in association with the cane department of the mills.
- The specialized cane cutting labour should be employed in other agricultural operations during the off-season to ensure their availability at the start of the season.

Mechanical cane harvesting demands certain prerequisites in planting system and the cane growers have to adopt the following new systems:

- Wider row spacing of 5 or 6 feet should be adopted while taking up planting preferably in single row instead of paired row.
- Ridges and furrows should be formed parallel to the electrical lines in a lengthier manner without hindrances like bunds and uneven structures.
- A spacing of minimum 12 feet has to be given at both the ends of the rows to facilitate easy movement of the cane harvester.
- To maintain appropriate field condition, withholding of irrigation shall be done 15 days prior to the mechanical harvesting.
- The cane grower shall tolerate the minimum loss caused by the usage of mechanical harvesters to realize the complete benefit of the same.
- There should be a cluster approach for wider row planting to enable the mechanical harvesters to operate continuously in a location and to avoid unnecessary transport.
- The sugar mills can identify and register reliable cane cutting labor sets available in the local area for planning daily crushing.
- The sugar mills should continue services like deducting the harvesting charge from the cane proceeds of cane growers and sending them to the bank account of cane cutting labourers
- The sugar mills should also initiate services like group insurance, safety trainings and medical camps to the cane cutting laborers as welfare measure to entice and retain them throughout the season.
- Gadgets like sickles, gumboots, gloves and rain coats shall be arranged to the cane cutting labourers to encourage them to harvest cane even in adverse conditions like varieties with spiny leaves, rain, etc.
- The sugar mills can also encourage cane cutting labourers by announcing attractive incentives to those who are consistently performing the harvesting operation.
- The sugar mills can arrange medium term loans from cooperative banks/ nationalized banks to the cane cutting labourers after obtaining necessary documents, as a measure to retain their bond with the mills.

Action plan for sugar mills

In the prevailing situation, sugar mills can fully depend neither on manual cane harvesting nor on mechanical cane harvesting. Depending on the availability of cane cutting labourers and daily cane requirement, the sugar mills should plan to blend both the manual and mechanical harvesting at an appropriate level. Hence the sugar mills have to formulate suitable strategies to retain and sustain the available manual labourers as well as to possess the required number of mechanical harvesters. The discussions indicated certain means by which sugar mills can facilitate farmers in harvesting.

- Training programs shall be arranged to the cane cutting laborers to give them exposure on clean cane harvest or scientific cane harvest.
- The sugar mills must evolve a sound cane development plan in their cane command areas for purchase of harvesters and other tractor drawn implements.
- The sugar mills can encourage private entrepreneurs to own cane harvesters and these machineries can be used on custom hiring.

- The sugar mills should come up with plans to modify and develop suitable crop geometry to facilitate the movement of machineries on cluster basis to facilitate the operation of the machine profitably.
- Financial assistance shall be extended to enterprising growers to purchase machines either directly from the mills or through banks.
- The sugar mills can maintain a tie up policy with the manufacturers and research organizations. As the popular 8000 and 4000 series cane harvesters require specific planting systems, there should be constant attempts to evolve a design, which is most suitable for the local field conditions.
- The misconception of the growers that wider spaced planting will not give good yield should be refuted by raising model farms.

Action to be taken by the government

Schemes like Sustainable Sugarcane Initiative, Precision Farming and Micro irrigation are formulated and implemented by the government to increase cane production and productivity. Whatever be the quantity of cane produced in the fields, the same has to be harvested and supplied to the mills for crushing to obtain the end products. Unless sugarcane is harvested and crushed in time, it will result in qualitative and quantitative loss. The discussions indicated that government can assist the cane growers / cane industry in the following ways:

- Minimum cane cutting charge shall be fixed for every season in the tripartite meetings in the same manner followed for fixing the minimum wages for agricultural laborers.
- The service charge levied by the Government from the sugar mills should be stopped, to allow the sugar mills to continue the services i.e., deduction of cane cutting charge from the cane proceeds of the grower and sending

the same to the bank account of cutting laborers by the sugar mills.

- Proper protection in the form of insurance should be ensured to the cane cutting laborers through proper legislation.
- The government shall arrange or permit the cooperative and public sector sugar mills to procure at least two cane harvesters per mill to satisfy the demand of both the sugar mills and cane growers.
- Incentives may be provided to the growers who come forward to adopt wider spacing in a cluster basis to develop sufficient area for operating mechanical cane harvesters in an effective and economical way.
- The government shall let the sugar mills to create the necessary infrastructure of 'Tippler' like cane unloaders, a special structure required for unloading vehicles carrying the billet type harvested cane by apportioning sufficient fund to the mills.
- To promote mechanization in agricultural operations particularly sugarcane harvest and to encourage the participation of private entrepreneurs, government may announce attractive subsidies similar to other agricultural implements.

Research needs

Studies conducted among sugarcane growers indicate the existence of wide technological gap as well as yield gap which leads to reduced production and productivity (Sezhian Babu 1990; Gupta 2009; Rajula Shanthi et al 2010). Even viable technologies like SSI, wider row spacing etc. are not readily accepted by the cane growers; rather they take their own time to adopt it. As far as mechanical cane harvesting is concerned, feasibility studies on technical suitability to native conditions and other methodical features are to be studied.

- The harvesters now in use need further testing and adaptations to facilitate harvesting of sugarcane particularly on small holdings. There should be concerted efforts for evolving machinery to suit to our local conditions.
- To evolve such a harvesting machine, research can be done involving cane growers, cane officers, technicians and engineers with a time frame.
- The ground level reality in cane harvesting and difficulties should be accurately assessed and appropriately projected to the administrators by conducting zone wise surveys and suitable remedies and suggestions should be offered to the policy makers.
- In coordination with the research and development wing of the sugar mills, survey should be conducted in every sugar mill to assess the human resources available for carrying out agricultural operations particularly cane harvesting. Depending on the availability of manual laborers and taking into consideration of the crushing programme of the sugar mills, researchers can suggest the manual and mechanical harvesting ratio to each mill.

Fauconnier and Bassereau (1970) evolved mechanization guidelines based on the ratio of the daily wage to the local value of a tonne of cane. These stated that: if the ratio is below 0.25, cut and load manually; between 0.3 and 0.45, commence mechanized loading; between 0.5 and 1.0, fully mechanize loading; and over 1.0, mechanize both cutting and loading. These guidelines remain valid, but the decision to mechanize is also influenced by local field conditions that may not favour machine operations (e.g. small fields, steep slopes, high rainfall, stones, etc.) and can justify manual

operations being maintained well beyond the usual economic limits.

Conclusion

In the changing scenario of agriculture, labour availability poses a major threat, more so in sugarcane farming. The only possible way to sustain sugarcane farming is through mechanization as sugarcane is a labour, drudgery and energy intensive crop (Rajula Shanthi and Muthuswamy 2012). For any tractor drawn implements, increased row spacing is a pre-requisite. Farmers have started realizing this crude reality and a considerable area is being practised under wider row spacing in the state.

Mechanized harvesting has its own advantages over manual harvesting. It provides improved resilience against cane productivity with reduced cost of cultivation, harvesting can be done in time on a large scale and paves way for uniform ratoon growth. However, mechanization is possible only in a wider spaced crop and the adoption of wide row spacing on a large scale is also questioned due to apprehensions of cane growers. In order to improve performance, measures are needed to develop mechanisms to accelerate the rate of acceptance and adoption of mechanized cultivation in sugarcane.

It is unwise to assume that any harvesting and transport technology can be successfully transferred to a different region. Careful analyses, particularly of the ability to maintain and operate large complex machines must be made, and practical trials should always be carried out before selecting a new system.

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