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SUGARCANE MECHANICAL HARVESTING-EVALUATION OF LOCAL APLICATIONS

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ABSTRACT

The design and commercial manufacturing of mechanical sugarcane harvesters have taken place firstly in Hawaii, Australia, Southern USA (Louisiana and Florida) and Japan where the sugarcane production is fully mechanized. Significant researches of mechanical cane harvesting have also been done in Barbados, Brazil, Trinidad, Cuba, India and several other countries. Normally there are two sugarcane mechanical harvesting systems classified as follow: 1-Whole-stalk sugarcane harvesting system (the system which delivers whole stalk of canes). Large self-propelled whole stalk harvesters operated only within full mechanization systems. Other tractor mounted machines or small single axle walkman steering cane cutters are fabricated for the conditions of developed countries. 2-Cut-chop-harvesting or chopper harvesting system (the system which chop the cane into billets while harvesting). This system is also called sugarcane combine harvesting system. All other cane harvesters are whole-stalk-harvesters developed to perform stalk base cutting as principle function and some of harvesters may include mechanisms for topping and/or windrowing in addition. Since manual harvesting of sugarcane is actually whole stalk harvesting by labors so that in changing from manual to a mechanical harvesting system, whole stalk harvesting may fit more easily. When replacing manual by mechanical harvesting whole stalk harvesting matches the existing system of reaping, transportation, storage and the feeding of cane into mill. Actually for semi mechanization, the machine will perform one or more of the functions done by the labor performing mix sugarcane harvesting system. Developed countries apply full mechanization for harvesting entire production of sugarcane. Australia use chopper machines for full mechanization sugarcane harvesting. United States of America apply full mechanization of sugarcane harvesting systems either by choppers (in Hawaii and Florida) or by solider whole stalk harvesters (in Louisiana). Countries grow large areas of sugarcane such as Brazil, India, Cuba, South Africa and China may have large agricultural sectors that economically apply full mechanization, medium sectors that apply semi mechanization and small size farms that still harvest sugarcane manually. These countries fabricate both of full and semi mechanization technology for sugarcane harvesting. Other countries such as Iran, Thailand, Indonesia, Vietnam and other developed countries fabricate successful semi mechanization harvesters. Several trails have been done to locally demonstrate imported sugarcane harvesters. The demonstrated machines were not accepted by the local farmers because of poor performance. Other trails to develop and test local designs of sugarcane cutter harvesters through graduate student research programs have not yet been succeeded. The current article devoted to review the commercially available cane harvesters, report the efforts to mechanize cane harvesting and evaluate the conditions that determine the application of cane mechanical harvesting.

Keywords: Mechanization- Types of cane harvester- full mechanization of cane harvesters- Semi mechanization of cane harvesters- Mechanize cane harvesting in Egypt.

INTRODUCTION

Cane harvesting is the single most costly operation in sugar cane farming. Although more sophisticated self-propelled sugar cane harvesters are in use in developed countries but manual harvesting is still practiced in most poor countries. Variable sizes and designs of semi mechanization sugarcane harvesting machinery are available. Full mechanization systems may be whole stalk harvesting system or chopper harvesting system. The important issues that have to be addressed are improving harvesting rates and reducing extraneous matter levels of the cane delivered to the factory. Further research is required to study the impact that crop residues have on ratoon crops especially under cool or wet conditions as well as alternative post harvest equipment and management systems (Meyer et al., 2005). Characteristics and performance of harvesters in Okinawa, where mechanization of sugar cane harvesting is well advanced, were reviewed based on the results of past research. There was a trend for the greater the engine power of the harvester, the higher the working efficiency, and the trash ratio and harvesting loss were lower. It turned out that large- and middle- sized wheel-type harvesters did not perform well in rain, while small crawler-type harvesters were often more operational regardless of rain. The field was most affected by soil compaction when the row width was narrower and the harvester operation speed was lower. It is expected that small harvesters will not only be introduced in areas unsuitable for middle and large sized harvesters, but also play a complementary role in areas where large- and middle-sized harvesters are already in use. The recommendations of the ISSCT workshop about mechanical harvesting were concluded by Norris et al. (2007). Experience has shown that to leap ahead to the use of chopper harvesters with no intermediate steps, involves the risk of costly failure and abandoned machines. Such a gradual process is most easily achieved by following the introduction of mechanical loading with a simple tractor-based cane cutter, retaining the same whole-stalk loading and transport system. The logical follow-up from this is a whole-stalk harvester as the same transport and factory cane storage system can continue in use, with consequent saving on capital outlay (Abdel-mawla 2000). Scott (1988) reported that the whole-stalk cut cane green and remove the tops, but make no other attempt at cleaning. So burning is required, after cutting. They are also not as tolerant of recumbent cane and adverse field conditions as choppers have become, even though their performance in the right conditions is superb. Market attitudes will undoubtedly change when whole-stalk machines become available, equipped with internal cleaning systems and exhibiting performance and versatility comparable with choppers. Huang and Wei (1989) reported the development of whole stalk harvester in China. A 67kW machine has been designed to harvest green cane yielding about 80 ton/ha. The power requirements are much lower than those required for chopper harvester thereby saving harvest costs. The first machine was developed at 1981 as a cane cutter; the tractor controls were reversed with the base cutter mounted on the 3-point linkage. The beaters covered with rubber were attached to the shaft of the base cutter in order to strike the whole-stalk cane to left side of the machine to form a windrow. In practice the wheel of the machine rolled over some of the buts, thus damaging the cane.

In 1985 the machine was redesigned to reassemble a reasonable a Solder-type-Harvester has proved to be feasible for harvesting green cane yielding about 80 ton/ha. The author concluded that the whole stalk sugarcane harvester operated efficiently in erect and semi erect cane. The pillars mounted on both sides of the machine saved field time losses. The engine power of only 67 kW was adequate and is much lower than that of chopper operating in similar conditions thereby reducing harvest losses. An effective field capacity of 23 ton/h has been achieved in green cane with a yield of 80 ton/ha in the past three harvesting season. However chopper harvester facilitates more convenient handling of the cane. Another advantage of the chopper harvester is its ability to gather and harvest sprawled and lodged crops. Field performance of chopper harvesters was also reported by Neto et al (1989). The most effective criteria were identified of the performance of chopper harvesting in green and burnet cane mostly tested for: 1- Effective speed (km/h). 2- Effective field capacity, (t/h). 3- Cane quality (purity % juice, poll % cane, fiber % cane). 4- Cane losses (stalks, fraction of stalks in the tops and fraction of stalks in the stubble). 5- Crop residues in the field after harvesting (green leaves, tops, dry leaves). Chopper harvester facilitates more convenient handling of the cane. Another advantage of the chopper harvester is its ability to gather and harvest sprawled and lodged crops. In this respect, it has a clear advantage over the whole-stalk harvester, which is severely limited to in sprawled cane. The gathering mechanisms have been improved over the years to the extent that heavy, sprawled crops lying flat on the ground across the ridges can be gathered. In Australia where chopper-harvester were used extensively, as a consequence of these improvement, cane variety with good yields but with a tendency to sprawl can be grown and farmers use more fertilizer without fearing for difficulties in mechanically harvesting heavy crops.

McConnell harvester system was basically designed for Barbados conditions, tested and reported by Blackburn(1984). The system consists of two machines, the first is a tractor front mounted harvester topper and the second is a tractor-trailed detacher and elevation. The one-row McConnel harvester mounted on a standard 75 hp agricultural tractor worked in a wide range of field conditions in Puerto Rico. No mechanical problems were encountered with the flail topper-cleaner or with the base-cutter. The mechanical problems encountered concerned the prime mover and included engine cooling, air cleaner, hydraulics, and PTO power transmission which can easily be solved by fabricating a prime mover to fit the field conditions and harvesting components. The idea of handling cane in-line by rubber-covered drums is not new, but the method of cleaning is, we believe, novel and has been patented. Several hundreds of analyses during trials in Barbados 1975, 76 and in Natal 1976 indicate that total extraneous matter levels for green whole-stick cane, cut, cleaned and loaded by the new system, is usually less than 10% and many samples were below 5%.Cane variety and yield are the main variables.

Meyer (2005) reported that in South Africa, the SASABY harvester has proved to be a very useful tool in the improvement of mechanical harvesting sites and harvester performance. Mechanical harvesting under experimental conditions does not affect cane yield. It is expected that sugarcane will be manually harvested in the short to medium term in the South African sugarcane industry. The current apparent shortage or unwillingness of labor to harvest sugarcane can be ascribed to several reasons. While high capacity sugarcane harvesters are commercially available from overseas, these are expensive to operate and in many instances not suited to large areas of South Africa. It is therefore vital that alternative sugarcane harvesting aids be developed to improve manual cutter productivity. On the other hand sugarcane growers should ensure that infield conditions and their field layouts are such that these are more acceptable to using harvesting machinery than is currently the case. One of the major challenges facing the South African sugarcane industry is that of moving to green cane harvesting regime. Green sugarcane cane harvesting presents the opportunity to develop new technologies and make significant advances in productivity and profitability while at the same time ensuring soil sustainability and protecting the environment. The cane harvester can handle up to 25 tons per hour was developed in South Africa. These made the initial trials with a test rig to prove the principle of "in-machine topping and cleaning". The importance of fabricating cheep efficient sugarcane harvester that can perform economically under the conditions of developing countries was discussed by Beer (1980). Starting from the conventional system of cutting and stacking manually, a grower cane mechanize by degrees, initially incorporating only a mechanical cutter. The main problems to be overcome with a green cane harvesting system related to vision, especially setting and seeing obstacles in the path of the base-cutter; row-following in lodged cane.

If the machine contains topping and gathering mechanisms, base cutter, etc., it may be too expensive in relation to the throughput permitted by this cleaning mechanism. Lubis (2014) reported that the South African made sugarcane harvester VICRO equipped with full-hydraulic drive. It can continuously and automatically complete the whole harvesting process of picking up fallen cane, topping, cutting, transmitting, truncating, separating cane and top, loading with truck elevate. The purpose of the sugar Cane Harvester is to be able to harvest and top burnt sugar cane as well as un-burnt sugar cane. The sugar cane harvester is attached to any tractor by means of the two point tractor linkage. The sugar cane cutter was designed and built in South Africa. The cane cutting machines are easily disassembled and shipped to any country in the world. Boast (1989) reported that a front mounted base-cutter has been developed for standard agricultural tractors of the 50 kW class. The base cutter is driven hydraulically from a pump coupled to the front crankshaft pulley or to the rear PTO shaft, depending on the tractor model. The tractor's internal hydraulic oil supply is used but is augmented by an additional 50 liters in an external oil tank. Alternatively all oil can be supplied from a tank mounted on the 3-point linkage of the tractor. The base-cutter operates automatically once it has been lowered to the land surface. Automatic ground following is effected by means of an intensifying pressure cylinder which controls base cutting height according to the resistance to culling. This allows the tractor operator to devote his attention to driving and makes cane culling a simple task. Without automatic height control a base-cutter mounted ahead of the front wheels of the tractor would result in unacceptable base cutting. The midway attached sugarcane harvester tested in the sugarcane farm of Malawy Research station during the harvesting season of 1995. The machine is an Australian made Bonnel type windrower topper sugarcane harvester. The machine included mechanisms for cane stalk base cutting, topping and windrowing. The performance of the machine showed poor compatibility with the existing agricultural practices such as inter-row spaces. The operation of the machine is also restricted to the erect cane. Yadava (1991) indicated that IISR tractor rear mounted cane cutter developed in India. The IISR tractor rear-mounted sugarcane harvester serves the purpose of stalk base cutting of single row of sugarcane stalk and windrowing the harvesting crop. The machine represents a mechanical harvester option for small sugarcane farms in India. Yinggang et al. (2013) reported the small size whole stalk harvester, mounted on hand tractor (11-14kW) manufactured by Guangxi Wuling-Guihua Machinery Manufacture company. The machine type is 4GZ-9 whole stalk harvester, mounted on 11-14.7 kW hand tractor, which was developed in 2002 by Guangxi Institute of Agricultural Machinery. The sugarcane stalks are laid down on the ground beside the machine after cutting. It can be used when the sugarcane is not seriously lodged. Its productivity is 0.1-0.15 ha/h, and it is adapted to row spacing ≥1.0 m. Gupta and Kiatiwat (1996) developed a self-propelled walking type sugarcane harvester-windrower in Thailand. It is one row single-axle walking-behind-type and works on the principle of impact cutting by knife blades. As the machine moves forward along the row, the cluster of cane stalks is guided from the divider by a two sets of lugged chains and a spring loaded guide frame. At the narrowest point of guided path, the canes are cut by blades of the base cutter, revolving at peripheral speed approximately 42 m/s. A pair of solid rubber-gage tractor wheels mounted in the front part of the machine prevents the base cutter blade from striking the ground and control the height of cut. The tread width can be changed by shifting a lock-pin along the shaft to make adjustment for various spacing along the adjacent rows. A new low-cost, self-propelled, single-axle walking-type sugarcane harvester powered by 6-kW (8-hp) gasoline engine. It was primarily designed for farmers of developing countries who cannot afford to purchase expensive sugarcane harvesters used in developed countries.

This machine reduced labor requirements for cutting and windrowing sugarcane stems. In field tests, the average field capacity of the machine was found to be 0.13 ha/h (0.32 acre/h) with average field efficiency of 71%.

The current research aimed to find out the technical and economical reasons of non successful efforts to mechanize sugarcane harvesting. Accordingly the research organized as follow:

1- Review the commercially sugarcane harvesters design and performance. The imported and locally demonstrated machines would be compared to the knowledge experienced from the reviewed technology.
2- Field evaluation of the labor requirements and costs of traditional sugarcane harvesting.
3- Reevaluate the local efforts of application and demonstration of the commercially imported sugarcane harvesters locally. Also reevaluate the efforts to develop local technology for sugarcane harvesters that done through research.

MATERIALS AND METHODS

The performance of imported or locally developed cane harvesters was extracted from published articles, non-published reports and graduation Thesis. The reevaluation done as follow:

a- The machine cost would not be considered because of the non-certainty about several parameters such as initial price, productive life of the machine and harvester reliability.
b- Labor savings of operating any of the reported mechanical sugarcane harvesters may be computed as follow:

$$L_S = L_T - (L_M\,(\frac{1}{FC \times H}) \qquad (labor.day/fed)$$

Where;

L_S: Number of labor saved (labor. day/fed) , L_T : Labor required for traditional manual harvesting (labor.day/fed), L_M: Labor required to operate the machine (labor.day/fed), FC: Field capacity of the machine (fed/h) and H : Operation hours (hours/day).

c- It is well known that cost of mechanical harvesting includes machine cost in addition to labor cost. Since the cost of machine owning and depreciation are not included, therefore, a comparison of labor cost required for mechanical harvesting to the cost of labor harvesting may indicate the major reasons for poor acceptability of mechanical harvesting.

RESULTS AND DISCUTION

1- Evaluation of labor requirements and costs of traditional harvesting:

Data were collected from sugarcane farms in four locations in Upper Egypt (Aswan, N. Hammady, Al-Oksor and Sohag). Table (1) shows the data collected from the above mentioned locations. Three groups of labors are required for harvesting, cleaning and windrowing the crop. In case of manual harvesting the sugarcane fields of average production 45 ton/feddan requires 16 labors for stalk base cutting, 40 labors dry leave cleaning and 3 labors for topping. Healthy labors are required for harvesting and windrowing with daily wage about 40 to 60LE/day. Younger labors are required for cane dry leaves cleaning with daily wage of 25to 30 LE/day. Variation of labor wages may occur depending on the location and the time of the season. Harvesting operation day starts at the early morning till noon.

Table (1) Cost of sugarcane traditional harvesting(LE/Feddan)

Location	Item	No. of labors	Dec.	Jan.	Feb.	March	April	May
Aswan	Base cutting	16	0.00	250	300	500	800	3400
	Cleaning	40	0.00	0.00	300	600	1200	
	Windrowing	3	150	150	150	150	150	
	Total	59	150	400	750	1250	2150	
N. Hammady	Base cutting	16	0.00	200	300	600	800	3000
	Cleaning	40	0.00	0.00	250	600	1200	
	Windrowing	3	150	150	150	150	150	
	Total	59	150	350	700	1350	2150	
Al-Oksor	Base cutting	16	0.00	150	380	550	800	3200
	Cleaning	40	0.00	0.00	300	600	1200	
	Windrowing	3	150	150	150	150	150	
	Total	59	150	300	830	1300	2150	
Sohag	Base cutting	16	0.00	200	320	550	800	3000
	Cleaning	40	0.00	0.00	250	500	1200	
	Windrowing	3	150	150	150	150	150	
	Total	59	150	350	720	1200	2150	
Average total cost		59	150	350	750	1275	2150	3150

Table (1) shows the change of the sugarcane harvesting costs along the season. Cane harvesting may starts early in December for to maintain the operation of molasses processing units that starts couple weeks earlier than sugar mills. At that time, the farmers harvest their cane free in front of green tops which the labors need for feeding their animals. The cost of sugarcane harvesting increase gradually through the season because the farmers have to pay for the labors especially those required for cane base cutters. In April the farmers have to pay full wages for all labors required for base cutting, cleaning the cane from dry leaves, as well as windrowing. In May when the sugar mills announce certain date for ending the processing season, the farmers harry up to catch the dead line where labor shortage occurred. At these particular conditions farmers have to deal with sugarcane harvesting contractors and pay more cost that may exceed 3000 LE/Feddan. The results are also illustrated in Fig (1)

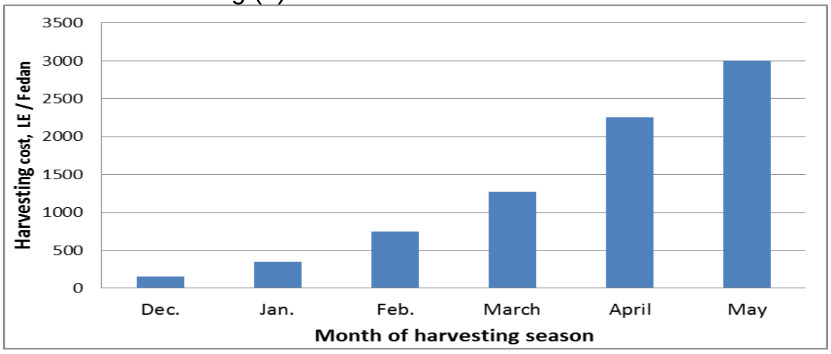


Fig (1) Change of sugarcane harvesting costs along the season

I- Performance of imported sugarcane harvesters:

Several types of mechanical sugarcane harvesters have been imported and tested. The most recognized demonstrations reported by Nour and Allam (1980) and Zawahry (1986). Some of the data of Table (2) collected from non-published reports of the sugarcane mechanization research program of AEnRI. The demonstration of the mechanical sugarcane harvesters have been sponsored by Agricultural Engineering Research Institute (AEnRI), Sugar Crops Counsel and the Sugar and Integrated Industry Company. The following notes may conclude the results of the data collected while demonstrating the imported sugarcane harvesters:

1- The chopper harvester is incompatible with the sugarcane transport system. The machine is also incompatible with the existing agricultural practices. Either at the time of demonstration or currently sugar mills don't receive chopped cane. Chopper harvesters are also of astronomical price operated in large fields where the economy of the Egyptian sugarcane farmer could not support owning such expensive machine. Other demonstrated machines are semi-mechanization whole stalk harvester-cutters. Cutter harvesters may replace part of the labors required for sugarcane.
2- Base cutting only.
3- Topping mechanism is of poor performance, complicate the machine and destroy the green tops which required for animal feed. The farmer has to manually harvest a strip from the side of the cane field before the machine start operation.
4- Farmers have to complete harvesting operation represented in cleaning, toping and pilling by labors.
5- The sugarcane harvester cutter may require 2 to 4 labors to operate the machine and to remove cane from the path of the next stroke.

III-Performance of harvester prototypes developed locally:

Three prototypes of sugarcane cutter harvesters have been developed through graduate students programs. Therefore the operation of such machines should be limited to erect cane crop as recommended. Table (3) shows the configuration and performance of the cane cutters developed locally. The most important remarks concerning the experiments done to test the above mentioned prototypes may be:

1- The first machine has to be pushed forward by a labor. The labor may gets exhausted after short time because of rolling resistance due to soil roughness. Other labor/s may be required to hold the cane while cutting so that the rate of harvesting by the machine may not be much more than that of manual harvesting by those two labors.
2- The tractor rear-mounted sugarcane harvester prototype developed and tested 2011 included a star-wheel that direct the cut cane stalks to fall behind the machine. The star-wheel may represent a simple windrower or handling mechanism. Major problems faced the operation of the machine may represented in poor control of cutting height, poor performance in lodged cane and failure of the star wheel to direct the cane stalks to fall

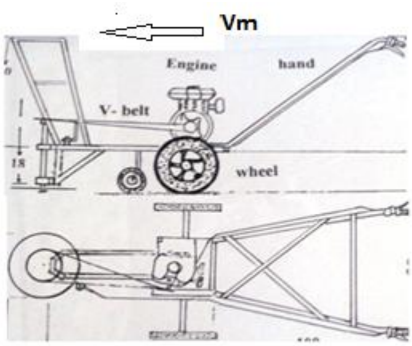
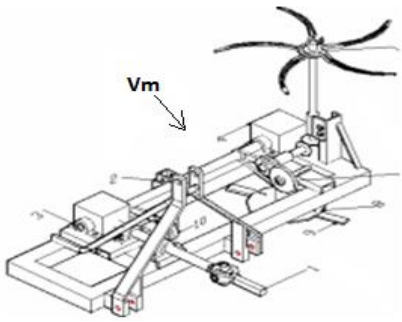
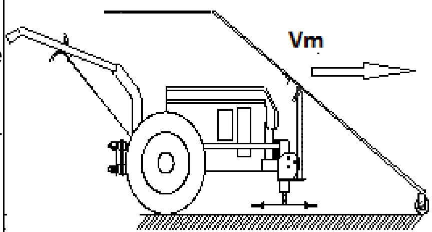
behind the machine unless the cane stalk is erect or lodged toward the falling direction.

Table (2) Performance of imported mechanical harvesters.

Season	Harvester & test data	Summary results	Technical notes
1984	Type: Bonnel Australia made Drive: Tractor mounted Function: Base cuter, topper & windrower Test location: Mallawy RS Tested by: Naway project team 1984	Losses %: 4.5 % Damage %: 2.5 % Capacity: 0.2 Fed/h Efficiency: 70% Labor saved: 30 % Cost saved: Negative	- The machine is heavy, expensive and of poor maneuverability. - The machine is incompatible with agricultural practices. - The farmer has to re-clean the harvested cane. - The machine cannot be operated to harvest lodged cane.
1986	Type: KPT1 Cuba made Drive: Self propelled chopper Function: Full mechanization Test location: Mataana RS Tested by: Zawahry & Youns 1986	Losses %: 6 % Damage %: 3 % Capacity: 0.7 Fed/h Efficiency: 0.80 % Labor saved: 90 % Cost saved: Negative*	- The machine chopper harvester (sugarcane combine) that is a very expensive machine. - The machine is incompatible with the cane transport system. - The performance of the machine was poor because the incompatibility with all existing agricultural practices.
1995	Type: South Africa made Drive: Tractor front mounted Function: Base cutter Test location: Mallawy RS Tested by: Abdel-Mawla & Ammary 1986	Losses %: 2.5% Damage %: 3 % Capacity: 0.25 Fed/h Efficiency: 85 % Labor saved: 20% Cost saved: Negative*	- The machine is a base cutter place the cane linearly to pass between tractor wheels. - The machine can only be operated in erect cane. - The machine is expensive powered by auxiliary hydraulic power system that is driven by the tractor PTO.
2007	Type: Brazil made Drive: Small power unit Function: Base cutter Test location: Armant Tested by: Ammary & Sugar Company team 2007	Losses %: 3 % Damage %: 3 % Capacity: 0.22 Fed/h Efficiency: 75 % Labor saved: 0.0 % Cost saved: Negative	- The machine is a base cutter with no parts for directing the fall of cut stalk so that two labors have to hold the cane before harvesting. - The machine does not save either labor or cost.
2010	Type: Chinese made Drive: Small power unit Function: Cutter windrower Test location: Mataana RS Tested by: Abdel-Mawla & Sugar Company team 2010	Losses %: 2 % Damage %: 2 % Capacity: 0.28 Fed/h Efficiency: 70 % Labor saved: 20 % Cost saved: Negative	- The machine does not have capabilities to top or clean the cane. - The farmer has to pick the cane from the windrow top it, clean it and pile it in a suitable size bundles. - The windrowing mechanism that complicate the machine did not save any cost or effort.

***Negative: The cost of harvesting a unit area of sugarcane using the machine is more than the cost of manual harvesting.**

Table (3) Performance of locally developed mechanical harvesting

Year	Information & prototype performance	Prototype configuration
2002	After Refai, E. M. A. Degree: MsC Title: A study on mechanization of sugarcane harvesting. Institution: Al-Azhar University Machine type: Walking man pushing Machine function: Base cutter + diflector Powered by: Small Engine (6 hp) Test location: Al-Oksor Average performance in erect cane: Losses %: 3 % | F. efficiency: 65% Damage %: 2% | Labor save: null F. capacity: 0.07 Fd/h | Cost save: null	
2011	After Mahmoud H. Ali Degree: PhD Title: Development of a single row harvester for sugar-cane Institution: Al-Azhar University Machine type: Tractor rear mounted Machine function: B. cutter + star-wheel Powered by: Tractor PTO Test location: Shandaweel RS Average performance in erect cane: Losses %: 4 % | F. efficiency: 70 % Damage %: 3% | Labor save: 20 % F. capacity: 0.12 Fd/h | Cost save: null	
2014	After Ibrahim, M. A. Degree: PhD Title: Developing a sugar cane harvester according to the physical properties and field condition Institution: Assiut University Machine type: Walking-man cane cutter Machine function: B. cutter + divider Powered by: Small single axle tractor (14 hp) Test location: Mallawy RS Average performance in erect cane: Losses %: 3.5 % | F. efficiency: 60 % Damage %: 2.5 % | Labor save: 10% F. capacity: 0.08 Fd/h | Cost save: null	

3- The third prototype represents a small sugarcane cutter fabricated by mounting the base cutter on the front of a small power unit. The machine is provided with a divider to separate the cut cane row and to help for determining the falling orientation. The divider could be adjustable toward the right or left sides. While experiments, it was clear that the distance of the power unit wheels is not matching row spaces. The machine divider was supposed to perform moderate except for some problems related to poor fabrication quality. The operation in lodged cane represented a problem and the machine rate was also low that did not significantly save labor effort or costs.

IV- Comparison of labor requirements and labor costs of mechanical vs traditional sugarcane harvesting:

Table (4) shows the labor requirements of harvesting sugarcane by machines in comparison to traditional harvesting. For the chopper harvester (sugarcane combine), only 1.7% of the labors are required. The problem is that the machine is not compatible either with field conditions or with the existing sugarcane transport systems. Other semi-mechanical harvesters require from 78% to 85% of the labors require for traditional harvesting.

Table (4) Labor requirements for mechanical harvesters vs traditional harvesting

Item	Traditional harvesting	Labor required for commercial harvester Labor. day/ fed					Labor required for developed harvesters, Labor. day/fed		
	Labor/fed	Cutter/topper /windrower	Chopper	FM base cutter	RM base cutter	Ridden windrower	Labor pushed cutter	T. mounted Cutter	Power u. mounted cutter
Base cutting	16	4	1	3	3	2	7	6	7
Cleaning	40	40	0.00	40	40	40	40	40	40
Handling windrowing	3	3	0.00	3	3	3	3	3	3
Labor req.	59	47	58	46	46	45	50	49	50
% of traditional	100%	80%	1.7%	78%	78%	76%	85%	83%	85%

CONCLUSION

Sugarcane mechanical harvesting systems may be fully mechanized or semi mechanized systems. In the full mechanization systems, the mechanisms of the sugarcane harvester perform a set of functions in sequence to complete harvesting operation. Full mechanization systems of sugarcane harvesting may either be self propelled whole-stalk harvesters or the chopper harvesters. Semi mechanization technology represented in the tractor mounted and small cane harvesters perform one or more of the functions done by the full mechanization harvester. Variable types of tractor mounted as well as small sugarcane cutters have been developed for the conditions of developing countries.

Several types of sugarcane mechanical harvesters have been locally demonstrated for farmers' acceptance. Most of the demonstrated harvesters cut the bases of cane stalks and leave them lying on the ground. The farmer has to pick the cane stalks, top it, clean dry leaves and arrange it in a pile suitable for loading. Therefore, the farmers determine that the use of cane cutters do not save cost or effort. The attempts of developing a local cane harvester limited to graduate students research with no chance for field demonstration. It seems like all the countries producing sugarcane have developed successful cane harvester for their local conditions except for Egypt. A national research program sponsored by the concerning organizations should be started to develop a sugarcane mechanical harvester suitable for crop conditions as well as Egyptian farmers' socioeconomically constrains.

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الحصاد الآلى لقصب السكر – تقييم التطبيقات المحليه

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حصاد قصب السكر عمليه مركبه تتضمن إجراء عدد من العمليات المتتابعه نسوقها كالتالى: 1- قطع قاعدة ساق القصب عند سطح الأرض مباشرة 2- إمساك وتداول الأعواد 3- وتنظيف الساق من الأوراق الجافه 4- وقطع القمه الخضراء للعود 5- وترتيب القصب فى أكوام مناسبه أو تحميله مباشرة على معدة النقل. ومعدات حصاد القصب التى تشتمل على آليات لإجراء تلك العمليات جميعها دون الحاجه للعمال تسمى آلات حصاد القصب بالميكنه الشامله. أما إذا كانت الآله تؤدى واحده أو أكثر من تلك العمليات وتستكمل باقى خطوات الحصاد بالعمال فإنها تسمى آلات الميكنه الجزئيه لحصاد القصب.

ويمكن تصنيف معدات حصاد القصب بالميكنه الشامله إلى معدات حصاد بالعود الكامل(Whole-stalk-harvester) ومعدات حصاد وتقطيع (Chopper harvester). وكلا النوعين آلات كبيره مرتفعة الإثمان تعمل ضمن منظومات محدده لنقل وتوريد القصب للمصانع. وتصنع آلات حصاد القصب بالعود الكامل الذاتية الحركه أساسا فى لويزيانا وتقوم الصين أيضا بتصنيع آلات ذاتية الحركه لحصاد القصب بالعود الكامل ويعتبر إنتشار تلك الآلات محدودا حول العالم لكونها لا تعمل بكفاءه فى ظروف القصب الراقد. أما آلات الحصاد والتقطيع فإن أداءها لا يتأثر كثيرا برقاد القصب لكنه يلزم الإسراع فى نقل القصب لأن تقطيعه يسرع من تدهور محتوياته من السكر. ولكلا النظامين مميزات وعيوب إشتملت عليها المقاله بالتفصيل.

آلات حصاد القصب بالميكنه الجزئيه لا بد أن تشمل على آليه أساسيه لقطع قاعدة العود وبالإضافه إليها ربما تشمل على آليه للتداول آو آليه لقطع القمه الخضراء. وجميع آلات الميكنه الجزئيه لحصاد القصب تصنف على أنها آلات حصاد بالعود الكامل. وتلك الآلات إما أن تكون معلقه على الجرار أمامه أوخلفه أو على جانبه وإما أن تكون آله صغيره مركوبه آو موجهه بالعامل. والقاسم المشترك أن غالبية البلدان الناميه المنتجه للقصب قد طورت طرزا من آلات الميكنه الجزئيه لحصاد القصب مناسبه لظروف حقولها فيما عدا مصر.

وقد إستعرض البحث التطبيقات التى تمت لتشغيل آلات الحصاد المستورده فى مصر والتى لم تلقى اى منها إقبالا من مزارعى القصب لعدم تحقيقها لمميزات خفض المجهود البشرى أو تكاليف الحصاد وعلى نتائج تطوير آلات محليه من خلال البرامج البحثيه التى تمت فى الجامعات المصريه والتى لم ترقى أى منها إلى مستوى التشغيل لدى المزارع. وبناءا على البيانات التى الحقليه عن حصاد القصب يمكن إستنتاج الآتى:

أولا: أنه لا يوجد لدينا أى قطاع يقبل تطبيق الميكنه الشامله لحصاد القصب أو يحقق إقتصاديات إمتلاكها وتشغيلها وأن الجهد يجب أن ينصب فى إتجاه تطوير ميكنه جزئيه محليه.

ثانيا: أن حصاد فدان من قصب السكر يحتاج إلى 16 عامل من الأصحاء لعملية قطع الأعواد وفصلها عن الجذر من على سطح الأرض كما يحتاج إلى 40 عامل من الأقل عمرا لتنظيف القصب من الأوراق الجافه بالإضافه إلى ثلاثة عمال للتكويم. وحيث أن أى آله لحصاد القصب تحتاج على الأقل إلى عاملين أو ثلاثه لتشغيلها وإخلاء القصب من طريق عودتها وبالنظر إلى بطء أداءها وتأثرها بالرقاد وضعف إنتاجيتها فإننا نجد فى النهايه أنها لا توفر كثيرا من عمال الحصاد (16 عامل). وبناءا عليه فإن أى آلة لحصاد القصب لا تشتمل على آليه للتنظيف لا يرجى أن توفر من العماله البشريه او من التكاليف ما يستحق.

ثالثا: أن غالبية المزارعين وعمالة حصاد القصب يعتمدون على القمم الخضراء لأعواد القصب كغذاء ضرورى لمواشيهم فى فتره طويله من موسم الحصاد. وبناءا عليه فإن آلة حصاد قصب تحقق ربحيه وقبول للمزارع ليس بالضرورى أن تشتمل على آلية قطع القمه الخضراء حيث انها تزيد من تعقيد الآله وتكاليف تصنيعها وتؤدى إلى تمزيق القمم الخضراء وعدم الإستفاده منها بالإضافه إلى أن الميل الطبيعى للأعواد يدنى كفاءة أداءها.

رابعا: أن تكاليف الحصاد اليدوى لمحصول القصب تكون قليله فى بداية الموسم وتظهر الأزمه الحقيقيه فى نهاية الموسم عندما يعلن المصنع عن موعد توقفه حيث يتبارى المزارعون فى الحصاد للحاق بموعد المصنع وترتفع تكاليف الحصاد لتشكل عبئا ضخما على المزارع. وبناءا عليه فإن إقتصاديات تصنيع وإمتلاك معدة حصاد للقصب يجب أن يتم حسابها على نصف الموسم الأخير فقط حيث تظهر الأزمه وتأخذ فى التفاقم.

خامسا: وأخيرا أن آلة حصاد القصب التى يرجى نجاحها فى ظروفنا سوءا ملحقه بالجرار أو موجهه بالعامل يجب أن تكون ذات تكاليف مناسبه ومتزنه ديناميكيا لا تتسبب فى إجهاد مشغلها وتتماشى أبعادها مع ما إستقر عليه المزارعون فى ممارستهم لتخطيط الحقل وأن تشتمل على جهاز تداول بسيط التصميم قوى يعمل بكفاءه ويدعم تركيب آلية أو عناصر لتنظيف للأوراق الجافه على الآله.