A SYSTEM FOR WHOLE STICK CANE HARVESTING

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ABSTRACT

By using a two-pass system, wholestick green cane can be cut, cleaned, and loaded with an acceptably low level of extraneous matter. The key to the cleaning process is that the untopped stalks are drawn tops first into the cleaning mechanism. The machines are described.

An important aspect of the system is that it can be phased in over an extended period to match labour decline, to spread capital requirements, and to give time to create a competent physical and psychological infrastructure to secure an economic operation.

It has now been proved that cane can be cut, topped, and cleaned, without using sharp edges. However, although this is a huge advantage in stony soils, there may be circumstances where sharp-edged base-cutting would be preferable in preparing the windrow of cane taken in to the Stage II machine.

Although a wide range of loaders are able to work with the system, a versatile loader has been specially developed which matches the requirements of hand-cut cane, and suits all stages of the machinery introduction.

The system has the potential for dealing with pairs of rows at each pass, without the penalty of wide or cumbersome machinery. Use of double-row planting is advocated.

On the basis of progress so far, with the machinery described, the Barbados Sugar Industry was able to revert to green cane harvesting in 1975 with considerable immediate, and long-term, benefits.

A brief assessment of the wider potential of the system is attempted, and it is concluded that the machines should have wide
application. Development is now being actively pursued in South Africa as well as Barbados.

INTRODUCTION

This paper has four objectives. The first is to restate clearly the strategy of the harvesting system developed jointly by the Barbados Sugar Producers' Association and F.W. McConnel Ltd. The second is to summarise the key features of the machines involved, with particular emphasis on two of these machines: (a) the “Stage II” which completes the green cane harvesting system in a second pass, and (b) a further development to achieve a once-over operation in burnt cane. The third objective is to put on record the fact that, after several years during which we resorted to pre-harvest burning, the Barbados sugar industry successfully reverted to a no-burn policy in 1973. Fourthly the relevance of the new system to other Industries is assessed in the light of experience so far.

STRATEGY

During the late 1960's there was a serious decline in the availability of labour able and willing to reap cane; and at the same time there was an alarming increase in cane fires with an increasing tendency to regard the cutting of unburned cane as “old fashioned”. What was needed was a whole-stick, green cane, mechanical harvester. Unfortunately nothing suitable was on the market.

In fact the “market” said that it was very unprogressive to ask for such a thing and that one had to learn to (a) live with burning, (b) gain experience as quickly as possible with burnt cane harvesters, (c) start changing the transport and factory-reception facilities because the most suitable harvesters for such conditions were chopped-stick machines, (d) remove all stones and obstacles from the fields.

At the time this advice seemed good, and earnest experiments were started in Barbados, mainly spurred on by the obvious success of the Queensland industry. However the fact remained that this approach was being dictated by the machinery market rather than what was actually needed — namely a system to deal with whole stick cane, without burning, and permitting a gentle evolution to give (a) minimum social and economic upheavals, and (b) maximum time to secure good field preparation to build the infrastructure needed for the economic operation of harvesting machinery.

A chance observation in 1966 came to hold increasing significance as offering an alternative route, and work to exploit it was initiated in 1970. The observation was that if unburned cane could be accelerated tops-first the green leaves and trash could be stripped from the stalk very easily; at the same time it was noted that the two weakest points in a cane stalk usually coincided with the two places where ideal hand cutting would be
recommended — i.e. at ground level and at the junction between the mature and immature internodes of the top of the cane. The relevance of these observations to a mechanised harvesting strategy is as follows.

(a) Unburned cane can be mechanically cleaned, without chopping it up, by a very simple mechanism, provided that it can be drawn into that mechanism *tops first*. The best way of achieving this is to harvest the cane in two passes — a “laying-down” pass and a cleaning/bundling pass. Multi-pass harvesting is well-known in many agricultural crops (including sugar cane) and has some very considerable advantages, especially from the point of view of unit simplicity. But in the sugarcane context there are five particularly interesting points. One is that eventually the two-pass approach could lead to a two-row approach with a quite modest machine size. Another is that self-propulsion is not obligatory. A third is that, since the cane is dealt with tops-first and “in-line”, a 100% topping operation is theoretically possible for the first time with mechanical cane harvesting. Fourthly the requirement for “accompanying” (and therefore specialised) transport is avoided (although the higher load density possible with chopped cane is sacrificed). The fifth point is as follows.

(b) Since two passes are required to achieve the cleaning of whole-stick, unburned, cane it is logical to devise the “laying-down” machine so that it can be introduced initially as a *reaping aid*. Up to now reaping aids have been a dead end which many farmers have, with justice, regarded with caution; all of the machines on offer could cope only with easy cane conditions and in some countries there was a fear that labour might “hold the machine to ransom”. However if the reaping aid is simply the first part of a complete system there is no such anxiety but only the advantage of an *evolutionary* introduction of mechanisation, with all the merits which that implies from the point of view of capital requirement, field preparation, creation of infrastructure, utilisation of existing transport, etc.

And, most important, such an evolution permits mechanisation to be tailored to the social obligations of each circumstance. In every sense we believe we can apply Dr. Schumacher’s*8* phrase “Appropriate Technology” to this concept without the overtones of “primitive” sometimes associated with “Appropriate Technology”.

Initially the reaping aid was produced with the assumption that labour would include topping as part of the cleaning exercise, but in fact the farmers whose opinions we sought at that time urged that a topping device be added. Of course when the complete system is used this is unnecessary — indeed a disadvantage — and the topper on the reaping aid (called “Stage I”) is the only part of the green cane system which becomes redundant when the system evolves to completion.

(c) The previous two sections, (a) and (b), refer to green cane. What about burnt cane?
For obvious reasons, burnt cane offers a much simpler task to harvest equipment. Not only is the volume of unwanted material very much less and the power requirements much lower, but row-following and obstruction-avoidance are greatly eased. There is no problem in using the Stage I machine as a reaping aid in burnt cane and high outputs of both machine and labour are achieved. It has also been found that even cleaner cane, and even higher labour outputs, can be achieved by cutting the cane before burning and then burning the cut cane subsequently.

But from the point of view of the machine evolution there is another major difference between green and burnt cane, namely that the complete system for upright burnt cane does not need two passes. When the progression is made from the reaping-aid stage, the base cutter is replaced by a simplified version of the green cane Stage I machine. In the case of burnt cane therefore the topper is retained as an essential component of the complete system with the base cutter of Stage I as the redundant component.

Since the system was originally pioneered for green cane our experience in burnt cane has been for a more limited period; but this situation is quickly changing.

(d) The original “break-through” observation included the fact that cane need not be cut by sharp edges. In the Barbados context this has considerable importance since the soils are often stony and even large rocks can escape the efforts to clear them from fields. The development of this method of cutting is obviously worthwhile for industries or areas where stones are a serious problem but the operation of the complete system for green cane does not depend upon the novel method of base cutting. Some industries may prefer a first-pass machine which employs sharp base cutting (c.f. Fowler1).

(e) Loading. Compared with the problems of cutting, cleaning, and assembling piles of cane, loading is a simple operation and at the time of writing there were at least 7 different types of loader working in conjunction with Stage I or Stage II machines.

However, from the point of view of smaller farms, sloping land, heaped green cane, and the step-wise introduction of machinery, “the market” did not seem to supply exactly what we would like to use. In addition it was felt that, since the Stage I and Stage II machines both use a wide range of medium power wheeled tractors, farmers would like to standardise on a single tractor model for cutting, piling and loading; a suitable loader, able to clip on to any such tractor did not appear to be on the market. For this reason the “Cane Loadster” has been created to satisfy this need, especially in the context of the green cane system.

(f) Sections II — V of this paper describe in more detail the machines involved in the BSPA/McConnel system.
FIGURE 1. The three basic machines in the green cane progression. (a) Loader. (b) Stage I reaping aid. (c) Stage II cleaner/bundler.
THE STAGE I (REAPING AID)

This machine (figure 1b) was the main subject of a paper at the previous ISSCT Conference (Hudson2) which should be consulted for details. In summary the Stage I is tractor-mounted, and tops, cuts, and partially cleans, green or burnt cane, leaving the cane in an orderly swath lying lengthways along the cane row. A reduced labour force, using a special knife, recovers the cane from the swath, trims it and piles it in the usual way. It replaces an arduous task for which few people are well fitted by an easier task for which many people are suited. The Stage I machine exploits the two naturally weak points found in all canes, one at the base and the other at the junction between the mature and immature internodes. Severance at these two points normally maximises the recoverable sucrose harvested.

An unforeseen trend is that because the machine is getting the reputation of being able to cope with tough, “unsuitable”, conditions, it is often therefore denied the chance of showing what it can do in good stands of cane in well-prepared fields. For example two machines working on a large well-managed farm in Natal frequently achieve sustained outputs (burnt cane) of 40-60 tons per hour. The per crop output of one machine is over 30,000 tons. Examples like this highlight the point that although machines like the Stage I can “get through” in severe conditions, money spent in “smoothing their path” can result in tremendous increases in productivity.

THE LOADSTER

The Loadster (figure 1a) is a simple tractor-mounted slew loader able to retrieve cane from a wide area and deliver it into virtually all existing field transport.

In 1968 the Barbados Sugar Producers’ Association offered to cooperate with F.W. McConnel Ltd. in the design of a cane loader suited to the loading of heaps of green cane on small farms with awkward land. The result of that venture was a converted sugar beet loader called the “Cane-boy”. Although it met the objectives set for it, mechanically it showed that the rigours of the cane field were much more severe than those of sugar beet fields in England. With the advent of new tractor cab requirements in the United Kingdom the development had to be curtailed and a new development, based on a forestry-type loader, was undertaken.

The main features include a 6 m reach, universal mounting on to virtually any tractor model (and with the ability to remove it quickly to free the tractor), ability to tow the trailer into which it is loading, 360° slew, a rotatable grab, stability on slopes. Recently a device to extend the slope range has been added (Randoll3). The objective, in other words, is a grab loader with a high degree of versatility which can fit in with the sequence of introduction of the green cane system, dealing in the first instance with hand-cut, hand-piled cane, then, with machine-cut hand-piled cane, and finally with the bundles left by the Stage II machine.
On smaller farms (up to 150-200 Ha) the "Loadster" or a similar machine can easily cope with the Stage II operation but on larger farms, especially if the cane is being cut burnt, a higher capacity operation is necessary. If the culture is reasonably flat the best method developed to date is to drop the bundles in regular rows across the field and use Louisiana-type loaders (the push-piler attachment can be used since the cleaner/bundler machine scrapes the trash from under each bundle as it is dropped). However, if the field is set up in appreciable ridges this across-the-row operation is not applicable and it is necessary to utilise either a number of Loadster-type machines or the same type of machine but of much higher capacity.

THE STAGE II (GREEN CANE CLEANER/BUNDLER)

Figures 1c and 3 show the machine in photographic and diagramatic form, essentially as required for 2-pass working in green cane. The Stage II moves in the opposite direction to Stage I; cane is therefore gathered tops first (c.f. all singlepass harvesters where the canes come in butts-first).

Gathering: Cane is gathered into the machine by ground-following hinged sweeps. The gathering unit is actually a simple adaptation of the base "cutter" of the Stage I machine. Gathering tops-first greatly facilitates this operation and a slow rotation is sufficient (about 80 rpm). Rocks are pushed sideways from the 1.2 m wide throat because they cannot climb the ramp up which the cane is passed.

Cleaning: The cleaning mechanism exploits the fact that leaves are flexible whereas cane is rigid. Each "hurler" drum is formed of three treaded rubber pads which accelerate the canes rapidly from the conveyor. Leaf material tends to wrap around these drums and as the cane is projected rearwards this leaf material, trailing to each side is knocked off by the counter-rotating cleaning drums above and below. The movement of leaves attached to the "coot" is sufficient to break it from the cane and eject it from the machine. (Thus, in both the Stage I and Stage II machines topping exploits the same naturally weak point in the immature internodes). The cleaning drums consist of four metal paddles rotating at about 3 times the speed of the hurlers. They also move a certain amount of air and have been called "fans" but an investigation into the importance of this air movement was not concluded at the time of writing. 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 Natal (1976) indicate that total extraneous matter levels for green wholestick 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.
Since much of the dry trash is left in the throat of the Stage II or falls off the head of the conveyor, the cleaning mechanism is mainly removing green leaf material. This particularly applies to the material emerging off the top hurler drum, which can be optionally collected. Casual feeding trials, for cattle, sheep and horses, with this product indicate good palatability and the advent of the Stage II machine raises the possibility of retrieving substantial amounts (5-8 tonnes/ha) of *fodder as a by-product* of the harvest operation. (In another development a simplified Stage II is to be used to harvest untopped green cane for pelleting as a cattle feed).

*The Bin* has to be able to accommodate canes over 3 m long and accounts for about half the machine’s length. In the present design the bin can be set to form a bundle to either side of the centre line, allowing off-set dumping when the floor is lowered. This facility will not be needed with a 2-row operation. Its capacity is over ½ tonne.

All drives are mechanical, consisting of: PTO shaft, 1¾” (31.75 mm) chain drive and overload clutch to the gathering drums, a right angle gearbox driving a cross shaft which drives (a) via belts and a reduction gear to the conveyor and (b) by 1” (25.4 mm) chain to the hurling mechanism. The cleaning drums are powered by belts and step-up gear from each hurler drum. The bin is operated hydraulically. Total weight is about 3½ tonnes.

**FIGURE 2.** The hybrid I/II machine working in burnt cane as a once-over operation. (Note rocks in foreground).
Attachment to the tractor. To gain maximum manoeuvrability and traction, whilst retaining the advantage of using standard tractors, the design team of F.W. McConnel have developed two interesting hitches. Both utilise a centre-pivot just in front of the gathering unit. For the twice-over operation (green cane) the tractor can be mounted with an adaptation of the three point linkage which allows the front wheels to be removed (figure 3). Steering is accomplished by rams beside the centre pivot (as is normal for centre-pivot tractors). This arrangement throws all the weight of the tractor, plus about a quarter of the weight of the Stage II, on to the driving wheels so that not only is the unit highly manoeuvrable but traction is excellent. For the once-over hybrid I/II machine (burnt cane), this method of attachment can not be used because of the weight of the dividers and toppers on the front of the tractor. In this case the standard tractor lower links are used but with the lift arms removed and with rams sited across the attachment of the centre-pivot structure to the arms. This allows a simple hydraulic circuit from all tractors to operate the hitch and the bin rams. (A four-wheel drive tractor is envisaged as required for this hybrid machine except in the easiest circumstances).

FIGURE 3. Details of operation and design of the Stage II machine for green cane.
because the gathering mechanism of the trailed machine is acting as a cutting mechanism too, the hybrid machine is at present limited to cane grown on a more or less flat culture. At the time of writing, this hybrid machine had achieved along-the-row outputs of up to 50-60 tonnes/hour.

The hybrid machine has the following key components. Spiral dividers and flail topper with independent hydraulic supply, are mounted on the front of the tractor exactly as standard for Stage I. (Promising trials with a side-throwing topper have also been carried out). A simplified Stage II machine is towed in place of the basecutter of Stage I, and because of the centre pivot arrangement the turning circle is good in spite of the overall length of the unit. The gathering sweeps pass the cut cane onto the conveyor and it is accelerated from this conveyor by the same mechanism as for green cane. However, since the cane is coming in butts-first, very little leaf material is wrapped round the accelerating drums and the cleaning drums ("fans") can be omitted, with consequent simplification.

BARBADOS' EXPERIENCE

The first privately-owned Stage I machine was bought in 1973 and, by 1976, there were 37 privately-owned machines and 2 belonging to the Barbados Sugar Producers' Association. Experience with the first Stage I machines, and satisfactory progress with the prototype trials of Stage II, led the Minister of Agriculture to conclude in 1975 that the technology and machine capacity had reached a level which justified the prohibition of cane fires (whose effects had reduced production by over 25% by that time). The response from the Industry, labour, and the general public was good and from 86% pre-harvest burning in 1974 the figure was reduced to 8% for 1975, and only 3% for 1976. It was also interesting that the existence of a mechanical alternative to green cane harvesting apparently stimulated the labour supply (and productivity) so that the machines have not had to work to anything like their potential.

Yields, relative to rainfall, have been monitored for three decades and the same analysis for the 1976 crop indicated that it had benefitted to the extent of about 20 000 tons of sugar from the no-burn policy of the previous crop. The value of the extra sugar from this crop alone was worth about twelve times the total expenditure on developing and purchasing the green cane harvesting machinery! At the time of writing it appeared that a similar scale of benefit would be obtained from the 1977 crop. Such dramatic benefits would also be expected in any other countries which are beset by poor rainfall distribution and thin soils, and where the retention of a trash mulch is important. (However, where moisture balance is less erratic and more favourable, smaller benefits from trash retention would of course be expected).
POTENTIAL OF THE NEW IDEAS

With the very limited resources available for reconnaissance surveys, it is still not possible to offer a comprehensive assessment of the potential of the equipment on a world-wide basis, though recently a number of other important industries (notably South Africa) have become involved in development and evaluation.

a) Varieties

Since there has been virtually no variety selection with the system in mind, the fact that a majority have behaved satisfactorily is very encouraging, and suggests that it is not difficult to select varieties suitable for the new methods of topping, cutting and cleaning.

Although the majority of varieties in any country have been satisfactorily handled by both the Stage I and Stage II machines, there are a number which have one or more of the following disadvantages: failure to break at the base of the stalk when pushed over; tendency (especially when immature) to have a region (rather than a point) of weakness in the top so that a joint of millable cane can be lost during topping; one or two varieties have been found with unusually high leaf strength (which exaggerates wrapping tendencies) and one or two with very poor leaf strength (which need a special setting of the cleaning mechanisms of Stage II); very brittle stalks (resulting in lost pieces); very tightly-held leaf sheaths.

b) Cultures

Best work is done in level cultures where the cane was planted in a deep furrow which was subsequently filled in after about 3-4 months of growth. However, satisfactory operation with furrow-planted and ridge-planted cane is usually possible and special settings of the base cutter are available. Operation is usually poor when the cane is in sharp-sided furrows much deeper than 20 cm, especially in wet weather. The hybrid Stage I/II machine for burnt cane is limited to more or less flat culture at present.

c) Row Spacing

The economics of cane harvesting improve as the width of the strip of land dealt with at each pass increases; likewise the stability of the machine. Our experience so far leads us to believe that this principle holds true up to a width of strip of about 2.40 m. However, the most usual spacing for optimising yields is typically around 1.10 — 1.40 m in many (though not in all) countries.

There is therefore a serious conflict of interest between (a) harvest efficiency and machine stability, and (b) the optimisation of yields, so long as the harvesting system is designed to take only a single row at a time.
For this reason although adaptations to the machines for narrow row operation have been designed, the ability to deal with pairs of rows has been increasingly emphasised in recent development work (e.g. Roux'). Pairs of rows up to about 1.30 m spacing have been successfully dealt with by both Stage I and Stage II machines. However really successful two-row work depends on the simultaneous planting of pairs of rows; we are particularly interested in the idea of planting pairs of rows at 0.50 — 0.80 m, with intervals of 1.30 — 1.60 m between each pair of rows. This gives a wheel track of between 1.80 m and 2.40 m. Such plantings are being tried in a number of cane industries, many of the trials stimulated by a paper by Matherne'. Figure 4 shows a simple planting machine putting a pair of rows into a deep furrow with a 2.00 m wheel spacing, and an established field with a 2.30 m overall spacing.

**FIGURE 4**. Double-row planting trials in Barbados. (a) Semi-mechanised planting into a deep furrow. (b) Double rows between a 2.30 m wheel track; note the closed canopy between the pairs of rows after only 3 months, suppressing weed growth almost completely.

d) **Slopes**

The centre of gravity is low in all the machines. Especially if the equipment is used to deal with pairs of rows between wide wheel spacings (see above), the potential for dealing with sloping land is ultimately limited only by the transport stability. The Stage I machine can be mounted on 4-wheel drive tractors for severe slopes and the "two-wheel hitch" version of Stage II allows it to negotiate any slope which can be cut by Stage I.

e) **Output**

As a result of experience in countries outside Barbados we have had to revise upwards our estimates of potential output, in both green and burned cane, compared with the suggestions in the previous ISSCT paper (e.g.
Depending on field size, terrain, field preparation, and experience, outputs as follows have been sustained over periods of an hour or more:

Stage I
- green cane — up to 40 tonnes/hr.
- burnt cane — up to 60 tonnes/hr.

Stage II
- green cane — up to 25 tonnes/hr.

Hybrid I/II
- burnt cane — up to 40(+) tonnes/hr.

f) Base-Cutting

Experience during the last three years has confirmed that the claims and limitations of the new base cutting method, made at the 1974 Congress, were about right. However, it is now known that suitable choice of variety and husbandry techniques make the method feasible in much lighter soils than we originally thought (for example with some varieties and cultures successful base-cutting has been achieved in volcanic soils in Costa Rica and light sandy soils in Paraguay).

Generally ratooning has been good after using Stage I, Stage II and the Hybrid I/II machines. However, as predicted, there have been examples of poorer ratooning with varieties with very bad basal breakage characteristics, and in circumstances where the canes were attacked by root-eating pests. There is also some evidence that, in sub-optimal conditions for ratoon regrowth, there can be a slower initial regrowth but we do not yet know if this is due only to the low base cutting or to a compaction effect as well (Moberley in South Africa, private communication, and observations in Barbados) or if it only occurs when previously hand-cut stools are reaped for the first time by the new method (Mamet in Mauritius, private communication).

g) Yields

Unburned cane to 120 (+) tonnes/hectare has been satisfactorily harvested with both Stage I and Stage II machines (depending on variety). No limit to work in burnt cane has yet been identified. With heavily lodged (i.e. bent) cane of brittle varieties the cane breakage in Stage II may be considerable, and reasonably strong varieties must be planted in circumstances where lodging is expected.

h) Cane Quality

A review of 34 experiments reported from a wide range of other industries as well as Barbados indicated the following key points. (a) Burnt
cane, if cut immediately after burning, is not at greater risk quality-wise than green cane until at least 3-4 days after it was burnt (contrary to frequently expressed beliefs). (b) There is evidence of faster deterioration if the cane is not cut immediately after burning. (c) The product of chopper harvesters is at considerable risk of deterioration after 12-24 hours depending upon climate and conditions of cutting (though experiments with hand-chopped cane seldom show such high risks). (d) Explosive build up of dextrans is confined to burnt cane.

In the context of the new system of cane harvesting described in this paper these key points are interpreted as follows. (a) That the system's ability to handle green cane is a real advantage if there is a risk of milling delays greater than, say, 3 days after burning — due to long transport distances, organisational problems, risk of rainfall after burning, etc. (b) That a greater advantage (in all but the most efficient industries) is that it deals with whole-stick cane.

i) Simplicity

We have been obsessed with the need to clothe the simplicity of the concepts with simplicity of machine design and ease of maintenance. A considerable portion of the cost of the machines is due to this obsession; wherever possible components have been made stronger than the tractors likely to power them. For countries like Barbados entering cane mechanisation, simplicity (including the use of ordinary tractors as the power units), is very important in creating a mechanically-minded ownership and easing the problems of operator-training.

CAPITAL COST

We have concluded elsewhere (Hudson and Boycott³) that, in the typical situation where the proposed system is appropriate, the “hidden” costs (and benefits) of mechanical harvesting are typically greater than the conventional “visible” costings. Discussion of “costs” outside the context of each specific cane situation can thus be extremely misleading, a point made repeatedly by many other authors but, in our experience, with remarkably little impact.

Our hopes for extremely low cost equipment have not been realised for the same reasons that have made all cane machinery so much more expensive than equivalent machinery for other crops — viz. the inherent difficulties of the crop itself and the need to pass such large volumes of relatively low value material through the machines each season. However, the capital cost of the system described in this paper, relative to the annual tonnage required to be handled, is certainly not more, and usually much less, than that of other systems. There are also the following advantages.
(a) Because of simplicity, the use of conventional tractors, and low weight, the machines are inherently less expensive than many others.

(b) If the stage-by-stage principle is accepted then the capital cost may be spread (and the labour situation may be such that it is never necessary to mechanise fully).

(c) Wholestick harvesting permits the retention of existing field transport and most loaders.

(d) Because of inherent simplicity the working life is potentially longer (Symes).  

(e) Smaller farms can use the same tractor for both the Stage I and Stage II operation if necessary. Also tractors are available after crop (or even during crop at weekends) for other work.

(f) The infrastructure ("back-up") needed is relatively undemanding and therefore cheaper; special management skills for day-to-day operation do not have to be hired.

It has been argued that the trend in cane harvesting should be towards contractor operations. In situations of relative land uniformity, a reasonably consistent climate, and a well-organised industry, there are good arguments for contract-harvesting. Although we have aimed these developments at owner-operated farms of the 100-350 ha size, there is no reason why the same machines cannot be used on farms, and in contracting systems, of much larger scale. Indeed the ability to use a module unit of relatively small size, and the fact that the system lends itself to night-time operation, should be attractive to such large operations.

REFERENCES

UN SISTEMA DE COSECHA DE CAÑA DE TALLO ENTERO
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RESUMEN

La caña sin quemar y con el tallo entero, ha sido cortada y limpiada mecánicamente usando un sistema de dos pasos. Se describen las máquinas y procesos. Con una simple adaptación de estas mismas máquinas, la caña quemada puede ser cosechada con una operación de un solo pase.

El sistema de cosecha, incluyendo el alza, ha sido diseñado para permitir una introducción en fase con vistas a equilibrar la disminución en la mano de obra, disponibilidad del capital, y el ritmo al cual se puede crear una infraestructura competente.

El corte y descogollamiento se lleva a cabo sin el empleo de cuchillas afiladas y el sistema es inmune al daño ocasionado por las piedras. Las máquinas son simples y resistentes. Se pueden trabajar dos surcos al mismo tiempo.

Con la ayuda de estas máquinas, la industria azucarera de Barbados ha retornado a la cosecha de la caña sin quemar luego de un período en el cual la quema antes de la pre-cosecha reducía drásticamente los rendimientos.

Se discuten los amplios potenciales del sistema y los factores limitantes.