ABSTRACT

The population growth rate of developing countries is currently 2.4% per year. Many of these countries are already experiencing widespread unemployment. The growth in GNP for most developing countries, South Africa included, is too low to rectify existing unemployment situations appreciably, with little hope of catering to the expected future population increase. Everything possible should thus be done to increase job opportunities, especially in the rural areas of these countries.

For various reasons, manual harvesting of sugarcane might become less attractive to laborers. Mechanical alternatives should therefore be available for use when labor becomes unobtainable. Developing countries should not, however, indulge in highly mechanized farming systems, but should strive for the optimum combination of labor and equipment to suit their particular circumstances.

Towards this end the Experiment Station of the SASA has developed several cane cutters which, when integrated into suitable cane handling systems, allow for a gradual increase in the degree of mechanization. The design of all of these machines is simple. Maintenance and operation is well within the capabilities of ordinary tractor drivers. A number of semi-mechanized harvesting systems, incorporating these cutters, have been evaluated. Labor productivity can be increased over a range from 4.5 to 15.0 t/man-day. Harvesting costs can be kept reasonably low, and in the current South African situation they should be much lower than those of completely mechanized chopper harvesting systems.

INTRODUCTION

South Africa is a developing country with a black population of 19.6 million, 70% of which live in rural areas. The average annual growth rate of this section of our population is 2.9% compared with 1.2% for developed countries (Wyndham72).
Based on present predictions, a population explosion which may be more severe than almost anywhere else in the world is expected. Half of the present black population is less than 16 years old.

Due to a general slowdown in the economy, unemployment is already a serious problem. To rectify this situation and to take care of the increasing labor supply, it is estimated that 500,000 new jobs per year will be required throughout the nineties. For this requirement, an annual growth rate of more than 6% in GNP would be needed. Present prospects are not anywhere near this figure. In fact, the increase in the GNP from 1973 to 1978 was only 2.5% per year (Ardington). Unemployment is thus likely to be a feature of the foreseeable future, and agriculture should therefore be assured of a plentiful supply of labor as long as there is a will to work. There is considerable incentive for the country and the sugar industry to encourage young South Africans to seek employment in agriculture.

In these circumstances it is anomalous that there should be a strong trend towards mechanization in traditionally high labor-intensive fields such as mining and agriculture. In 1974 the gold mining industry announced a R90 million research program into new techniques of mechanization (Anon). Sales of tractors more powerful than 60 kW increased from 3 to 8% of the total tractor market from 1971 to 1976. Tractors of 150 kW are becoming a common sight on South African farms. Undoubtedly, mechanization may lead to outstanding increases in food production, but the particular situation demands the development of efficient labor-intensive techniques. Emulation of the super-mechanized farming systems of countries such as the USA and Australia, where agricultural labor is scarce, should not be done. Labor-intensive production methods do not however preclude the use of machinery. The optimum combination of labor and equipment should be considered.

Experience in many parts of the world has shown that sophisticated machinery is often introduced to developing countries without the precautions being taken to ensure that operators are adequately trained, that necessary after-sales maintenance will be carried out satisfactorily, and that the standard of management will be sufficient to keep the total system running well. Without these precautions being taken, the situation usually ends in disaster. It is easy to agree with Burleigh that the economic and social justifications for the use of combine harvesting systems in sugarcane are questionable since there is a large population of unemployed or underemployed laborers.

It must be accepted that manual cane cutting and loading is an onerous and arduous task. Experience in most overseas cane-growing countries indicates that no matter how high wages may rise, cane cutting will eventually become an unacceptable way of earning a living. Our steadily rising standards of education will make this development most likely to occur. Thus, despite the prospect of a large available labor force, it would be dangerous to rely on it entirely for the harvesting
of our sugarcane crop.

In 1973 it was decided at the Experiment Station to develop semi-mechanized, low-cost harvesting systems for the South African sugar industry. These systems were to be compatible with existing manual harvesting and handling methods, and were to provide mechanical alternatives for all facets of the harvesting operation. Additionally, they were to be applicable on slopes up to 30% and on fields not carefully prepared for mechanized operations. The machines would have to be simple enough to be handled and maintained by ordinary tractor drivers and mechanics. Only whostalk cutters were to be considered because practically all South African sugarcane is harvested and transported as whole stalks.

MACHINES DEVELOPED

Full descriptions of the various cutters that were developed can be found in Annual Reports of the Experiment Station from 1973/4 to 1978/9 and in papers by Pilcher and van der Merwe and by van der Merwe et al. In chronological order of development, these machines were:

Gobbler cane harvester

The intake of this machine is based on the chopper harvester principle so that recumbent cane can be accommodated. After topping, the cane is pushed forward and cut at the base. Instead of being chopped at this stage, the stalks are gripped at the butt end by special ejector rolls and thrown into a bin. The bin has a capacity of 200 kg of cane and this load is dropped as a loose bundle onto the ground for subsequent mechanical loading. This procedure eliminates the necessity for push-pilling. The machine has a low center of gravity and is side-mounted on a conventional tractor (Fig. 1). Two prototypes were built and tested in 1973 and 1974. Disposal of the bundles of cut cane from this side-mounted machine proved to be a problem, however, and it became necessary to consider adapting the Gobbler principle to a machine which straddled the row being cut. Further development of the Gobbler has been shelved pending the results of a number of other projects.

Sasec cane cutter

Various models of the Sasec cane cutter were developed from 1974 to 1977. This machine is side-mounted onto any agricultural tractor of 50 kW or more and is carried on the 3-point hitch (Fig. 2). The Sasec can be hitched or detached in a few minutes and the tractor can then be used for other duties. Cane is topped, base cut down and laid down in a 'sausage' windrow. Depending on row width and tractor wheel spacing, a complete field can be cut and the windrows of cane left for subsequent manual stacking, bundling or crosswindrowing. Latest modifications include a more reliable hydraulic drive to the base cutter which aids cutting
FIGURE 1. Gobbler cane harvester

FIGURE 2. Sasex cane cutter in its simplest form

In poorly prepared fields, the Sasex can handle recumbent burnt cane yielding up to 110 t/ha. Modifications are available to allow cutting of heavier, more recumbent cane.

Edgecombe cutter

The first prototype of the Edgecombe cutter was built in 1976 to overcome
the greatest shortcoming of the side-mounted Sasex. When operating on steep slopes or in unsuited row spacings the Sasex tended to run over cane which had already been cut. At first the Edgecombe was basically a Sasex mounted on the front of a tractor. In 1977 the machine was built on the rear of a two-wheel drive tractor with reversed controls (Fig. 3). During its development it was found that the croplifters, as used on some of the Sasex machines, were more of a hindrance than a help in a recumbent cane. These were removed and drums were fitted around the base cutter shafts. These did an excellent job of disentangling the cane and drawing the crop to the base cutters. The twin base cutters were driven hydraulically. Cane from two rows was topped, base-cut and left in a single ‘sausage’ windrow. Row spacings of 1.0 to 1.5 m could be accommodated. Because the Edgecombe machine straddled the cane rows, it could cut a cane face in any direction and was also able to open up a field without damaging any cane on either side of the machine. Heavy, recumbent burnt cane (up to 140 t/ha) can be handled and the Edgecombe can also cut fire breaks in green cane yielding up to 110 t/ha.

**FIGURE 3.** Edgecombe cane cutter

**Midway cutter**

This is another ‘sausage’ type machine developed in 1978 as a further option for growers whose requirements were not adequately met by the Sasex and the Edgecombe. The Edgecombe is a relatively complicated machine to build and the Sasex can only be used with certain row spacings, and where the crop is neither too heavy nor recumbent. The hydraulically driven base cutter of the Midway is mounted between the front and rear wheels of a tractor (Fig. 4). It has a rotating drum arrangement similar to that of the Edgecombe. The front right hand wheel of
the tractor was moved inwards by means of a spacer. The base cutter has an anti-
clockwise rotation and the 'sausage' is placed beneath the tractor. The operator has
an excellent view of the base cutter. The topper is mounted in front of the tractor
to allow for the installation of a bin in which to catch the tops. This innovation
could help to reduce considerably the amount of extraneous matter in consign-
ments of cane. Burnt recumbent cane yielding up to 130 t/ha can be handled by the
Midway.

The machines described thus far are all built into or attached to standard
wheeled agricultural tractors. Maintenance and repairs can be done in normal farm
workshops. Hydraulic pumps and motors are available on an exchange basis so that
any breakdowns should be of short duration.

Cutting rates will depend on field conditions. The Sasex and Midway cutters
are recommended for growers harvesting up to 100 tons per day. The Edgecombe
can handle 200 tons per day and can cut as much as 60 tons per operating hour. All
three machines can operate on slopes up to 30%.

FIGURE 4. Midway cane cutter

Plans of the Sasex, Edgecombe and Midway cutters are available to cane
growers. A number of engineering shops are prepared to build machines on order.

HARVESTING SYSTEMS

Manual cutting and stacking is the most common harvesting system being
used in South Africa. Self-loading trailers are used to pick up and transport stacks
of four to five tons to a transloading zone, or directly to the mill. This is a very flexible system with one self-loading trailer capable of handling 75 t/day. Each trailer and its crew is completely independent and can haul stacks when convenient without any assistance from other machines.

Manual cutting and windrowing with mechanical push-pile loading is popular in the Natal Midlands and Eastern Transvaal. As what happens in other countries, large quantities of soil are delivered with the cane to the mill when push-pile loading is practiced. Ash (soil) percent dry matter of pushpiled cane from a number of large estates was monitored in 1978. The average was 5.5% and individual samples exceeded 20%. A mechanical loading system entails the combination of a loader and a trailer. One cannot operate without the other and growers cutting 50 t/day or less may find that loader waiting time can be as much as 70% of the total time spent in the field.

Instead of mechanizing the loading operation, the cutting operation can be mechanized. The effort of retrieving the cane from the sausage windrows is less physically demanding than manual cutting if machines such as the Sasex, Edgecombe or Midway are used. Labor to perform this task should still be available therefore even when manual cane cutters are not.

Handling systems which include an increasing degree of mechanization are available to meet the demands caused by a dwindling labor supply. The systems listed in Table 1 were evaluated by the Experiment Station during 1977 and 1978 on our La Mercy Farm. Commercially grown cane was used in this project and it was harvested at rates between 50 and 100 tons per day. The variety was NCo 376 giving an average yield of 110 t/ha. It was planted in rows 1.5 m apart. The productivity shown in Table 1 for cane cut mechanically, may be compared with various averages for manually-cut cane in the South African industry. These are 2.7 t/man-day for cutting and stacking and 3.6 t/man-day for cutting and windrowing in the industry as a whole, and 4.5 and 6.0 t/man-day for the same two systems, respectively, under similar conditions on neighboring estates.

The labor requirements for the various semi-mechanized systems shown in Table 1 include all field personnel such as gleaners and loaders or assistants to the cutters but they exclude the machine operators themselves.

The first system comprised stacking the cane from the ‘sausage’ windrows manually. Tops and other extraneous matter which may have been in the windrows were thus generally left in the field. This resulted in the cleanest possible cane with a minimum of soil being delivered to the mill. Productivity was 7.5 tons/man-day.

By stacking mechanically from small manually prepared bundles, the productivity per man-day was increased to 9.8 tons in system 2. For this operation a loader of the ‘Bell’ type was required. This South African loader is extremely maneuverable and can stack cane more efficiently than normal slewing-type loaders.
Changing from self-loading to box-type trailers, and loading mechanically from manually prepared windrows, as in system 4, gave results similar to those obtained with system 2, viz 10 tons/man-day. Note that when dealing with recumbent cane, topping during windrowing was required to remove the tops missed by the topping device on the cutting machine (System 3). This reduced productivity to 6 tons per man-day.

By stacking mechanically with a Bell loader directly from the sausages, as was done in system 7, productivity was increased to 14.9 t/man-day. Again there was a reduction in productivity when manual topping or cleaning of stacks was required (Systems 5 and 6).

The final system to be evaluated was that of mechanical loading by Bell loader from the sausage into box trailers (System 8). While waiting for a trailer to return from the loading zone, the loader prepared 'windrows' of cane. This resulted

<table>
<thead>
<tr>
<th>System</th>
<th>tons/man-day</th>
</tr>
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<tbody>
<tr>
<td>Manual stacking, self-loading trailers</td>
<td>7.5</td>
</tr>
<tr>
<td>Foaming small bundles manually, mechanical stacking*, self loading trailers</td>
<td>9.8</td>
</tr>
<tr>
<td>Manual windrowing and topping**, mechanical loading into box trailers</td>
<td>6.0</td>
</tr>
<tr>
<td>Manual windrowing, mechanical loading into box trailers</td>
<td>10.0</td>
</tr>
<tr>
<td>Mechanical stacking* after manual topping**, in the sausage, self-loading trailers</td>
<td>6.2</td>
</tr>
<tr>
<td>Mechanical stacking*, some manual cleaning of stacks, self-loading trailers</td>
<td>11.7</td>
</tr>
<tr>
<td>Mechanical stacking*, self-loading trailers</td>
<td>14.9</td>
</tr>
<tr>
<td>Mechanical windrowing*, manual topping**, mechanical loading into box trailers</td>
<td>10.2</td>
</tr>
</tbody>
</table>

* by Bell loader
** large number of tops missed by mechanical topper due to lodged cane, removed by hand
in faster loading of the trailers without affecting the labor requirements. Productivity was 10.2 t/man-day. This included manual topping. Unfortunately this system could not be tested in erect cane. Had this been possible, the effect of manual topping on productivity could have been established. From experience gained when using the other systems, a production of 15 t/man-day can be expected if manual topping can be avoided.

DISCUSSION AND CONCLUSIONS

The harvesting systems discussed here are based on simple cane cutters which they provide a wide choice to growers who might be forced to reduce their labor requirements. All these systems are compatible with existing manual or semi-mechanized whostalk harvesting operations and the extent of mechanization can be left to the discretion of the grower.

Starting from the conventional system of cutting and stacking manually, a grower can mechanize by degrees, initially incorporating only a mechanical cutter. The transportation system does not need to be altered and productivity could be raised from 4.5 to 7.5 t/man-day (67%). If the availability of labor decreases further, the acquisition of a Bell type loader for mechanical stacking could be introduced to increase labor productivity to 14.9 t/man-day, while still retaining self-loading trailers.

The use of a mechanical cutter may increase labor productivity from 6 to 10 t/man-day (67%) for growers who cut and windrow the crop manually. This would not require a change of existing loaders and box trailers. For improvement on this system, a Bell type loader would be necessary for productivity to increase to 15 t/man-day.

The total harvesting cost per ton of sugarcane will depend on the tonnage harvested annually. For growers cutting less than 50 t/day, manual cutting and stacking (at 4.5 t/man-day) is still the cheapest harvesting system in South Africa today. If the cost of this system when harvesting 50 t/day is assumed to be 100 cents/ton, that of other alternatives would be:

(i) mechanical cutting (Sasex), manual stacking : 115 cents/ton
(ii) manual cutting and windrowing (6 t/man-day) : 133 cents/ton mechanical loading
(iii) mechanical cutting, mechanical loading or stacking (Bell) : 142 cents/ton

The cost of all of these semi-mechanized systems compares favorably with that of a fully mechanized chopper harvesting operation.
The South African sugar industry is presently in a favorable position. Labor willing to harvest sugarcane is plentiful and while it is available, manual harvesting should be practiced. Semi-mechanized harvesting systems, based on cutters developed by the Experiment Station, may be used to compensate for any shortfall in labor that might occur in the future.

REFERENCES

SISTEMAS SEMI-MECANIZADOS PARA COSECHA DE CAÑA DE AZÚCAR EN UN PAÍS EN DESARROLLO

A. G. de Beer

RESUMEN

Actualmente la población de países en desarrollo aumenta a un ritmo de 2.1% anualmente. Muchos de estos países ya se están enfrentando a un gran aumento en desempleo. El crecimiento de GDP para la mayoría de países en desarrollo, incluyendo África del Sur, es muy bajo para rectificar notablemente la situación existente de desempleo con pocas esperanzas de mejoramiento para el futuro aumento en población. Debemos hacer todo lo posible para aumentar las oportunidades de empleo, especialmente en las áreas rurales de estos países.

La cosecha manual de caña de azúcar se hará menos atractiva a la clase obrera por varias razones. Por lo tanto, debe haber disponibles alternativas mecánicas para cuando la mano de obra se haga más escasa. Sin embargo, estos países en desarrollo deben esforzarse en lograr una combinación de labor y equipo apropiada para su situación en particular en vez de tratar sistemas de agricultura totalmente mecanizados.

Con este fin la Estación Experimental de SASA ha desarrollado varias cortadoras de caña las cuales, al ser integradas a sistemas de manejo de caña apropiadas, permitirán un aumento gradual de mecanización. El diseño de todas estas máquinas es sencillo. Su mantenimiento y operación están muy al alcance de las habilidades de operadores de tractores no diestros. Se ha evaluado un número de sistemas de cosecha semi-mecanizada incorporando estas cortadoras. Se puede aumentar la productividad laboral de 4.5 a 15.0 T/obrero-día. Los costos de cosecha pueden mantenerse razonablemente bajos, y en la situación actual de África del Sur deben ser aun mucho más bajos que los de un sistema de cosecha totalmente mecanizado.