THE DEVELOPMENT OF A SIMPLE CANE CUTTER

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Abstract

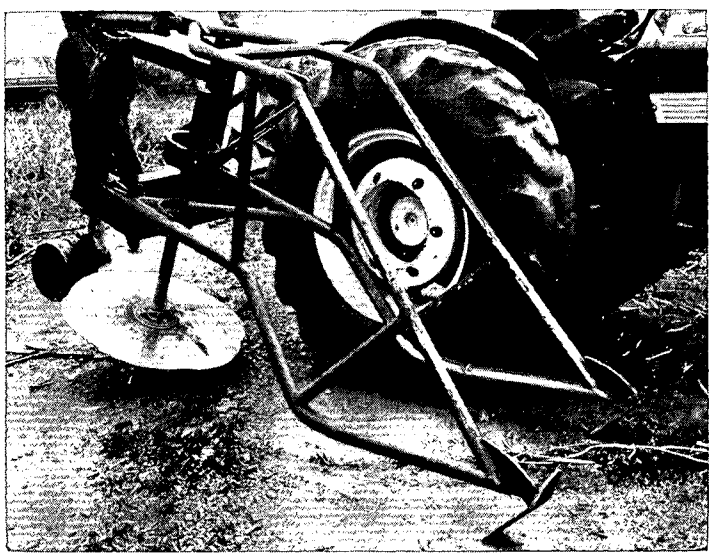
The evolution of the Sasex cutter for the whole stalk sugarcane is discussed. The original concept was a very simple machine known as the "Cane Sny". From this was developed an economical cane cutter able to operate under a wide range of conditions. It is claimed that the Sasex can significantly reduce harvesting costs and labour requirements.

Introduction

The concept of the Sasex Cane Cutters, which are the subject of this paper, originated from a machine known as the "Cane Sny". This machine was designed by Mr. Frans Snyman of Nkwaleni and further developed on the Riversbend Sugar and Citrus Estates.

When the Cane Sny was first inspected in mid-1974 it was extremely simple. The machine was mounted on the three-point linkage of a tractor, with the base cutter set out beyond the right hand rear tractor wheel. The main frame of the machine comprised a random selection of channels and angles and the cane gathering frame was of tubular steel, being lifted for transport by an hydraulic ram.

The base cutter was a 61 cm diameter scalloped harrow disc mounted on a 51 mm shaft which was carried in plummer block bearings and driven by 4 Beta Vee belts through a Massey Ferguson PTO-driven belt-pulley gearbox.



CANE SNY Cutter after fitting of depth wheel.

The machine was intended to cut only burnt cane and in straight cane it showed great promise, leaving the cane in what might be described as a continuous "sausage".

One of the simplest aspects of sugarcane harvesting is the actual cutting (base cutting) of the stalk at ground level. The difficulty is what to do with the cane once it has been cut, and how this should be done. There are several alternatives. At one end of the scale is the simple cutter which allows the cane to fall whichever way it will, necessitating removal of the cane by hand before the next row can be cut. At the other end is the sophisticated chopper harvester which loads the cane directly into a trailer, thereby involving an absolute minimum of manpower.

Between these extremes are machines such as the McConnel, which leaves the cane in a sausage for subsequent manhandling into windrows (with up to eight rows going into one windrow), or for building into stacks. There are also whole stalk soldier-type harvesters such as the Cameco which will place five cut rows into one windrow. Unfortunately, the soldier-type machines handle only very straight cane at all well, whereas the McConnel will cope with sprawled and fallen cane.

It should be possible to design a machine which could windrow each row singly, but this would mean push-piling every row, or at best every two rows if manual labour were used to pull the second row into line with the first. Excessive push-piling is undesirable, chiefly because it increases the danger of soil inclusion. Such a machine would have more than a minimum of moving parts and its use would almost certainly be confined to the cutting of straight cane. It should also be possible to design a machine to make bundles of 300 to 500 kg for subsequent handling by loader, but such a machine is likely to be fairly complicated and therefore expensive.

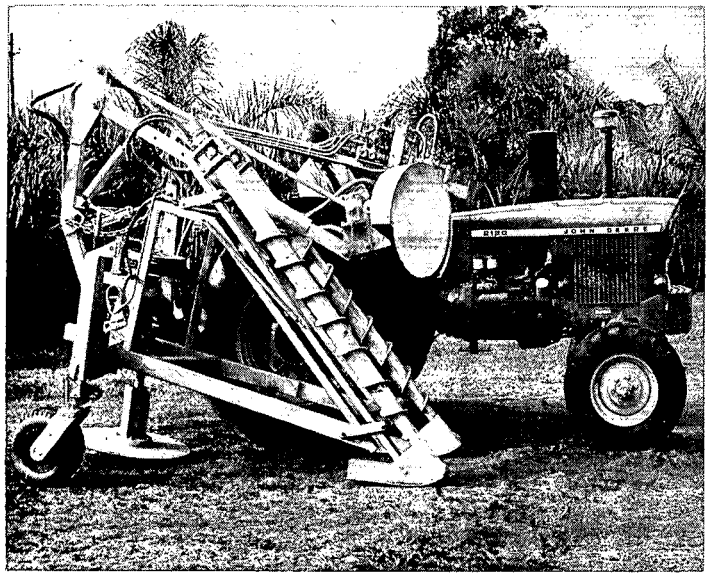
The concept of the sausage was pioneered by McConnel and it apparently reduced labour requirements by 50 to 60% when compared with hand cutting. As a task, one labourer was able to windrow 10 tons of cane per day from the sausage and, in Swaziland, this is now being done in as little as three hours by some women. At the present stage of the industry it was thought that a reduction of this size in labour requirement might be more acceptable than its complete elimination.

After consideration of all these factors, it was decided that the concept of the Cane Sny, suitably extended, offered an opportunity to design a cheap cane cutter as an implement for a tractor, attachable and detachable as easily as a plough, which would avoid the necessity of buying a tractor expressly for cane cutting. It was believed that this consideration would be more attractive to the small grower than to estates. The machine must have a topper and should be capable of cutting lodged, or at least partly lodged, as well as straight cane. It should be capable of operating on hillsides.

Fitting a depth wheel and trying different base cutters on the Cane Sny occupied some time, but it was soon realised that the only way to develop the concept would be to build a new machine incorporating all the features which brief acquaintance with the Cane Sny indicated would be necessary. These included such items as a depth wheel, a larger diameter base cutter, a longer top link to give a vertical lift to the implement, powered crop lifters with a greater width at entry, provision of a topper, increasing the width of the machine and making it fold for transport. Thus Sasex I was built in an attempt at combining all the features thought to be desirable.

Sasex I

Sasex I had a main frame made of 152 x 76 mm RS channels welded toe to toe to form a 152 x 152 box section. This was hinged behind the right hand tractor wheel so that the whole machine could fold up behind the tractor for transport. The considerable overall width of side mounted machines had caused trouble on narrow farm roads and even when travelling on national roads. Hinging the beam overcame this problem.



SASEX I Cane cutter.

Initially, a 750 mm diameter plough disc mounted on a 65 mm diameter shaft was used as a base cutter and this was vee belt driven by 6 Beta Section belts from a layshaft formed of an extension of the hinge pin. A 25,4 mm duplex chain drove the layshaft from an MF belt pulley right angle drive gearbox driven by the PTO.

The crop lifters were made from 101 mm NB pipe tapered at the lower end. Three lengths of 9 mm round bar were welded on top of each other to form a spiral around the pipe. The crop lifters were driven by Ross MAC 06 Hydraulic motors, through a Reynolds chain coupling. The two crop lifters were mounted on a tubular steel frame which was hinged to the beam at the bottom and attached to a ram at the top, the latter being used to pick up the whole assembly for transport and manoeuvring.

The topper comprised a 76 x 25,4 mm flat bar with a mower section bolted to each end. The whole was mounted on a horizontal shaft driven at about 1500 rpm by a gear-type hydraulic motor. A plate was mounted in front of the topper rotor in such a way that only the bottom blade actually cut the cane. An interesting observation made in connection with these blades was that, if they were attached with the bevel upwards, they would bend downwards and break but, with the bevel on the under side, no problems were experienced. To determine the optimum position for the topper in relation to the base cutter the supporting arm was made telescopic to allow for testing in various positions.

The depth wheel was mounted at the end of the beam and ran in the interrow, just behind and to the right of the base cutter. The wheel was designed to caster, and was made from two 8 x 4-inch (203 x 101 mm) wheels. As a depth wheel it worked well enough but there were other problems associated with it which will be discussed later.

The machine was much too heavy and after a while the hydraulics of the Ford 5000 on which it was mounted were showing signs of stress. In addition, the very considerable overhung load was damaging or threatening to damage the lift arms. Because it was so heavy, another caster wheel had to be provided, fitting between the crop lifter arms, to support that end of the machine in order to transport it in the folded position. Although the wheel assembly itself was easy to attach, the ram controlling the crop lifter frame was too short and could not lift the frame high enough to facilitate attachment of the wheel. The machine therefore had to be backed over a donga to give extra clearance, or the top link had to be adjusted. This all proved very tedious.

A serious defect in the Cane Sny concerned the top link. Originally this machine had no depth control other than the tractor hydraulics and the top link was of a conventional length as when used with a plough or other normal implement. Utilising the hydraulics to lift the implement while operating actually caused it to tip forward initially, thereby digging the forward edge of the base cutter into the ground. This was overcome on the Sasex cutters by making the top link the same length as the lower links and parallel to them in a vertical plane, and thus achieving a vertical lift at the leading edge of the base cutter.

The hinge on the main beam was too flexible and resulted in variations in the tension of the 25,4 mm duplex chain drive. In order to run the hydraulic pump, the whole drive assembly had to be run and, as hydraulic power was required to operate the two rams, it had to be able to run in both the folded and unfolded positions. Unfortunately, in the folded position the topper mast fouled the tight side of the Vee Belt drive and a jockey pulley had to be fitted to deflect them.

It was found that, when the base cutter jammed, the belts would slip and, because they were horizontal, they would sometimes jump off.

The 750 mm diameter base cutter was still on the small size and required accurate driving if wide ratoons were to be completely cut. Six 6 mm mild steel blades, hardened underneath, were therefore welded on and these cut very well but required sharpening at least every two days, the interval depending on ground conditions. The plough disc cracked on a few occasions. Why a plough disc? Apart from the fact that the Cane Sny used one it seemed a good idea because plough discs could be purchased almost anywhere. A disadvantage of the conventional base cutter, comprising essentially a flat disc to which flat rectangular sections are bolted, is that the cane lying in the sausage behind the machine will be snicked by the blades at the back of the base cutter. The curvature of the plough disc satisfactorily overcame this problem.

The speed of the base cutter is considered to be an important factor in obtaining a clean cut and a blade tip speed of around 1 500 m/min seems to give the best results. This does, of course, result in a higher rate of wear of the blades but the life of these is quite good and they are relatively inexpensive.

The crop lifters were not effective in heavy, lodged cane and the small diameter, particularly at the bottom, encouraged weeds and trash to build up round them, which usually resulted in jamming. They were also underpowered.

The topper cut the tops off extremely effectively. Unfortunately the cut was so clean and easy that heavy tops were undeflected and built up in front of the topper until no tops were being cut at all. This problem was slightly alleviated by angling the topper 30° in the direction of blade travel and subsequently by fitting a thicker blade, which then knocked the tops sideways. A disadvantage with this type of topper is the tendency for each stick to be cut, or partially cut, several times. If the direction of rotation is towards the tractor, this and the driver become spattered with small chips of cane and, if it is in the opposite direction, the tops do not fall away as cleanly as one would like because of interference from the next row of standing cane.

The principle of depth control on both models of the Sasex has been that the harvester is set up so that the beam is parallel to the ground. The depth wheel is then adjusted to give the correct height of cut under average conditions, variations due to poor land preparation being catered for by manipulation of the tractor's hydraulics. The tractor must be in depth control. This system seems to work quite well.

The depth wheel should have good flotation properties. Because the depth wheel on Sasex I was mounted at the end of the beam (not in line with the tractor wheels) it was necessary for it to caster to avoid scuffing. Because castering takes a lot of space a small wheel was chosen and, to obtain additional flotation, two wheels were used. This caused a lot of trouble. The caster wheel assembly was now quite wide and the line of action from the pivot to the point of contact under the wheels varied by almost 45° on either side of centre. Thus, on uneven ground, the assembly would oscillate between extremes as first one wheel and then the other took the most weight. Furthermore, in wet conditions, trash and mud would build up between the wheels, forcing the tyres apart until, eventually, they would jam on the yoke and cease to rotate. Naturally both these phenomena resulted in side drag on the tractor, making the unit impossible to steer.

A problem with any side mounted machine of the type which leaves cane on the ground is the danger of running over the cane on the next pass. For certain row spacings on the flat no problem arises, but the Sasex was intended as a universal machine able to operate in burnt cane under a wide variety of conditions. On hillsides it was found that the sausage would slide sideways, compounding the problem in one direction but possibly alleviating it in the other.

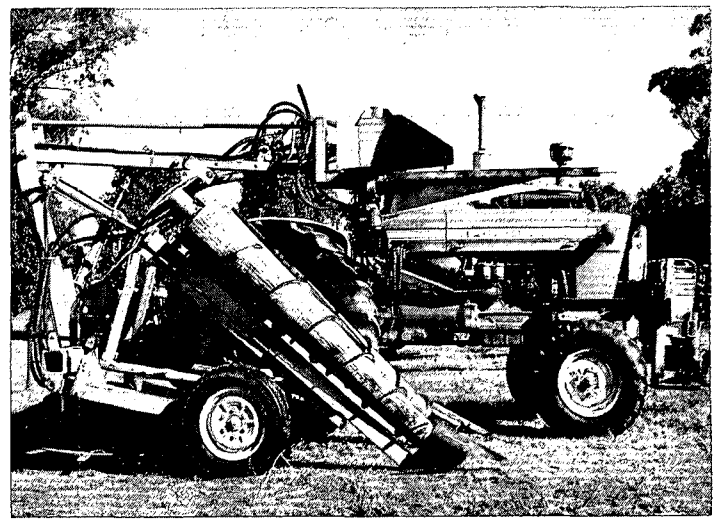
Since right-mounted machines necessarily work from left to right, the closer one could get the sausage to the left of the unit the sooner it would be out of the way on subsequent passes. The base cutter on Sasex I rotated clockwise, thereby placing the sausage on its right (the wrong side). Initially short rubber paddles were fitted to the base cutter shaft in an attempt at assisting the flow of the sausage backwards. However, these had the effect of moving the sausage even further to the right and they were subsequently removed.

Sasex I cut approximately 1 000 tons of cane and showed enough promise to justify building a second machine which would eliminate the major shortcomings of the first model. Improvements envisaged were concerned with the weight, the base cutter rotation, the crop lifter diameter and power, provision of a more efficient topper and elimination of castering depth wheels as well as of Vee Belt and chain drives, particularly horizontal ones.

Sasex II

Sasex II was built by using a 127 x 127 mm beam made up of channels welded toe to toe. A mistake was made here in putting the joint in the vertical plane instead of the horizontal. To save weight the left hand end of the beam was used as part of the oil tank, by which approximately 26 extra litres of capacity were gained, together with a good increase in surface area. However, the beam cracked, which resulted in oil leaks, partly because of its wrong orientation and partly because insufficient attention had been paid to the welding preparation. In addition, a small oil tank was used to save weight but there were no signs of overheating of the oil until a later stage, when a different pump was fitted to serve extra motors.

The crop lifters were tapered and made out of 1,5 mm steel plate. The pitch of the scrolls was varied in an effort to achieve a gradual initial lifting of fallen cane and an increase in lifting rate as it came up. The crop lifters were leant towards each other at the top in an effort to bring fallen cane into a suitable bunch to facilitate topping. The bunching worked so well that the top pitch of the scroll had to be removed because the cane was being held instead of being allowed to pass under the machine to form the sausage. In addition, all this unfortunately took place behind the topper, which could not be moved far enough back to chop the tops.



SASEX II Cane Cutter with sausage shifter.

The base cutter was again PTO driven, via a Massey Ferguson belt-pulley gearbox with a drive shaft incorporating a slip clutch of the audible type, into another gearbox and on into the base cutter shaft via a Nardi solid rubber coupling.

Whereas the base cutter shaft on the Sasex I was a simple shaft carried on two plummer block bearings spaced about 300 mm apart, that on Sasex II used a torpedo housing with a tapered roller bearing at top and bottom, which saved at least 300 mm in overall length. This was important in avoiding too great an angle in the drive shaft universals.

This change produced a problem which was never encountered in Sasex I. The fact that, on the latter, the base cutter shaft was rotating discouraged cane stalks from passing on the wrong side of the shaft, which would inevitably have caused blockage. With Sasex II blockages occurred in exactly this manner, especially in fallen or crooked cane. A deflector plate was therefore fitted, running from the base cutter shaft forwards at 45°. It was later extended straight forward up to the depth wheel. Such deflectors satisfactorily overcame the problem of blockages due to cane passing on the wrong side of the base cutter shaft, and the machine performed extremely well in straight or slightly lodged cane.

In severely lodged cane, whilst the crop lifters very effectively picked it up and straightened it out, there was a very definite reluctance on the part of a sausage of curly sticks to pass through the machine and an occasional blockage occurred. A rotating element was therefore fitted round the base cutter shaft and a second shaft with rubber flippers was provided on the other side of the sausage. These changes appear to have overcome the problem. The second shaft is hydraulically driven from an additional pump.

The new topper comprised two horizontal rotating discs made from circular saw blanks which just overlapped and formed what might be described as continuous scissors. The discs were machined at 15° to give a fine edge and later small nicks were ground into the cutting edges to improve their bite on the cane. Impellers were mounted above the discs to deflect the tops. This topper worked extremely well from the outset, but a recent improvement was to use 400 mm discs which increased the width of the throat and reduced the tendency, in heavy tops, for the cane to be pushed forwards.

The crop lifters were themselves mounted on a sliding door beam which ran on matched rollers bolted to the crop lifter framework. The framework itself was very much lighter than that on Sasex I but trouble caused by breakage of the sliding

door gear attachment bolts was expected. So far this has been one of the few things which have not given trouble.

The depth wheel on Sasex II is in line with the tractor wheel and therefore does not have to caster. A 185 x 14 SR pneumatic tyre is used.

The controls for the Sasex are mounted on an arm which is welded to the beam, and are located at the driver's right hand above the mudguard. Only three control valves and two flow dividers are used on the basic machine. The flow dividers, once adjusted, are very rarely altered in the field. One control valve is used for on/off switching of the topper and crop lifters, one for topper height and one for the height of the crop lifter frame.

Miscellaneous problems

Structural: The gearbox mounting and top link lug bracket is not strong enough and tends to crack off the beam. The drawings have been modified and there should be no further trouble. Similarly, the attachment of the topper mast and control arm needs modification and again the drawings have been altered.

Weeds: Trouble has been experienced, in bad burns, with weeds clogging the gap between the base cutter and deflectors, and a coulter wheel has now been mounted on the crop lifter frame which effectively cuts the weeds and has overcome the problem.

Slopes: On hillsides above about 12° there is a tendency for the tractor to slide off the row. The effect is more pronounced when the harvester is below the tractor but can be overcome quite well by the use of the brakes. A 4 WD tractor would probably overcome this difficulty and the machine might then be used up to about 18°.

Row spacing: No trouble is experienced, as far as running over the sausage is concerned, on row spacings of 1,4 m and above. A row spacing of 1,2 m on level lands can also be handled but, on a slope, the sausage will be trampled in one direction. At row spacings less than 1,2 m, the sausage will be trampled under most conditions.

Since a great deal of cane is grown on less than 1,2 m centres, a rotating device (sausage shifter), has been designed, mounted on the front of the tractor, to shift the sausage sideways out of the way of the tractor LHS wheels. This works quite well and should enable the machine to be used in the Midlands. However, row spacings of less than 1,1 m are still a problem with side mounted machines.

Coupling: One of the features of the Sasex is that it can be detached from a tractor as quickly as a plough so that the tractor may be used for other purposes. The addition of the sausage shifter, as fitted to our tractor, has to some extent nullified this feature. It has also required a new pump and has led to overheating of the hydraulic oil when the original small tank has been used.

Green cane: Although it was never intended to do so, it has been found that the Sasex II is able to cut fairly straight plant green cane extremely well. The addition of the extra drive rollers and rotating element on the base cutter shaft is probably responsible for this. In ratoon green cane preliminary trials have so far been less encouraging, but the reasons for this are not obvious. The effect of pulling the cane from the sausage, top end first, is to strip much of the trash off the cane. In any case, the trash left on the cane is no more than that usually left nowadays by a manual cutter. Some varieties strip more readily than others so a varying degree of cleanliness will be achieved.

Conclusion

Results of tests indicate that the Sasex II offers a relatively inexpensive method of cutting cane, particularly when burnt. The machine is as manoeuvrable as the tractor on which it is mounted and its width provides stability on slopes. There is a limitation caused by narrow row spacing but this can largely be overcome by the addition of the sausage shifter. Under good conditions the machine has cut at 40 tons per hour, over two consecutive 8-hour periods, in very light cane (about 60 tons/hectare). Under conditions of heavier cane it should improve on this performance. Its ease of detachment from the tractor should enable an average grower to cut his daily quota in the morning and cart it with the same tractor in the afternoon.

The farmer who can guarantee predominantly straight cane would not require the crop lifters or, in burnt cane, the additional feed rollers and rotating element on the base cutter shaft. Provided farm roads were wide enough there would be no need for the hinge on the beam.

The use of the Sasex should significantly reduce the quantity and quality of labour required, since women and teenagers can be used to arrange the sausage into windrows (preferably at least 5 rows into 1) or build stacks, according to the farming method employed.

An interesting point which was observed during the development of the Sasex II was that it would perform very adequately on one farm but, when it was taken to another, a different set of conditions would apply and all sorts of new problems would arise. It would be a fairly simple matter to design a machine to work on one particular farm. Attempts have been made to make the machine reasonably versatile, but to build a machine to cater for all conditions would not be economic.

Whither in the future?

We do not believe that much more development is worth while on a side mounted machine which has a major row spacing limitation, coupled on occasion with side draught, particularly in badly lodged cane.

We do believe, however, that leaving a sausage of cane on the ground would not be such a bad thing, particularly for the small farmer (for whom the machine is designed) because he would always have a nucleus of labour on the farm for planting, weeding and other miscellaneous duties who, with or without their families, could handle the sausage. At daily outputs of over, say, 100 tons there might be merit in mechanising more fully.

It appears, therefore, that an in-line machine of modular construction, which could cut all row spacings down to, say, 1,1 m with single row operation or less than 0,9 m with 2 row operation, would have a place in the industry. Such a machine would be front mounted and could be even cheaper than the Sasex II. It is on the design of such a machine that the Experiment Station is now engaged.

Acknowledgements

A difficulty experienced by the Experiment Station in developing machinery is that it does not have cane of its own to cut. We hope that this will be resolved during the coming season now that La Mercy farm is starting cane production.

We had, therefore, to ask farmers to co-operate and, in this connection, we should particularly like to thank Natal Estates who, as a rule, see machines only in their infancy, when they cause the most trouble and perform badly. We can only have been a nuisance to them. We should also like to thank Ken Gordon of Figtree at Hillcrest and Henry Harris at Umbumbulu on whose farms most of the development work on Sasex II has taken place. Riversband Sugar and Citrus Estates are also thanked for their tolerance of Sasex I.

Development is a frustrating business for both ourselves and the farmer. For him because, when conditions do not suit the machine, we want to make modifications and for us because, when we have made the change, there is no longer any suitable cane on which to try it out. One can only find out the weak points after hours of working under different conditions and the only way to achieve this is to cut cane commercially.

It would be very desirable to try the machine in the heavy irrigated cane of Swaziland or the Eastern Transvaal. Even La Mercy farm will not provide all the answers. We shall still want to try the narrow row spacing of the Midlands as well as heavy cane elsewhere, and we shall still have to rely heavily on farmers for their co-operation.