AN ECONOMICAL MECHANICAL FRONT-MOUNTED CANE CUTTER FOR TRACTORS

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Key words: cane cutter, automatic height control, base cutter control, harvesting

ABSTRACT

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 litres 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 cutting. This allows the tractor operator to devote his attention to driving and makes cane cutting 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. One of the advantages of this implement is that, when locked in the raised position, it fits neatly onto the front of the tractor, making the tractor available for any other task on the farm.

INTRODUCTION

Since the beginning of the SASA Experiment Station's mechanical harvesting project in 1974, a number of machines have been designed, built and developed. Two approaches to mechanical sugarcane harvesting were considered. One was a "total" harvesting system where the sugarcane would be cut mechanically and prepared either as chopped billets or as whole-stalk (usually in bundles) for subsequent mechanical loading onto infield trailers. The second was a labour assisting system whereby the cane would be cut mechanically with whole-stalks placed into windrows. Labourers would then make 4 to 5 ton stacks for self-loading trailers, or bundles of approximately 200 kg for mechanical loading into basket trailers. For cane growers choosing to load mechanically, a topping device has been developed which allows topping of the bundled cane while it is being loaded into trailers.

By the end of 1985 labour was still available to cut cane by hand, but the costs had risen and were continuing to rise. Experience with various harvesting systems had shown that by cutting cane mechanically, using fewer better trained labourers to handle the cut cane, the same or increased production rates could be achieved at a cost similar to that of manual harvesting.

The windrow cutting machines that had been developed were not economic for small growes (2000 - 6000 ton/annum), so a new cutter was developed that, even when mounted permanently on a tractor, still allowed the tractor to perform other farm duties when not being used for cane cutting (see Fig 1.) The base cutting unit is mounted centrally in front of the tractor's radiator. It consists of two frames, one of which is fixed to the front of the tractor in place of the standard weight frame, and the other is attached to the base cutter assembly. The two frames are connected by parallel arms on each side of the tractor. An hydraulic cylinder between the two frames lowers and raises the base

Figure 1. Front End Cutter

cutter-assembly. Due to the unequal length of the arms, the leading edge of the base-cutter disc is raised during lifting. At maximum lift the leading edge is pointing upwards, giving adequate clearance of obstacles.
In the fully raised position the base-cutter assembly rests very close to the radiator grill, where it can be locked.

AUTOMATIC GROUND FOLLOWING

The development of a relatively inexpensive automatic height control for base-cutters made it practical to attach a cane cutting implement to the front of agricultural tractors of 50 kW or larger, depending on the production rate required. The design of automatic ground following systems was discussed by Boast[1] who concluded that further development was necessary. From an improved version of the SASEX base cutting assembly (Pilcher and van der Merwe[3]) and hydraulic system pressures that were measured during the cutting operation, an improved and compact control unit was designed. The important part of the system is an oil pressure intensifier (Fig 2). Two connected pistons of different diameters move in a stepped diameter cylinder, permitting different pressures on the two ends to be in balance, the area of the larger piston being 2.44 times that of the smaller piston.
The system was designed to carter for speeds between 3 and 5 km/h. The quality of base cutting decreases at speeds over 5 km/h because forward speed relative to base cutter blade speed becomes excessive, and damage to the butts of the stalks is caused. Conversely, a speed of less than 3 km/h is regarded as impractical because of low productivity. Table 1 shows the system pressure when cane which is growing on a medium loam soil is cut with a SASEX base cutter, travelling at 3 to 5 km/h. Cane yields of 80, 100 and 120 t/ha were studied. Hydraulic system pressure whilst cutting cane above ground level changed according to tractor speed and yield of cane. Blade contact with the ground

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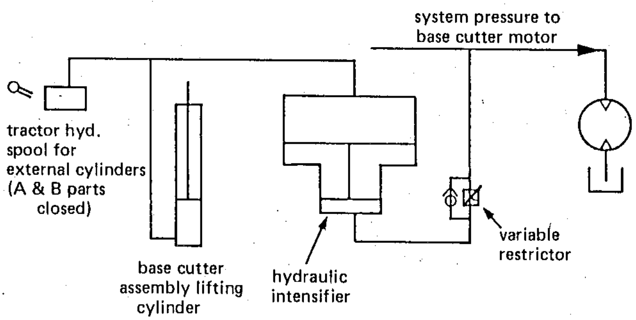

Figure 2. Hydraulic circuit for automatic base cutter height control

and different soil types would also affect the system pressure. For the best quality of base cutting it was found to be desirable to have the blade just make contact with the ground. It is evident that system pressures change constantly during the cutting operation, hence a range of conditions has to be accepted if the automatic height control unit is to be used. These are:

(a) speed to average between 3 and 5 km/h

(b) up to 20 mm of stubble may be left over short distances (10 metres)

(c) up to 10 mm soil penetration may be permitted over short distances (10 metres). The ideal is 2 to 3 mm.

The best friction pressure for the Sasex base cutter is 2 MPa which occurs when the blades penetrate 2 to 3 mm into a medium loam soil (see Table 1). The downward force depends on the mass of the base cutter assembly. When conditions are not within acceptable limits this force can be altered by adding or subtracting weights from the frame of the implement to alter the range of the intensifier pressures.

Table 1 - Relatioships between speed, cane yield and hydraulic pressures when cutting burnt cane

Speed km/h	Cutting pressure MPa at t/ha			Ideal friction pressure at t/ha MPa			Controlled total pressure at t/ha MPa			Balancing lift pressure at t/ha MPa			Lift pressure at Kg added		
	80	100	120	80	100	120	80	100	120	80	100	120	0	60	90
3	5	7	9	2	2	2	7	9	11	2.9	3.8	4.6	3.8	4.4	5.0
3.5	5.5	7.5	9.5	2	2	2	7.5	9.5	11.5	3.1	3.9	4.8	3.8	4.4	5.0
4	6	8	10	2	2	2	8	10	12	3.3	4.2	5.2	3.8	4.4	5.0
4.5	6.5	8.5	10.5	2	2	2	8.5	10.5	12.5	3.5	4.4	5.2	3.8	4.4	5.0
5	7	9	11	2	2	2	9	11	13	3.8	4.6	5.4	3.8	4.4	5.0

When unburnt cane is cut the system pressure relief needs to be set at 25 MPa. In Table 2 examples are given of what happens to system pressure when a single parameter changes. Fig 3 and Table 3 are derived from Table 1 and can be used as a guide for the operator provided he knows the speed range of the tractor's gearbox.

Example (using Fig 3 and with 60 kg added)

If the cane yield estimate is 90 to 110 t/ha, then:

- the 90 t/ha line cuts the 60 kg line at 5.5 km/h

Table 2 - Effect on cutting and friction pressures for various cane yields, soil types and cutting speeds with no weight added

Yield t/ha	Soil type	Speed Km/h	Cutting pressure MPa	Friction pressure Mpa	Comment
80	Medium	3	5	4	Excess penetration, increase speed
100	Medium	3	7	2	Established balanced pressures
100	Heavy	3	7	2	No change necessary
100	Light	3	7	2	Excess penetration, increase speed
120	Medium	3	9	0	Stubble is left. Decrease speed or add weight
120	Light	3	9	0	Stubble is left. Decrease speed or add weight
80	Medium	5	7	2	Established balanced pressures
100	Medium	5	9	0	Stubble is left. Decrease speed or add weight
100	Light	5	9	0	Stubble is left. Decrease speed, do not add weight

Table 3 - Limits according to Fig 3 with 60 kg added

Cane Yield t/ha	Tractor Speed km/h
120	0.5 - 3.0
110	1.5 - 4.0
100	2.5 - 5.0
90	3.5 - 6.0
80	4.5 - 7.0
70	5.5 - 8.0

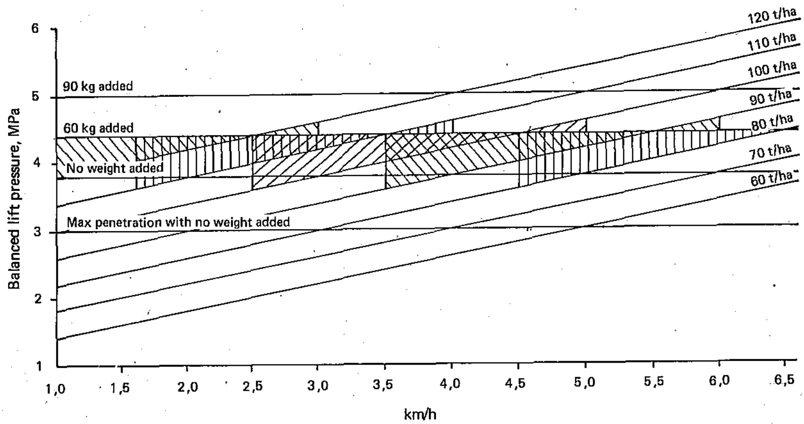

Figure 3. Relationship between weight added, cutting speed and cane yield for burnt cane

Shaded areas show the position of the blades relative to ground level when 60 kg are added, eg for a crop yielding 110 t/ha, the blades would be in balance when the speed is 3.5 km/h. At higher speeds the blades float, but the height above ground level should not exceed 3 mm, equivalent to 4.1 km/h. Similarly, the blades should not penetrate more than 13 mm into the ground, equivalent to a speed of 1.6 km/h.

- the 110 t/ha line cuts the 60 kg line at 3.5 km/h
  The average is 4.5 km/h

or

If the average yield is 100 t/ha, the 100 t/ha line cuts the 60 kg line at 4.5 km/h.
The average is 4.5 km/h
Therefore the average speed required to operate successfully in cane yielding 90 to 110 t/ha is 4.5 km/h with 60 kg added.
If gears are such that it is not possible to travel at exactly 4.5 km/h, the gear providing the nearest speed below 4.5 km/h is selected. Yields above or below the estimated yield, say 120 t/ha and 80 t/ha, will cause the base cutter to leave stubble or penetrate deeper into the soil respectively.
To alleviate this problem a variable restrictor has been fitted to the system pressure line

to the intensifier. This allows instant response to lift but restricts the rate of return. The damping effect enables the height control to stabilize at an average operating depth, resulting in even cutting between stools which are as far as 500 mm apart, and where soil conditions change over a distance of 2 to 3 metres. When the base cutter makes contact with a large solid object such as a rock, the pressure surge causes an instant lift of 300 mm, and the restricted rate of return usually allows time for the obstruction to be negotiated before the base cutter again returns to its average cutting height.

When the weight that is added is sufficient for the heaviest yield that is likely to be encountered there will be adequate response to normal yield variation without any further adjustment to the implement. For the example given above, 80 to 120 ton/ha can be cut at 2,5 km/h (Fig 3 and Table 3).

In practice, the operator will select the best speed for the average field condition and if the estimate is incorrect, observation of the depth of cut will indicate the need to change gear. Increasing forward speed will reduce the depth of cut and vice versa. This change of speed should also be exercised if large areas within a field are above or below estimated yields. An experienced operator has no difficulty with adjustment. It has been found that on medium to heavy soils there is seldom penetration deeper than 10 mm.

Restrictions on height

Where cane yields are poor on light soils, base cutting depth becomes excessive. To prevent this happening the hydraulic lift cylinder is mounted in such a manner that the base cutter cannot penetrate deeper than 4 mm, and an adjustable stop is also fitted to adjust the cutting height to above ground level if required.

THE COOLING SYSTEM

Because the radiator is susceptible to clogging from trash, ash and other material, heating problems occurred. A high capacity radiator with larger fin apertures was fitted, as well as a reverse flow fan to blow through the radiator. Although no further overheating problems were experienced during the 1987 trial period, excessive flowering of the crop during the 1988 season caused overheating problems which affected the cutting rate considerably. Further investigation will have to be made to cure this problem. A large company operating a commercial machine found a solution by fitting an additional radiator behind the driver's seat, with cooling air supplied by a hydraulically driven fan. While not aesthetically pleasing this modification was effective.

PERFORMANCE

Many factors affect cutting rate and for the front end-cutter the data given in Table 4 illustrates this. Productivity in terms of tons/h varied according to factors such as yield, soil type, slope and weather. Often the most important factor was the length of row (Pellizzi *et al*[2]).

A reliable assessment of cutting rate can only be made over a season on a particular farm. The La Mercy farm field records (Table 5) indicated that an average cutting rate of 21 to 27 tons per hour could be expected.

Fuel consumption averaged just over 5 l/h. Records kept by a miller-cum-planter cutting 15 000 tons with a commerical version of the front-end cutter under similar conditions gave similar results.

COSTS

The ease with which the tractor can alternate between harvesting and any other task

Table 4 - Performance of cane cutter as affected by field conditions

Field	Area ha	Tons cane	Yield t/ha	Total op h	Field h	Tons/ op h	Fuel, litres	Fuel cons ℓ/h
A	2.9	185	64	4	3.8	46	25	6.3
B	5.6	392	70	14.3	13.8	27	91	6.3
C	3	135	45	7.6	7.4	17	40	5.3
D	2.9	255	88	6	5.6	42	34	5.6
E	0.9	61	68	3.1	2.9	19	13	4.2
F	2.2	118	54	2.1	2	56	13	6.1
G	5	295	59	13.4	12.6	22	61	4.5
H	1.5	79	53	4.6	4.3	17	31	6.7
I	2	108	54	3.6	3.4	30	16	4.4
J	2.4	134	56	9.4	8.4	14	58	6.1
K	1.8	102	57	6.3	5.9	16	41	6.5
L	4.8	206	43	8.8	7.9	26	39	4.4

Table 5 - Field records - harvesting only

Season	Average cane yield t/ha	Tons cut	Operating hours	Cutting rate t/h	Average fuel consuption ℓ/h
1987/88	102	3 000	110	27	5,1
1988/89	69	9 390	443	21	5,4

ensures maximum use of the most expensive component, the tractor. This results in a relatively low hourly cost, making mechanical cutting economic for many cane growers. Over a six month period during the 1988/89 harvesting season the tractor operated for 762 hours, of which 443 were spent on cane cutting (Table 6). These results indicate that when working on a farm where about 14 000 tons of cane are harvested per year, the tractor should operate for 1 500 hours in total, including 700 hours for cutting. Base cutter blades were replaced after every 1 200 tons of cane cut.

Table 6 - Operating hours for various tasks during a six month period in 1988/89

	Harvesting	Cane haulage	Grass slashing	Labour transport	Land Planing	Quarry hauling	Dising	Herbicide spraying	Total
Operating hours	443	153	108	29	24	2	1	2	762

CONCLUSION

The front-end cutter is a simple, low maintenance machine suitable for most cane growers. One such machine cutting an average of 20 tons per hour, would be able to cut up to 30 000 tons per annum at a very competitive cost. For smaller annual tonnages the tractor can be used for other tasks, again resulting in reasonable costs for cutting.
When cutting on a regular basis, attention to tractor engine cooling and cleaning of

inlet air will be required, and some modification will be necessary. For extended use as a cutter, operator comfort will be an important consideration, and items such as a pressurized and cooled cab may be indicated.
The success of this cane cutting aid is based on the automatic ground-following base cutter. Without this innovation the front mounted cutter would not be a practical proposition.

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UN SYSTÈME ÉCONOMIQUE DE COUTEAU MÉCANIQUE FIXÉ À L'AVANT DES TRACTEURS POUR LA RÉCOLE DE LA CANNE

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Mots-clés: couteau pour la canne, contrôle automatique de la hauteur, contrôle du couteau pour la coupe à la base, récolte.

EXTRAIT

Un couteau mécanique qui coupe la canne à sa base e été produit pour être fixé à l'avant des tracteurs agricoles d'une puissance de 50 kW. Le couteau est actionné hydrauliquement par une pompe couplée à la poulie de l'arbre vilebrequin avant ou à l'axe de prise de force arrière, dépendant du modèle du tracteur. L'huile hydraulique du tracteur est utilisée mais ele est augmentée de 50 litres provenant d'un réservoir externe. Alternativement, tout l'huile peut être fournie par un réservoir fixé sur l'attelage du tracteur.
Le cocteau opère automatiquement aussitôt qu'il est abaissé jusqu'au niveau du sol. L'ajustement automatique du niveau se fait au moyen d'un cylindre à pression amplifiant qui contrôle le niveau auquel le couteau coupe la base de la canne en fonction de la résistance rencontrée. Cela permet à l'opérateur de consacrer son attention à la conduite du tracteur et rend donc la récolte plus facile. Sans ajustement automatique de la hauteur, un couteau qui coupe les tiges à leur base et qui est fixé devant les roues avant d'un tracteur ne donnerait pas de résultat satisfaisant.
Un des avantages de cet outil est qu'il s'adapte exactement à l'avant du tracteur quand il est relevé, rendant ainsi ce dernier disponible pour d'autres tâches sur la ferme.

UN ADITAMENTO CORTADOR DE CAÑA DE AZUCAR DE BAJO COSTO

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Palabras clave: Aditamento cortador de caña de azúcar, Control automático de la altura de corte, Control de La cuchilla, Cosecha.

RESUMEN

Se ha desarrollado un aditamento frontal para el corte de caña de azúcar, que se puede montar en un tractor agrícola de la categoría de los 70 HP. La cuchilla es operada hidraulicamente mediante una bomba acoplada a la polea del cigueñal o a la toma de fuerza trasera, dependiendo del modelo del tractor. Se utiliza el sistema hidráulico del tractor, que puede ser aumentada su capacidad en unos 50 litros. Por otro lado, todo el aceite hidráulico puede ser suministrado desde un tanque montado sobre el enganche de 3 puntos.

La cuchilla opera automaticamente una vez bajada a nivel de la superficie del suelo y en posición de trabajo. Un cilindro de presión controla la altura de corte de acuerdo con la resistencia que se ejerce sobre la cuchilla. Así el tractorista puede concretarse exclusivamente a la guía, haciendo de ésta una operación muy sencilla. Sin este control de la altura de corte, sería inaceptable este aditamento.

Otra de las ventajas de este implemento cortador es que, una vez trancada la cuchilla en posición de descanso encaja perfectamente frente al tractor, el cuál puede utilizarse en otras labores agricolas.