CANE EXTRACTION SYSTEMS FOR STEEP TERRAIN

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Abstract

Six extraction systems, developed by sugarcane growers, are described. Maximum daily cane extraction rates and maximum practical slope limits are given for each system. It is concluded that the efficiency of traditional cane extraction systems can be improved and that dependence on manual labour can, if necessary, be reduced by mechanical loading on fields as steep as 50% and even steeper when manual stacking is possible.

Introduction

Various systems have been developed to extract cane efficiently from reasonably flat fields. If labour is available, traditional hand cutting and stacking is probably the most economical cane handling system for most private growers. To reduce dependence on labour mechanical loading and/or cutting can be introduced effectively. Slewing push-pile loaders give good results, but when slopes exceed 20%, their effectiveness is drastically reduced.

In South Africa, many hectares of cane are cultivated on slopes exceeding 25% which are beyond the capabilities of normal self-loading trailers or slewing loaders. On these steep slopes, cane has to be carried to stacks near an extraction road for loading onto self-loading trailers. A shortage of labour will thus affect operations on these steep areas first.

Private growers and estates on steep terrain have developed alternative extraction systems which are practical and economically viable. The Experiment Station evaluated some of these established systems and this paper is a report of the investigations.

Systems Evaluated

If labourers are available to stack cane but are reluctant to carry cane to an extraction road, two alternatives can be considered.

Ralfe self-loading trailer

The Ralfe trailer can be used as an ordinary self-loader in fields where slopes are less than 25%, where the trailer can be parked next to a cane stack, or the tractor can winch stacks down the slope to the trailer parked on a road in steeper fields.

Two conductors are required to assist the tractor driver when winching stacks down slope. One conductor remains in the field to pre-thread the next stack with an extra length of cable and to clear a path through the trash for the bundle to move down. Another length of cable is threaded from a capstan around a small roller in the centre of the trailer bed and connected to the cable already in position around the stack.

To prevent spillage the stacks must be neat. The technique and experience of the tractor driver are important. While dragging the stack down to the trailer it must be carefully watched and the winching rate adjusted to prevent the stack from rolling. Once the stack is close to the trailer, the first cable is disconnected and removed. The free end of the cable around the stack is threaded around a roller on a post on the far side of the trailer and taken from there back to the capstan. The bundle is then loaded conventionally. Once the stack is on the trailer, tension is maintained on the cable to allow two chains to be fitted around the stack.

At the loading zone the stack is unloaded by means of a hydraulically operated side-tipping mechanism on the trailer. Operating as an ordinary side-loader on flatter fields the performance of the Ralfe trailer, loading stacks averaging four tons each, was as follows :

	Time (min)	Time (%)
Arranging cables and chains on trailer and around stack	6,9	72
Winching time	2,7	28
	9,6	100

When winching stacks down slopes ranging from 27% to 65% and over distances of 17 m to 33 m, the following average times were recorded :

	Time (min)	Time (%)
Arranging cables and chains on trailer and around stack	9,5	60
Winching time	6,3	40
	15,8	100

If the distance from the field to loading zone is one kilometre and if bundles average four tons each, the output of a single Ralfe trailer should be 8 t/h, or 13 000 t/year on slopes exceeding 20%, and 12 t/h, or 20 000 t/year, on flatter slopes. Both burnt and trashed cane can be loaded.

Winch tractors with mascane trailers at Natal Estates

Two-wheel drive, 50 kW tractors are modified to winch cane stacks upslope to trailers. An hydraulic winch is powered by a pump mounted on the crankshaft of the engine, with a large rear-mounted hydraulic oil reservoir. The winch is mounted in front of the tractor on an extended subframe which carries the front axle and wheels. The winch is provided with an 80 m long, 15 mm diameter cable. The winch tractor has power steering and dual rear wheels to help with traction.

Bundles are stacked on chains and winched by the winch tractor onto tandem sets of mascane trailers, one bundle to a trailer. On very steep slopes the bundles can be pushed down by the winch tractor to a lower extraction road or can be winched up to 80 m up the slope. The haulage tractor and set of trailers remains on the extraction road.

Four "rampmen" and a driver are required to operate the system when loading more than 200 tons per day. The "rampmen" position skids at the sides of the trailers so that bundles can be dragged onto the trailer.

Maintenance costs of the winch tractor are high, but output is good and the cost per ton loaded should be reasonable. As the mascane trailers are simple devices, their running costs are low, compensating for that of the winch tractor. One winch tractor can normally keep up with four haulage tractors, each with two single bundle mascane trailers, hauling one kilometre to a loading zone.

When within 15 metres of the bundle, and on slopes ranging from 7% to 40%, the average time taken to load two bundles of average total mass of 7,9 tons, was 5,2 minutes.

Winching over longer distances required 0,11 minutes per metre while the time required to unwind the cable was 0,06 minutes per metre. Based on an average winch distance of 40 m, the output of a single winch tractor should be 48 tons per hour, or well over 350 tons per day (70 000 tons per season).

On slopes of less than 27%, and depending on field conditions, the haulage tractor would normally bring the trailers into the field and park next to the bundle to be loaded. On fields with slopes steeper than this, bundles must be winched to the trailers. On slopes over 60% only experienced drivers will be able to operate and then only when conditions are favourable.

This system can be used for burnt or trashed cane.

When manual stacking is to be eliminated, the following systems can be considered :

The Landers extraction system

All cane is burnt prior to cutting. Windrows about 25 m apart are formed downhill across the rows. Table 1 describes the loading system used on various slope categories. Extraction roads are built on the contour. Two Evans rear-loading trailers haul the cane an average distance of 1,8 km to a loading zone. A Bell loader used in the field has dual front tines, each with an hydraulic ram on the grab to reduce spillage. High-torque wheel motors and standard tractor rear wheels are used to improve performance.

The Landers handling system was observed in a field where the slope was 21% and the extraction roads about 65 m apart. The tractor and Evans trailer parked midway down the field between two windrows, having entered the field from the top access road. The trailer was tipped and the retrieving cable was pegged behind it. The Bell then fetched cane from both windrows, forming a stack against the upright trailer deck. Any cane left behind was gleaned by the person who made the windrows. Once the bundle was made, the tractor driver and an assistant fastened the chains, attached the retrieving cable and the trailer deck was winched to a horizontal position. The tractor and trailer then left the field via the bottom access road. Four people (excluding cutters or gleaners) were involved in this operation. They were the Bell operator, two tractor drivers and one field assistant. As shown in Table 2, the Bell loader was well matched to the two Evans trailers.

Average bundle size was 5,04 tons giving an extraction rate of 12,7 tons per hour or about 100 tons per eight hour day, equivalent to 20 000 tons per year.

TABLE 1

Landers loading systems used on various slopes

Category	Slope (%)	System
Normal	0–25	Cane loaded by Bell on trailers infield
Moderate ..	26–36	Bell loader brings cane to top or lower access road where second Bell loader loads it onto the trailers
Steep	37–50	Windrowed cane is bulldozed by Bell loader to the bottom access road where second Bell loader loads trailers
Very steep ..	more than 50	Cane is removed from the field by hand and loaded by Bell loader on access road

TABLE 2

Loading operation on 21% slope using the landers extraction system

Operation	Av. time (min.)	% of total time
Load from windrow	5,8	24,6
Travel to trailer	10,8	45,8
Stack against trailer	0,6	2,5
Winch stack on trailer	5,9	25,0
Wait for next trailer	0.5	2,1
Total:	23,6	100,0

On fields steeper than 36% the spacing between extraction roads was as narrow as 30 m. Two Bell loaders were required on these fields, one to push-pile cane down the windrows on to an access road and the second to load the push-piled cane on a rear-loading Evans trailer as described above. On fields as steep as this the trailer stayed on the extraction road. Whenever the quantity of cane became too great for push-piling, the loader would take a grabful and carry it down to the trailer. If conditions permitted this cane was placed directly on the trailer. Alternatively, the cane was dumped at the side of the road for the second loader. On average each 30 m windrow yielded 1,7 tons of cane.

On the fields where this operation was observed, the push-piling loader handled cane at a rate of 28 t per hour. Push-piling occupied 30% of the time, returning to the top of the windrows 23%, picking up the cane 37%, dumping the cane 7% and other travel 3%. Cane tended to spill from the push-piled bundles and necessitated repeated accumulation of small amounts of cane to give a grabful. This accounts for the large proportion of time taken to pick up cane.

Schmidt Estates system

Cane is cut unburnt. Six rows are formed into one windrow and consist of discrete heaps of cane of about 300 kg each. Having the cane in heaps instead of a continuous windrow expedites mechanical loading by Bell loaders and results in less trash being loaded. Tops and trash are placed in the space between windrows to be raked into a uniform mat subsequent to cane loading. Cane rows follow the contour and flat culture is practised.

Loading is done by two Bell loaders. A third is on standby for peak periods. The loaders are equipped with dual wheels for improved traction. Three eight-ton lorries and one five-ton tractor-trailer combination are loaded in-field and transport 280 tons of cane per day directly to the mill which is 10 km away. An old crawler tractor is available to assist the transport vehicles out of the field.

The transport vehicles approach from a ridge above the field. The vehicle travels down the field, across the cane rows to a position indicated by the crawler driver, who is the harvesting overseer. The vehicle is parked facing downhill and loaded from either side by the Bell loaders. The advantage of this system is that the Bell loaders operate mainly on the contour with limited movement up and down the slope. This improves the performance of the loaders quite considerably. The 300 kg heaps prepared by the cutters suit the grab capacity of the Bell well, and the whole pile can be lifted with one grab. When loaded, chains are put into position and then tightened by the crawler. The transport vehicles continue down the slope to a road in the valley. A cable from the crawler, hooked either to the rear, side or corner of the vehicle prevents it from turning over or running out of control.

Time taken to load the lorries with this system was as follows :

	Time (min)	Time (%)
Picking up a grabful of cane	7,6	32
Travel to lorry	7,6	32
Load into lorry	5,0	22
Travel back empty	3,3	14
	23,5	100

The average lorry payload was 8,9 tons, giving a potential loading capacity of 23 tons per hour per loader.

This system has been in operation for a number of years and works smoothly. When slopes exceed 36%, however, it is necessary to carry cane manually to an access road.

Dunlop system

The cutting system is similar to that of Schmidt Estates. Small bundles of unburnt cane are prepared for loading by a Bell loader. A 59 kW tractor and two rear-tipping trailers transport the cane to a loading zone. When the empty trailer returns from the zone, it is unhitched for loading and the full trailer is hitched to the tractor.

When fields are too steep for the tractor and trailer, the trailers are parked on a lower extraction road and loaded with cane from the panel above. The Bell loader has dual wheels with the tyres reversed to provide maximum traction when reversing up the slope to fetch cane. The average loading rate was 10 tons per hour on slopes up to 40%, and 56 tons per day were loaded in 6 hours. The trailers are 5,5 m long with sufficient capacity for 7,5 ton bundles. Bundles are chained for rear-tipping at the loading zone.

Galloway system

This cane handling system is similar to the Dunlop system but varies from it in the way the windrows are located. Windrows normally follow the contour but on fields steeper than 32% they are formed downhill, as with the Landers system. Where possible, trailers are loadel in the field, but on slopes greater than 25% trailers remain on the extraction roads.

Two tractors haul three rear-tipping trailers to a loading zone. Loads average 8,1 tons and in very wet fields four-wheel drive tractors are required.

Loading is by Bell loaders. Normally one loader handles the 114 ton per day allocation but on steeper fields a second Bell loader assists. According to the grower a single loader should handle 90 tons per eight hour day on terrain such as that found in the Doornkop area. The Bell loaders operate on slopes as steep as 42%. Cane from steeper slopes is normally carried down to extraction roads.

Applicability of the Systems

The conditions under which various cane extraction systems, including those reported in this study but excluding those where cane is carried manually to an extraction road, are applicable are summarized in Table 3. If manual stacking is feasible, slopes as steep as 70% can be accommodated. When manual stacking is no longer possible, special mechanical loaders, such as the Bell, can operate on 42% slopes in trashed fields and up to 50% when loading burnt cane. These limitations were established on fields not necessarily prepared for the machines, and it may well be possible to operate on even steeper slopes.

TABLE 3

Applicability of systems

System	Slope (%)	Burnt or trashed	Capacity (t/day)
With manual stacking:			
1 Self-loading trailers..	0 – 25	B & T	100/trailer
2 Ralfe trailer	0 – 65	B & T	65/trailer
3 Natal Estates	0 – 70	B & T	350/winch tractor
With mechanical loading:			
4 Slewing loader	0 – 20	B	200/loader (average)
5 Landers	0 – 25	B	100/loader
	26 – 50	B	100/two loaders
6 Schmidt Estate ..	0 – 36	B & T	140/loader
7 Dunlop & Galloway	0 – 42	B & T	90/loader

Conclusion

As a first step to improve extraction efficiency, farms should be planned with a network of extraction roads spaced at correct intervals. Banks next to extraction roads should be eliminated whenever possible and fields should be smoothed to improve the performace of loading and hauling machines.

It is clear that considerable scope exists to improve traditional cane extraction systems and, if necessary, to reduce dependence on manual labour on fields as steep as 50% by mechanical loading and even steeper slopes when manual stacking is possible.

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