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Alternative Cane to Mill Delivery Systems

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Abstract

The role of alternative sugarcane delivery systems represented in lorries and tractor-trailers equipped for cane to mill transportation have been increased because of problems that face the main system (decauvelle slide lines and wagons). Cane transported from fields to stores at the main asphalt roads at which lorries of variable sizes are loaded and travel to the mill. The use of tractor-trailers for direct transport of cane from fields to mill may have advantages specially at cane regions close to the sugar mill. Sugarcane delivery season start at January and last till May which lie within winter calendar, therefore actual full operational day is 10 hours and may be expanded for maximum two hours to complete a trip if necessary. Cane delivery by lorries and trailers was analyzed to determine delivery rate (ton/h) and transport rate (ton/day) as related to actual variation of vehicles capacity and location of fields in respect to the mill. Percentage of cane may be transported without delay either from stores or from fields was also determined.

Lorries of capacities from 8 to 16 tons loaded by labors delivered about 1.3 to 1.8 ton/h from stores as far as 50 km/h from the mill. In case of mechanical loading, a lorry of an average capacity 12 ton may deliver 3.7, 3.3, 2.9, 2.6 and 2.3 ton/h at store to mill distances 10, 20, 30, 40 and 50 Km respectively. In case of labor loading, an average size lorry (12 ton capacity) may travel two trips/day at store to mill distances up to 40 Km. Mechanically loaded 10 ton capacity lorries may travel 3 successive trips per day when store to mill distance was up to 40 Km and that of larger size may only complete two trips. To facilitate continuous operation of lorries and other system elements, enough cane should be ready in the store before start vehicle loading which may maximize the number of trips per day. Percentage of cane transported from field and delivered to the mill at the same day *(Q_t%)* was up to 35% and 28% in case manual and mechanical loading respectively.

Maximum field to mill distance at which the trailer pulled by tractor travel a successive trip within 10 hours may be 35 Km. At field to mill distances 15, 20 and 25 Km, cycle time was 6.5, 7.5 and 8.5 h therefore farmers may have the chance to delay loading operation for 3.5, 2.5 and 1.5 h to harvest a percent of 25%, 18% and 11% of trailer load respectively. At field to mill distances more than 30 km, farmers should load the trailer as early as possible to permit completing a transport cycle within the day time and the chance to harvest a part of trailer load at the same day may reduced to be zero.

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Introduction

The use of lorries as alternative system for cane to mill delivery have been increasing dramatically. The increasing role of lorries for cane to mill delivery is mainly due to the problems facing the operation of the main delivery system (decauvelle slide lines and wagons). The low rate and longer delivery time of decauvell system is one of the major reason to use trucks. The net of slide lines on which the decauvell move is becoming older and accidents of decauvelle wagons turn up while the train moving more frequently occurred. The loaded wagons may turn a side on the slide line and cane drop out of the wagon causing multiple problems. More cost required to reset the turn wagon on the slide line and to reload the cane, which has to be done immediately to release the line for other trains. Therefore problems such as cane delay and intensive cane losses occurred due to the accidents of wagons turn a side while moving to the mill.

According to the annual reports of the "Sugar Crops Counsel" the percentage of cane delivered by lorries and tractor-trailers to all sugar mills was 11.4% at 1985/86 season increased to 25% at 96/97 season and finally to more than 38% at 2000/2001 mills operation season. Average lorry load increased from 6.6 ton at 85/86 season to more than 9 ton at 99/2000 delivery season which mean that larger lorries have been introduced for cane transport. The Sugar and Integrated Industries Company established a special unloading line for lorries and tractor trailers in all sugar mills. The sugar mills deal with lorries and tractor-trailers as the same and average load reported as general average considering neither lorries nor tractor-trailers.

The current study based on the data collected through the activities of sugarcane mechanization program of AnRI which have been supervised by the author since 1985. The recent activities included a study titled "Evaluation of alternative cane delivery systems" 1998/2000. The study included evaluation of the different chains of cane delivery from variable points of view concerning equipment performance, cane delay and deterioration. According to the final report of that study, using lorries for cane to mill delivery reduce sugar losses due to cane delay. Sugar losses in the cane transported by lorries was about 7 Kg/ton compared to 22.3 Kg/ton of that transported by decauvell. The study aims to evaluate rates of delivery (ton/h) and rate of transport (ton/day) for a lorry as store to mill transport unit and for a tractor-trailer as field to mill transport unit. All possible lory sizes and field to store distances were considered and cane quantities transported from field to store at the same day were also evaluated. The percent of trailer load may be harvested and delivered to the mill within one day without delay was also determined.

Review of literature

Billy J.C. and R .W.Whitney (1978) developed a nomograph and equation systems for determining values for the transport system components to predict cane transportation cost. The relationships using the theory of finite source was adapted to predict the delivery rate of sugarcane from the field for a given transport system. The probability of no transport units waiting or of the loader being idle was calculated. The probability equation which will encompass a system that using any number of loading units, or any number of transport units. The relationship of mill delivery rate and loader rate for various numbers of transport units was developed as a result of the simulation. For a given total trip time, the advantage of increasing the number of transport units decreases as more units are used. By combining the results of the simulation model and the theoretical analysis, the effect of the major components of a transport system on delivery rate can be related by a nomogragh. The capacity of predicting the delivery rate or determining the size and number of components needed for a given transport system is more meaningful if it is associated with economics.

Donawa (1978) studied a system for handling sugarcane in Trinidad and stated that, it is evident that each area has to develop its own transloading and transport systems to service its mechanical harvesting developments. It is not always possible for a ready-made system to be transferred from one country to another. Certain basic principles must remain but, in the context of each country's soils, labor, weather, costs, environmental conditions and regulations, each system would be developed and become unique to that area. Although part of any system could be used in another place, it would always contain an element not seen in the original country.

Kepner et. al. (1980) stated that where as four-wheel wagons are generally preferred for field operations in the United States, two-wheel units are rather popular in England and some of the other European countries particularly for general-purpose use on small farms. Two-wheel trailers are compact and more easily maneuvered than four-wheel units, and the loads can be distributed so as to add considerable weight to the tractor wheels for increased traction needed under muddy, hilly or other adverse conditions.

Crossley. C. P. (1982) reported that, transport at the small farm level in developing countries is a very important factor in increasing agricultural productivity. Information about vehicle performance and operating costs would be very useful both at the vehicle design stage and to enable appropriate vehicles to be selected. The author developed a computer program to predict vehicle performance and costs based on the combination of a number of technical, agricultural and economical factors concerned with the vehicle and terrain over which it is operated in addition to performance limitation. The program results were compared with practical survey information obtained by the "Transport and Road Research Laboratory" in Kenya. For the limited comparisons that can be made it was conclude that correlation is acceptably close.

Friday. N. (1985) reported that about 98% of the cane harvested in Guyana is carried to the factory in barges or punts towed along a network of canals by tractors travelling along unpaved roadways or dams; however, during rainy periods. The dams become deeply rutted and severely hamper cane transport. Arrangement, in which a tractor was fitted into a modified punt and the wheels replaced with steel paddles, paved the way for the development of a water-borne prime mover known as a paddle tug, while later incorporation of an irrigation pump led to the development of a jet tug. Details were given of the system and of the results achieved.

Anon. (1988) reported a new 6-wheel-drive infield cane transporter as an articulated unit made up of four side-tipping bins each of up to 3 tones capacity; the cab be raised to 1m to improve visibility during unloading. The transport is capable of turning through 90° and each bin is tipped separately to a height of 3m. Average cane transport and loading costs in South Africa account for about 34% of total costs, rising to 40% when machinery holding costs are included, so that it is important for the systems to be as efficient as possible for maximum profitability. Advice is given on preparation and application of a farm plan to provide for optimum location and construction of loading zones and roads whereby haulage distances can be minimized.

Harold P. (1989) reported that .the cost per ton-mile can be reduced dramatically. Finally, some basic principles and ratios may be mentioned which will affect costs:

1- Never if possible, use tandem wheel bogies with a gooseneck draw bar. The tractor can turn under the gooseneck at 90 degrees to the trailer and subject both the bogie and the tiers to high stresses and damage by turning without any forward motion tires walls may be distorted to destruction.

2-The ratio of steel weight to pay load should not exceed 1 to 2, i.e. a tractor and trailer weighing 7 tones should haul 14 tones of cane at least. The result is that, of every gallon of fuel consumed, one third carries metal and tow-third carries pay load. It should always be remembered that half of the life of a transport system is the return haul empty, which should be as light as possible.

3-With a "load transfer" system, and the traction generated, the ratio of power to payload should be approximately 5 hp per ton of payload.

4-Above all, vehicles should be well designed with good brakes; the tractor brakes should never be used. For the rest, good transport management and systematic maintenance.

Haywood. and Boevey (1989) reported that much of the cane harvested in South Africa hauled by tractor/trailer units on gravel-hardened road on which excessive wheel slip and loss of traction sometimes occur. Under certain conditions, the larger diameter of tires tended to slip less than smaller ones. However, the average performance of the haulage unit did not alter significantly with change of rear wheel tire and other types and combinations of tires need to be tested before conclusions may be drawn on performance.

Bezuidenhout (1993) reported that in the South African sugar industry, sugarcane is usually transported from field to mill in speller vehicles. At the mill, spilling of the load is effected by chains, on to which the cane bundles are loaded in the field. The system may result in revenue loss from cane lost en route, cane remaining in the vehicle after spillage, littering penalties and cleaning costs and time lost in vehicle cleaning. Experiments were conducted in which the chains were replaced by a wide canvas blanket supported by nylon straps. Better efficiency and cost savings were achieved. The estimated cost savings are conservative, but undoubtedly the potential revenue is high. Further tests are required to ascertain whether a synthetic medium can be used to replace the well tested chains. The durability of the synthetic medium has to be established for wear and tear, and for corrosion from sugar juice. Cane spillage on freeways is a hazard to other road traffic, and often uncomplimentary comments are frequently leveled at the sugar industry in this regard.

Dias et al (1994) evaluated vehicles used for road transportation of sugarcane and discussed the conditions and parameters affecting transport operation and compared the performance for efficient combinations. Transport planning and organization in the sugar industry must be based on the progress already made, so as to reach a degree of perfection that guarantees rapid and secure movement of the harvested cane at low cost.

Ken G. (1998) reported that transport of sugarcane from the fields to the mills is major element of the cost of sugar production. Many different transport systems are used, such as narrow gauge railway systems, and the use of trucks in various forms and fashions. However, the use of the agricultural tractor, with trailers of various forms, is the main method of hauling cane in many sugar estates throughout the world. If we consider a typical mill, which might grind. 1.5 million tones of cane in season, perhaps lasting 200 days, then it is necessary to haul an average of 7,500 tones of cane per day. Depending upon the average haul distance, the capacity of the trailers, the number of hours worked per day, and the percentage availability, then such an estate might need 50 or more tractor-trailer combinations, of 10 tone capacity with each combination averaging 15 loads per day.

Abdel-Mawla (2000) Stated that according to the annual report of Sugar Crops Council "2000" about 64.6% of the total cane production was transported by the traditional single trip delivery systems. Decauville trains, railway wagons and ships which travel one trip per day. The decauville slide system transported 59%, railway wagons transported 3.9% and the cross Nile ships transported 2.7%. These systems are designed to transport cane from certain stores at their travel lines performing single trip per day. The other 34.4% of the total cane production transported by alternative equipment which may perform repeated trips per day.

Materials and methods

Lorry transportation:

A lorry or a trailer may travel more than one trip depending on the cycle time. The lorry or a trailer may have to wait for sometime either at the store/field before start loading and in the mill reception before unloading. Transport cycle time may be computed as follow:

$$SMT_{CT} = S_T + L_T + R_T + (\frac{2d}{v_2}) \qquad (1)$$

Where;

SMT_{CT}= store to mill transport cycle time (h)

S_T = Time the vehicle wait for loading in the store, (h)

L_T= Loading time (h)

R_T= Reception waiting time including unloading and other time (h).

v_2 = Average trip (for both travel and return) speed, (km).

Delivery rate may then be computed as follow:

$$D_R = \frac{V_{2L}}{SMT_{CT}} \qquad (2)$$

Where;

V_{2L} = Load of cane to mill transport vehicle (ton)

Compensating SMT_{CT} from equation 1 to equation 2, delivery rate is:

$$D_R = \frac{V_{2L}}{S_T + L_T + R_T + (2d/v_2)} \qquad (3)$$

Where;

D_R = Store to mill delivery rate (ton/h).

d = Store to mill or field to mill dstance (km)

v_2 = Average travel and return speed (km/h).

Mechanical loading of lorries:

The following notes should be considered for lorry mechanical loading:

a-Store yard should be wide enough for storing cane of several farmers and for both lorry and loader maneuver.

b-The cane should be arranged in the store so that the loader operator can easily reach and load for any farmer.

c-Each farmer should be sure that a quantity of cane equivalent to the lorry load is ready in the store before the loader start loading.

d-Loader operator load each lorry individually.

Loader rate related to grab capacity, cycle time and operation efficiency. The following forms was developed for computing loader rate:

$$L_R = \frac{60 \times L_E \times G_C}{L_{CT} \times 1000} \qquad (4)$$

Where:

L_R = Loader rate (ton/h)

L_E = Loader efficiency (%).

G_C = Average loader grab capacity (kg)

L_{CT}= Loader cycle time (min.)

Loading time of individual vehicle:

$$L_T = \frac{V_{2L}}{L_R} \quad (5)$$

Compensating L_R from equation 4 to equation 5, L_T become:

$$L_T = \frac{1000 \times L_{CT} \times V_{2L}}{60 \times L_E \times G_C} \quad (6)$$

Rate of cane (ton/day) transported to the mill by a lorry or a trailer is:

$$SMT_R = V_{2L} \times N_3 \quad (7)$$

where;

SMT_R = Transport rate (ton/day)

N_3 = Number of complete transport cycles/day.

Cane delivered to the mill within one day:

Quantities of cane transported from the field to the lorry store at the same day (Q_l%) depend on the number of transport cycles (N_3), store to mill cycle time SMT_{CT} and the transport rate of the vehicle that transport cane from the field FST_R. Part of lorry load should be transported to the store at the former day/s plus the part may be transported at the same day while loading (Q_l%) should be equivalent to the vehicle load multiplied by the number of cycles/day. Therefore Q_l% may be computed as follow:

$$Q_l\% = \frac{SMT_{CT} \times (N_3 - 1) \times FST_R}{V_{2L} \times N_3} \times 100 \quad (8)$$

Cane harvested and delivered to mill by trailer within one day:

The percent of trailer load may be harvested and delivered to mill within one day (Q_{1H}%) depend maximum daily operation hours (FMT_{OH}) field to mill cycle time (FMT_{CT}), labor harvesting rate (H_R) and number of harvesting labors (N_l). The following form was used to compute Q_{1H}%:

$$Q_{1H}\% = \frac{[FMT_{OH} - (FMT_{CT} \times N_3)] \times H_R}{V_{2L} \times N_3} \times 100 \quad (9)$$

Results and discussion

Cane stores at which lorries loaded are located at a main asphalt road. Farmers transport cane from fields to be loaded either manually or mechanically. The basic data of cane delivery by lorries and tractor-trailers are presented in Table (1). The table show that lorries transport cane from distances up to 50 km from the mill and travel at average speed 40 Km while trailers travel up to 20 km at average speed 10 km for travel and return trips. Both lorry and tractor-trailers work for up to 12 hours, depend on the number of cycles/day. Trailers are of same size with a average load is about 7 tons and lorries are of variable types and sizes where load may vary from 9-16 ton.

Cycle time components are store waiting time, loading time, reception waiting time and trip (travel and return) time. Waiting time in the store ore in the field for loading was considered zero in case of manual loading and may be as much as 0.5 h in case of mechanical loading. Loading time may vary according to the vehicle load and average reception waiting time was estimated as 1.5 h. Table (2) show the average forms for computing total cycle time considering the variations of vehicle capacities and travel distances.

The rates at which delivery elements perform may depend on some variable components that change according to labor availability, equipment size and operation conditions. Table (3) show performance rates of the delivery system elements in forms where values of variable items can be compensated when identified. Harvesting rate is variable according to labor availability, labor loading rate is variable depending on the number of labors and cycle time which may be variable from type vehicle to another. And vehicle transport rate may vary according to vehicle load and trip distance. The range of variable items is also shown in Table (3).

Lorry transport:

Lory delivery rate was computed on the bases of vehicle load and cycle time to reflect the rate of cane delivered to the mill along the operational hours. At the same store to mill distance the larger the lorry size the higher the delivery rate. At stores of variable locations from the mill, the lager the field to store distance the longer the cycle time and therefore the lower the delivery rate of the lorry. Transport rate (ton/day) computed as the total quantity of cane transported by a lorry at full operational day which represent the total productivity of a lory per day under the given conditions. Transport rate of a lorry of certain size depends on the number of trips from store to mill. Trip time (travel and return) is the variable component of cycle time that may determine number of lorry trips per day either for mechanical or labor loading. Figures (1) and (2) show delivery rate (ton/h) and transport rate (ton/day) for lorries that loaded by labors. Figure (1) show lorry delivery rate of lorries of variable sizes that transport cane from distances as close as 10 km or as far as 50 km from the mill. In case of a lorry loaded by labor delivery rate vary

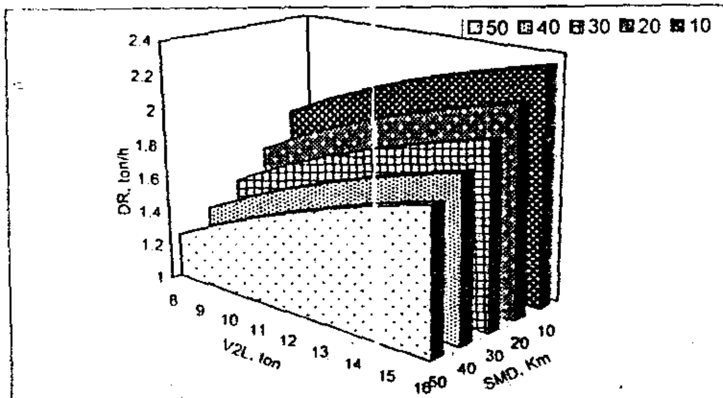

Figure (1) Lorry delivery rale (labor loading)

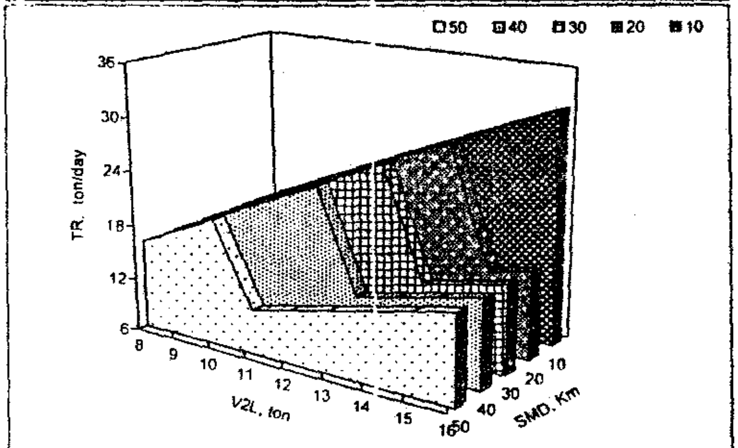

Figure (2) Transport rate, ton/day (labor loading)

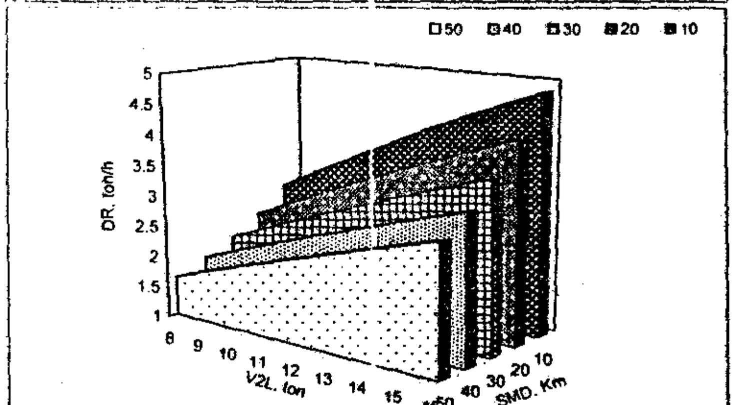

Figure (3) Lorry deliveryt rate, ton/h (mechanical loading).

from about 1.8 ton/h to about 2.4 ton/h for lorry capacities from 8 to 16 at stores as close as 10 km to the mill. The same range of lorry sizes may deliver about 1.3 to 1.8 ton/h from stores as far as 50 km/h from the mill. A lorry of an average size (12 ton capacity) may deliver from about 2.1 to about 1.6 ton/h depending upon the store to mill distance. Figure (2) show that at a store as close as 10 to the mill, a lorry of any size can travel 2 trips per day (operation hours up to 12 h). An average size lorry may travel 2 trips at store to mill distances up to 40 Km. Actually, cane areas located more than 40 Km from the mill may be limited for all sugar mills. The Figure show that transport rate drop suddenly at certain lorry capacity and store to mill distance which mean that 2 trips cold not be completed within operational day. It seems that there is a critical size of the lorry which can complete 2 trips per day when transporting cane from a store at certain distance from the mill.

Table (1) Average data of repeated trip cane transport vehicles

Item		Symbol	Value
Number of harvesting labors for field to mill transport trailer		N_1	5-10
Distances:			
Lorry transport			
Store to mill distance	(Km)	*SMD*	*up to 50 Km*
Field to store distance	(Km)	*FSD*	*up to 5 Km*
Trailer			
Field to mill	(Km)	*FMD*	*up to 40 Km*
Labor loading			
SMT Lorry	(min)	ML_{CT}	*1*
FMT Trailer	(min)	ML_{CT}	*1.6*
Number of labor loading		N_2	N_{2F} = *Variable*
			$N_{2S}=2$
Mechanical Loading:			
Loader cycle time	(min)	L_{CT}	*0.9*
Loader efficiency:	(%)	L_E	*85 %*
Avg. Vehicle Load	(ton)	V_{2L}	
Lory			*9-16*
Trailer			*avg. = 7*
Op. time of repeated trip vehicles		T_{OH}	
(h/day)			*up to 12 h*
Lorries			*up to 10 h*
Trailers			
		v_2	*40 Km*
Avg. travel speed.	(Km/h)		*10 Km*
Lorries			
Trailers			

Table 2 Cycle time of transport vehicles.

Vehicle	S_T	L_T	R_T	Trip time	Total time (h)
Lorry					
ML	0.0	$ML_T = 0.3V_{2L}$	1.5	2d/40	$1.5 + 0.3V_{2L} + (2d/40)$
L	0.5	$L_T = 0.05V_{2L}$	1.5	2d/40	$2 + 0.05V_{2L} + (2d/40)$
Trailer	0.0	$ML_T = (V_{2l}/N_2)$	1.5	2d/10	$1.5 + (V_{2l}/N_2) + (2d/10)$

Table 3. Operation rate of equipment and labor employed for cane delivery.

Operation or Vehicle	Performance Rate (ton/h)	Variable Values
Harvesting	$H_R = 0.1\ N_1$	$N_1 = 5\text{-}10$
$Q_H\%$	$Q_H\% = [10-(FMT_{CT} * N_3)] * N_1 / 7\ N_3$	
Labor loading	$ML_T = (1.6 \times N_2) / ML_{CT}$	$N_{2F} = 1\text{-}4$ $N_{2S} = 2$
Loader loading	$L_R = 20$ (t/h) single vehicle	$L_{CT} = 0.9$ min
SMT		
Lorry (Labor load)	$SMT_R = V_{2L} / [1.5 + 0.3V_{2L} + (2d/40)]$	$V_{2L} = 9\text{-}16$
(Mech. load)	$SMT_R = V_{2L} / [2 + 0.05V_{2L} + (2d/40)]$	
Trailer	$FMT_R = V_{2l} / [1.5 + (V_{2l}/N_2) + (2d/10)]$	$V_{2L} = 7$

Mechanical loading reduces one of the most important components of a lorry transport cycle, which is loading time. Figure (3) and (4) Show delivery and transport rates of lorries of variable sizes loaded by loader and transport cane from stores at variable distances from the mill. For lorry capacities from 8 to 16 ton, deliver rang from about 2.8 to 4.8 ton/h and from 2.4 to 4.2 ton/h for store to mill distances of 10, 20 km respectively. For the same range of lorry sizes, delivery rate ranged from 2 to 3.7, from 1.8 to 3.3 and from 1.6 to 3 ton/h at field to store distances 30, 40 and 50 Km respectively. A lorry of an average size (12 ton) may transport 3.7, 3.3, 2.9, 2.6 and 2.3 ton/h at field to store distances 10, 20, 30, 40 and 50 km respectively. The reduction of delivery rate is due to the increase of cycle time because of longer trip time.

In case of the smaller lorry size (8 ton capacity), transport rate was 32 ton/day only at 10 Km store to mill distance. At this particular conditions the vehicle may travel 4 trips per day. At store to mill distance 10, Km/h except for the above mentioned case, transport rate ranged form 27 to 48 ton/day for lorries of sizes from 9 to 16 ton which mean that each vehicle may achieve 3 successive cycles/day. Figure (4) show that at transport rate directly increased at store to mill distance of 20 Km at which all lorry sizes within the

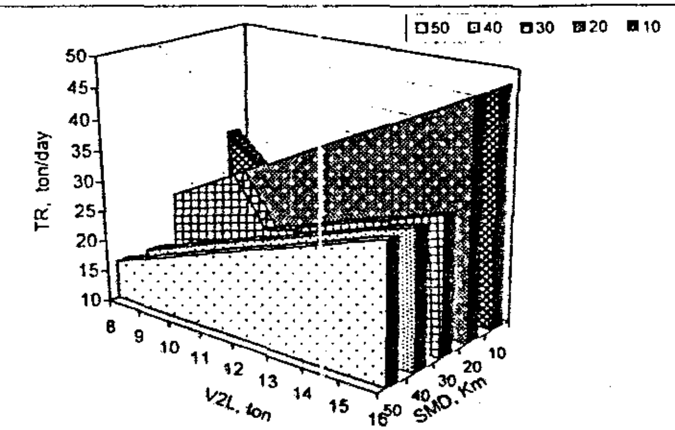

Figure (4) Lorry transport rate (ton/day) mechanical loading

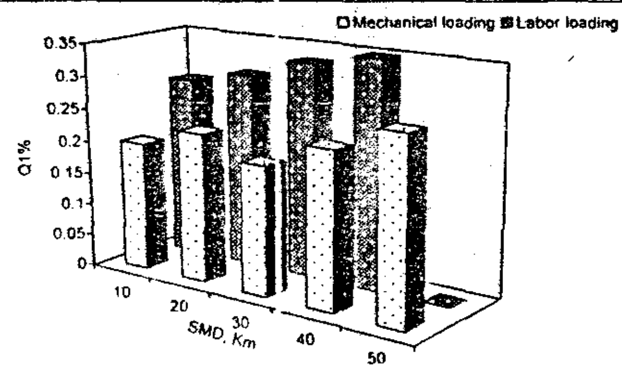

Figure (5) Percent of lorry load delivered within one day, Q1%

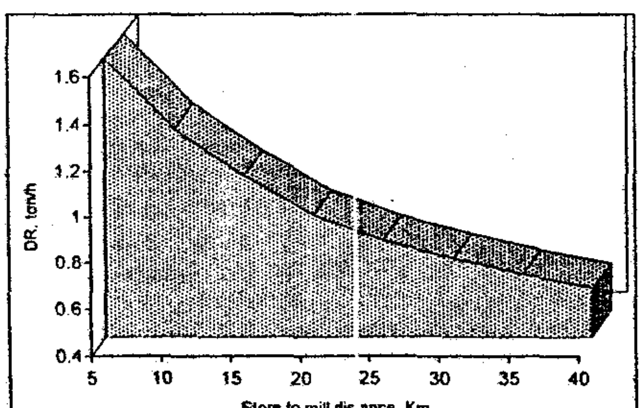

Figure (6) Trailer delivery rate (ton/h) given range may complete 3 trips along the operation day. For store to mill distance up to 40 km, lorries within 10 ton capacity may complete 3 successive trips and that of larger size may only complete two trips. As the Figure show transport rate decreased suddenly from 30 ton/day for the 10 ton capacity lorry to 22 ton /day for that of 11 ton capacity. For mechanical loading of lorries of given capacities and store to mill distances more than 40 km, vehicles may complete only 2 cycles and transport a quantity of cane equivalent to double load per day.

Farmers continue transport cane from fields to lorry stores using trailers pulled by tractors. The trailers of average capacity of 3 ton continue transport cane for lorries during the day time and transport rate depends mainly upon field to store distance. Quantities of cane may be transported from fields to store and considered for loading on lorries at the same day depend on the number of trips and cycle time of main vehicle. The ratio of number of field to store vehicles to store to mill vehicle is 1:1 as prevailing (i.e. one trailer handel cane a lorry). Lorries loading start at the early morning therefore a quantity of cane equivalent to one lorry load should be transported from field to the store from the former day, specially in case of mechanical loading and small capacity lorries. Percentage of lorry load transported from field and delivered to the mill at the same day *(Q_l%)* may reflect the consistency of the delivery system. The values of Q_l% was determined for average conditions represented in average lorry size (12 ton capacity) and average field to store distance (3 km) in case of labor and mechanical loading. Figure (5) show that for labor loading Q_l% was 28%, 3%, 33% .35% and 0.0% when lorries transport at stores 10, 20, 30, 40 and 50 Km from the mill respectively. At store to mill distance more than 40 Km the lorry complete only 1 cycle per day. Since cane has to be loaded on the lorry at the early morning therefore it may not be a chance for the farmer to transport a part of that load from the field at the same day. In case of loader loading Q_l% was equivalent to 20% and 23% at store to mill distances 10 an 20 Km respectively. At larger distances 20, 30 and 40 Km the value of Q_l% was 20%, 24% and 28% respectively. At distances as close as 20 Km to the mill, average size lorry may complete 3 cycles when mechanically loaded and at longer distances only 2 cycles may only be completed. The increase of Q_l% as store to mill distance increased may be due the longer cycle time that enlarge the chance of field to store transport if the same number of cycles achieved per day.

Trailer transport:

Tractor-trailers equipped for transporting cane from fields to mill with average capacity 7 tons work for maximum 10 hours per day. The trailer cycle time depends on field to mill distance, loading time, and reception time. A number of 4 labors can load the trailer within 2 hours and the trailer may wait for 1.5 hour in the mill reception. Since average speed of the trailer (travel and return) about 10 Km/h, therefore cycle time may be within 4.5 and 5.5 h at 5 and 10 Km field to mill distances where 2 trips may be achieved within an operational day of 10 ± 1 hours. At longer field to mill distances, one trip only may be achieved per day. Maximum field to mill distance at which the trailer pulled by tractor may travel a successive trip within 10 hours may be 35 km. As shown in Figure (6) delivery rate was 1.6 and 1.3 ton/h at fields 5and 10 km from the mill. In case of longer field to mill distances, delivery rate decreased to be 0.93, 0.74 and 0.61 ton/h at field to mill distances 20, 30 and 40 km respectively. Transport rate may equal to 14 ton/day in case of a trailer that may complete 2 transport cycles or 7 tons/day in case of 1 cycle. Figure (7) show that transport rate (ton/day) decreased from 14 ton/day at field to mill distance 10 km to 7 ton/day and stay constant for longer field to mill distance. The difference may be in the total operational hours per day where a complete trailer cycle was 6.5, 8.5 and 10.5 hours at field to mill distances 15, 25 and 35 km respectively. Whenever the day time permit, farmers may delay starting the trip to certain time to harvest a part of the trailer load which may be delivered to the mill at the same day. Time available for harvesting a part of trailer load at the same day of transport depend upon the difference between maximum operation hours/day and cycle time multiplied by number of cycles. The quantity harvested at that time related number of harvesting labors. A number of 5 labors (house labors) or a number of 10 labors may be used to harvest cane for a trailer travel 1 or 2 cycles per day respectively.

Figure (8) show trailer cycle time *(FMT_{CT})* and percent of trailer load harvested and transported within one day *($Q_{H}\%$)* as related to field to mill distance. The Figure show that FMT_{CT} increased from 4.5 h to 10.5 h when the field to mill increased from 5 to 35 Km. At cycle time of 4.5 h, intensive harvesting labors (10 labors) can harvest a large part of the trailer load of the second trip which represent about 39% of total cane delivered and. At field to mill distances 15, 20 and 25 km, cycle times were 6.5, 7.5 and 8.5 h therefore farmers may have the chance to delay loading operation for 3.5, 2.5 and 1.5 h to harvest percent of 25%, 18% and 11% of trailer load respectively. At field to mill distances more than 30 km, farmers should load the trailer as early as possible to permit completing a transport cycle within the day time and the chance to harvest a part of trailer load at the same day may reduced to be zero.

Conclusion

The use of lorries as an alternative system for cane to mill delivery has been increased because of problems have been facing the main delivery system (decauvelle slide lies ans wagons). Lorries of variable capacities are used to transport cane from stores at the main asphalt roads. Agricultural trailers equipped for cane to mill delivery have also been used for direct

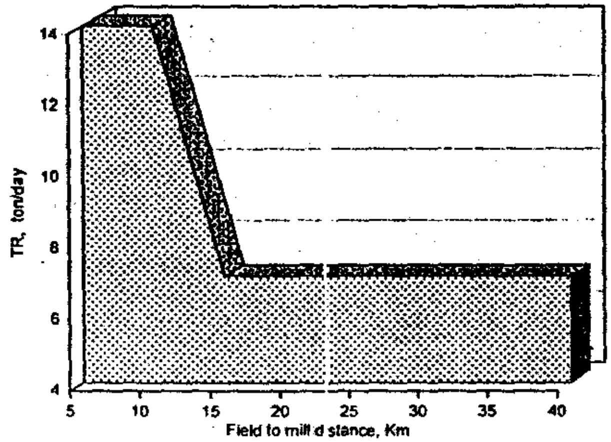

Figure (7) Trailer delivery rate (ton/day)

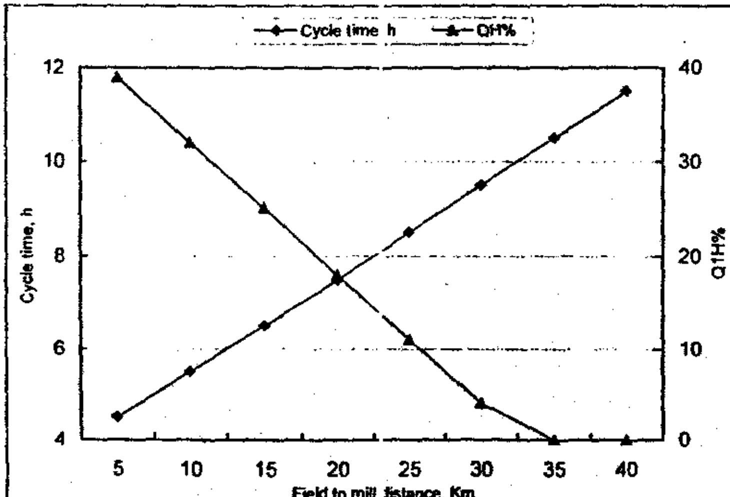

Figure (8) cane harvested and delivered to millat the same transport day delivery from fields to mill.. The results of evaluating cane delivery by alternative systems may be concluded as follow:

1- In case of manual loading an average size lorry of 12 ton capacity may travel 2 trips at store to mill distances up to 40 Km.
2- In case of mechanical loading, an average size vehicle may achieve 3 successive trips/day at store to mill distances up to 20 Km and 2 trips/day at longer store to mill distances.
3- Percentage of cane transported from the field and delivered to the mill within one day *(Q_1%)* was determined for average conditions represented in average lorry size and average field to store distance 3 km in case of labor and mechanical loading. In case of labor loading Q_1% was average 28%, 30%, 33%, 35% and 0% when lorries transport at stores 10, 20, 30, 40 and 50 km from the mill respectively. In case of mechanical loading average Q_1% was 20% and 23% at store to mill distances 10 and 20 km respectively. At larger field to store distances 20, 30 and 40 Km the value of Q_1% was 20%, 24% and 28% respectively.
4-Since average speed of the trailer (average travel and return speeds) about 10 Km/h, therefore cycle time may be within 4.5 and 5.5 h at 5 and 10 km field to mill distances where 2 trips may be achieved within a day of 10 ± 1 operation hours. At longer field to mill distances, one trip only may be achieved per day. Maximum field to mill distance at which the trailer pulled by tractor may travel a successive trip within 10 hours may be 35 Km.
5- At field to mill distances 15, 20 and 25 km, respective trailer cycle time was 6.5, 7.5 and 8.5 h therefore farmers may have the chance to delay loading operation for 3.5, 2.5 and 1.5 h to harvest 25%, 18% and 11% of trailer load respectively. At field to mill distances more than 30 km, farmers should load the trailer as early as possible to permit completing a transport cycle within the day time and the chance to harvest a part of trailer load at the same day may reduced to be zero.

Increasing field to store transport rate may facilitate increasing the part of lorry load delivered to the mill within one day. A tractor drown trailer should be designed specially for field to store cane transport. The new trailer should be of larger capacity and easy to be loaded for shorter transport cycle time and for higher field to store transport rate. Developing a special trailer with higher field to mill cane delivery rate may maximize quantities of cane delivered within 24 h. The trailer may also be tractor drown, larger capacity, higher stability and properly equipped for cane loading. A successful cane harvesting machine should be developed through a special research program to accelerate all chains of delivery system. A consistent cane delivery system may be established to control delivery delay by parallel development of cane harvesting, loading and transport equipment in addition to proper management.

References

Abdel-Mawla H A. (2000) Analysis of cane delay of traditional delivery systems: Paper presented to the MSAE, Menofia Univ.:25-26 October 2000.

Anon. (1988). Cane transport. South African Sugar J: 72.

Bezuidenhout. J. D. (1993). Prevention of cane loss from speller trailers. The South African Sugar Tech. Assoc.: June No. 67: 120-121.

Cochran, B. J. and Whitey, R. W. (1976). A technique for designing transports systems for sugar-cane, Agric. Eng. ISSCT; 2069 – 2079.

Crossley, C. P. (1982). Rural transport in developing countries- the development of the "CARTA" computer program. J. Agric. Eng.. Res; No 27: 139- 153.

Diaz. L. D. Ramos, E. C. And Sanntiago, A. M. (1994). Cane transport: truck-hauled versus tractor-hauled trains. Sugar-cane.,No. 5: 14-16.

Donawa, L. P. (1978). A system for handling, Transloading and transportation of mechanically harvested cane developed for Trinidad. Agric. Eng. ISSCT. Vol (2): 2059-2067.

Friday, N. (1985). The use of locally made marine prime movers for cane transport in Guyana. J. of Sugar Cane, No. 2: 26.

Kepner, Bainer and Barger. (1980). Prenciples of Farm Machinery. AVI. Pub.. Inc., Westport , Con., U. S. A.:.527.

Gardiner, K. (1998). The role of weight transfer hitches in cane transporting. Sugar-y-Azucar.: 22-23,

Sugar crops council (1986), (1997) and (2000) Annual reports: 65, 58, 66.

النظم البديلة لتوريد القصب لمصانع السكر

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يتزايد الإعتماد سنوياً على توريد القصب لمصانع السكر بإستخدام اللوارى والمقطورات الزراعية المجهزة خصيصاً لذلك الغرض كبديل لنظام خطوط الديكوفيل وعرباته الذى أخذ فى التقادم وتتزايد مشكلاته موسم بعد الأخر. وبناءاً على تقارير مجلس المحاصيل السكرية التابع لوزارة الزراعة فقد زادت نسبة كميات القصب المنقولة باللوارى والمقطورات إلى كميات القصب الكلية الموردة للمصانع من حوالى ١١% خلال موسم توريد ٨٥/٨٦ إلى ٢٥% خلال موسم توريد ٩٦/٩٧ وأخيراً إلى حوالى ٣٨% خلال موسم توريد ٢٠٠٠/٢٠٠١ . ويهدف البحث إلى دراسة أداء معدات النقل البديلة تحت الظروف السائدة فى مناطق القصب. وتناولت الدراسة معدلات التوريد (طن /الساعة) ومعدلات النقل اليومي للمعدة من مناطق القصب التى تبعد لمسافات تصل

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إلى ٥٠ كم من المصنع. كما قدرت كميات القصب القصب التي يمكن نقلها لمخازن شحن اللوارى ومنها إلى المصنع في ذات اليوم ، وايضاً الكميات التي يمكن حصادها وتوريدها بالمقطورات في ذات اليوم بدون تأخير. وأمكن إستخلاص الآتي من نتائج الدراسة:

١- في حالة شحن القصب على اللوارى بالعمال فإن اللورى متوسط السعة (١٢ طن) يمكن أن يؤدى دورتى نقل إذا كانت المسافة من المخزن للمصنع في حدود ٤٠ كم . ومن المعروف أن المساحات الأبعد من ذلك تكون محدودة في دائرة معظم المصانع . في حين أنه في حالة التحميل باللودر يمكن أن يقوم اللورى متوسط السعة بثلاث رحلات يومية عند نفس الظروف .

٢- كميات القصب المنقولة من الحقول لمخازن اللوارى ومنها للمصنع في ذات اليوم كانت ٢٨%، ٣٠% ، ٣٣% ، ٣٥% و ٠,٠% من حمولة اللورى في حالة التحميل العمالى للوارى في مخازن تبعد ١٠، ٢٠، ٣٠، ٤٠ و٥٠ كم من المصنع على الترتيب . وفي حالة الشحن الميكانيكى فقد أمكن نقل ٢٠% . ٢٤% و ٢٨% من حمولة اللورى في مخازن تبعد ٢٠، ٣٠ و ٤٠ كم من المصنع على الترتيب.

٣- حيث تبلغ السرعة المتوسطة للمقطورة لرحلتى الذهاب والعودة ١٠ كم/الساعة وكان مقدار زمن الدورة ٤,٥ ، ٥,٥ ، ٦,٥ ، ٧,٥ و ٨,٥ ساعة عند النقل من حقول تبعد ٥ ، ١٠ ، ١٥ ، ٢٠ و ٢٥ كم من المصنع فإنه يمكن إتمام دورتى نقل للمقطورة إذا كان يوم العمل في حدود 1 ± ١٠ ساعة ويمكن تحقيق ذلك فقط عندما تكون مسافة الرحلة من الحقل للمصنع في حدود ١٠ كم . أما في حالة المسافات الأبعد فإنه يمكن إتمام دورة نقل واحدة في اليوم . وإذا زادت المسافة عن ٣٥ كم فإنه ربما يتعذر إتمام دورة النقل إثناء النهار.

٤- في حالة ما إذا كانت دورة النقل ٦,٥ ، ٧,٥ و ٨,٥ ساعة (حسب المسافة من الحقل للمصنع) فإن المزارع يكون لديه الفرصة في تأخير شحن المقطورة ٣,٥ ، ٢,٥ و ١,٥ ساعة على الترتيب حيث يمكنه خلال ذلك الوقت حصاد ٢٥% ، ١٨% و ١١% من حمولة المقطورة (على الترتيب) لتنقل إلى المصنع في ذات اليوم بدون تأخير.

وأخيراً فإن نتائج الدراسة تشير إلى أنه يجب التخطيط لتطوير التوافق في المراحل المتسلسلة لنظم نقل القصب البديلة لتعظيم كفاءة أداء المعدات والتحكم في مدة توريد القصب الأمر الذى يؤدى لتقليل إحتمالات التدهور . وقد يتأتى ذلك بتطوير المقطورات المستخدمة لنقل القصب من الحقول إلى مخازن شحن اللوارى لتكون أسهل تحميلاً وأعلى سعة مما يزيد من كميات القصب المنقولة للمخازن ومنها للمصانع في ذات اليوم . وأيضاً يجب تصميم مقطورات خاصة لنقل القصب مباشرة من الحقول للمصانع بدلاً من إستخدام المقطورات الزراعية العادية بحيث يقل الشغل المبذول في تحميلها وتكون المعدة الجديدة أكثر إتزاناً ويمكن جرها بسرعات أعلى لتقليل زمن دورة النقل . كما يجب تطوير معدة حصاد ناجحة لقصب السكر بالتوازى مع تطوير نظم النقل لتحقيق التوافق المطلوب في نظم توريد القصب لتعظيم كميات القصب الموردة بدون تأخير .