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Contribution of mechanical loading in reducing delivery duration of sugarcane

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Abstract

Manual loading of sugarcane on both infield and main vehicles is expensive, time consuming and exhaustible operation. As a result of manual loading, sugarcane delivery systems perform inefficiently. Therefore, grab loaders have been introduced and operated to replace manual loading. The results based on continuous operation of self-propelled and tractor mounted grab loaders show that mechanical loading of the transport equipment largely increase infield transport rate and save the major part of the main vehicle loading duration. Mechanical loading may duplicate the transport rate of the road transport equipment and reduce sugarcane transport costs.

Keywords: sugarcane transport, sugarcane manual loading, sugarcane mechanical loading, loader performance, transport duration, cane delivery delay.

INTRODUCTION

Manual loading of sugarcane is expensive, exhaustible and time consuming that largely obstructs the performance of transport equipment. Sugarcane is transported from inside the field to trans-loading sits in which the main transport vehicles loaded and travel to the sugar mill. Mechanical loading of main vehicle represents first priority as recommended. Analysis of cane delivery delay due to manual loading and stated that, due to socio-economical constrains, cane is still harvested manually. When a properly sized mechanical system used for infield transport rate that match the rate of the main vehicles, another bottle nick may appear in the rate of cane harvesting. So that the field owner or the farmer should be concerned to achieve the following condition to avoid lower efficiency of infield transport equipment and/or cane delivery delay. $H_R \geq INFT_R$. Where; H_R = Total harvest rate of labors work in the field, ton/h and NFT_R = Infield transport rate, ton/h (Abdel-Mawla, 2000). Manual loading of sugarcane is usually carried out when the field conditions are poor, and where the annual tonnage handled does not justify mechanizes system. The main advantage of manual loading related to low extraneous matter levels. The main disadvantage of manual loading is that it is expensive and time consuming, resulting in poor vehicle utilization and therefore increased transport costs. In most instances the first step in mechanizing the harvest operation is the acquisition of a mechanical loader. However, any cost savings made during the manual harvesting operation and/or increase in transport payload must justify and cover the costs of owning and operating the loader (Meyer, 2000).

Mechanical loading of sugarcane in the Nile Valley in Upper Egypt is required to substitute for the decreasing availability of laborers for manual loading· Farmers have been striving to increase the number of loaders available. Practical procedures can be developed which may facilitate the operation of cane loaders with increased efficiency and productivity. Operational strategies that facilitate profitable operation of cane loaders will lead to a significant increase in the proportion of the crop which is mechanically loaded (Abdel-Mawla, 2001). Infield mechanical loading of the common size trailer may last for short time and the loader stop idle for the trailer to travel, unloaded in the site and be back to the field. Even if two trailers used for infield transport, the loader may stay idle for long time. Mechanical

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loading of main vehicles in the site is urgently required because the main vehicles loads may exceed 10 tons or more. Sugarcane loaders should be operated in conditions that facilitate reasonable efficiency, such as at large trans-loading sites where several vehicles ready to be loaded. Efforts should be exerted to gradually adjust scheduled date of harvesting as well as the determined harvest allocation for each cane plot area. Gradual adjustments to a common date of harvesting for neighboring fields could be applied through the cane delivery schedules prepared annually by the mill administration (Abdel-Mawla, 2001; Abdel-Mawla, 2010).

Front loaders mounted at the front-end of agricultural wheel tractors are increasingly employed for the mechanization of material loading and unloading operations into/from transport means or other locations on low and medium agricultural farms (Simion and Nastase, 2009). The constructive and functional parameters of front and rear loaders mounted on agricultural wheel tractors have to satisfy the requirements of the working process and of the dynamic stability and have to correspond to the structures of the tractors they are mounted on. Front-end loader is an indispensable machine for the off-road construction equipment industry. It is a classic example of a working machine with complex interactions between its subsystems (hydraulic, mechanical, and electrical). Dynamic models of the full-scale vehicle coupled with event-based operator models are currently used to help quantify the overall system performance, efficiency, and operability. However, these models are complex and not always necessary to characterize the response of individual subsystems. There is great value added to the design process–specially in prototyping of new vehicle platforms in development of simpler models that can quickly and accurately define first-order measures of system loads and performance (Worley and Saponara, 2011).

To ensure the long term viability of the small-scale grower sector, incentives should be put into place so that a cheaper, better quality service can be provided to the small-scale grower by the contractors, e.g. reducing transaction costs such as sourcing contract work, providing access to finance and allowing business expansion opportunities (Meyer, 2005; Meyer and Nothard, 2007). Furthermore, Government must play a strategic role by creating land markets, improving rural road infrastructure and reviewing the impacts of minimum wages in the rural areas. Detailed examination of sugarcane haulage vehicles involved weighing, dimension measurement and the recording of tire specifications, etc was recorded (Robotham et al., 2001). The survey database is unique within the sugar industry and has been used by legislators, haul-out manufacturers and tire manufacturers to produce more efficient, safer and legally conforming haul-out vehicles. Haul-out owners and operators involved in the survey have had an assessment and recommendations given for safe and legal operation of current vehicles. A simulation model that seamlessly addressed operations carried out by the supply system of sugarcane from the operations in the HF to the unloading within the mill (Johansson et al., 2010). Thus, the model could properly consider the impact of the freight and of the lead time in the value of the load of sugarcane supplied to a mill. The analysis allowed quantifying the waiting times of the raw material from harvesting to unloading within the mill and the resulting penalty imposed by the mill (known as discount) for the sugarcane of worst quality, reminding that the quality of sugarcane is inversely proportional to the lead time. The model included in its preparation, apart from the estimation of lead time and freight (referring to transportation), the size of the fleet of trucks and the costs of cutting and shipping.

MATERIALS AND METHODS

Equipment operated for sugarcane transport may include; a) infield trailers, b) decauville system, c) railway wagons and d) agricultural trailers. Table 1 shows the characteristics of sugarcane transport equipment and the percent of sugarcane production delivered to the mill by each of the transport systems. Figure 1 shows manual and mechanical loading of sugarcane in the field and in the trans-loading site.

Table 1. Sugarcane transport equipment and load characteristics

	Loading Surface dimensions *(W× L)* *m*	Vehicle Surface Height *m*	Load height from ground *m*	Load Height over surface *m*	Average load, *ton*	% of cane production transported
Deccauvelle	1.8 × 6	0.6	3.4	2.8	9	44%
Railway wagons	2.4 × 7	1.3	4.2	2.9	15	4%
Agricultural trailer	2 × 4	1.2	4.5	3.3	9	46%
Large trailer	2.5 ×6	1.3	4.5	3.3	16	
Lorry	2.4 × 6	1.5	4.5	3	14	6%

1. Loading rate:

Mechanical loaders may be operated in the field or in trans-loading sites. Imported self propelled and locally fabricated tractor mounted loaders are available. Loader rate affected by the weight of sugarcane bundle loaded in single loading cycle either by the labor or by the loader, loading cycle time and operation efficiency. Mechanical Loading rate may be computed using the following formula (Abdel-Mawla 2010):

$$L_R = \frac{60 \times G_C}{L_{CT} \times 1000} \tag{1}$$

Where:

L_R = Loader rate, ton/h.

G_C = Average weight of cane bundle loaded in one loading cycle either by the, or by the labor kg.

L_{CT} = Loader cycle time, min.

2. Loading time:

Loading duration of any sugarcane transport vehicle depends on loader rate and efficiency that computed as follow:

$$L_T = \frac{V_L}{L_R} \tag{2}$$

Where:

L_T = Time required for loading of a sugarcane vehicle, h.

V_L = Sugarcane transport vehicle load, ton

Compensating L_R from equation 1 to equation 2, loading time (L_T) was then given as follow:

$$L_T = \frac{V_L \times L_{CT} \times 1000}{60 \times G_C \times L_E} \tag{3}$$

Where; L_E = Loader operation efficiency.

3. Transport duration:

The main components of sugarcane transport cycle represented in loading time and transport time. Transport time depends on the average speed at which the vehicle travel either loaded or empty and the distance from the sugarcane trans-loading site to the mill.

Transport duration = Loading time + travel time + Mill reception time (4)

Figure 1. Sugarcane loading a) self propelled loader in site, b) Tractor mounted loader in site and c) Labor loading in site.

RESULTS AND DISCUSSION

Infield transport (supply to main vehicles)

In case of mechanical loading of infield trailer, the range of transporting the full load of any of the main vehicles was less than 5 h where transporting the full load of large transport equipment within the operation day may be possible (Figure 2). For infield sugarcane transport and especially if the cane is loaded manually, loading time represent the major component of the transport cycle time. Consequently, the slow mode of loading sugarcane have been representing the major reason for the poor performance of the system and also represent the main reason for delivery delay.

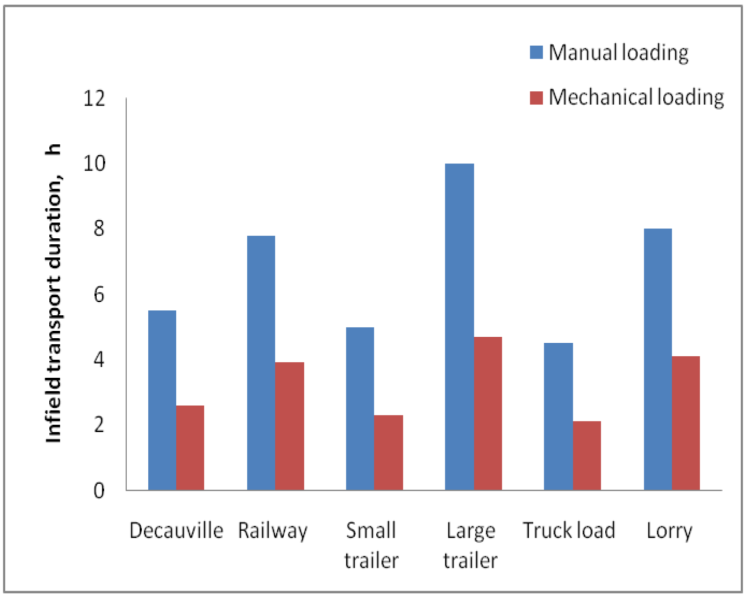

Figure 2. Infield transport duration required to handle the full load of sugarcane to main transport vehicles.

Main vehicle loading and transport duration

Figure 3 shows that mechanical loading of the main vehicles in site may last 0.7 h in case of small vehicles to up to 1.2 h in case of large vehicles. The short time of mechanical loading of the main vehicles may force the farmers to start infield transport from fields to sites as early as possible, use more than one infield trailer and go for infield mechanical loading to maintain transporting the full load of large vehicles on time.

The duration of loading which starts sometime in the morning may represent the major factor determining if the vehicle can perform more than one trip within the operation day. In case of manual loading, the duration of loading lasts for long time that represents a chance for the farmer to transport a part of the load from the field while the vehicle is loaded. In case of repeated trip of the road transport vehicles, the transport cycle time of the main vehicle may represent the time available for the farmers to transport from inside the field for the repeated trip/s of the main vehicles. Figure 3 indicates the transport duration of the road transport equipment either manually or mechanically loaded. The results emphasize the capability of the road transport vehicles to perform more than one trip within the diurnal operation day.

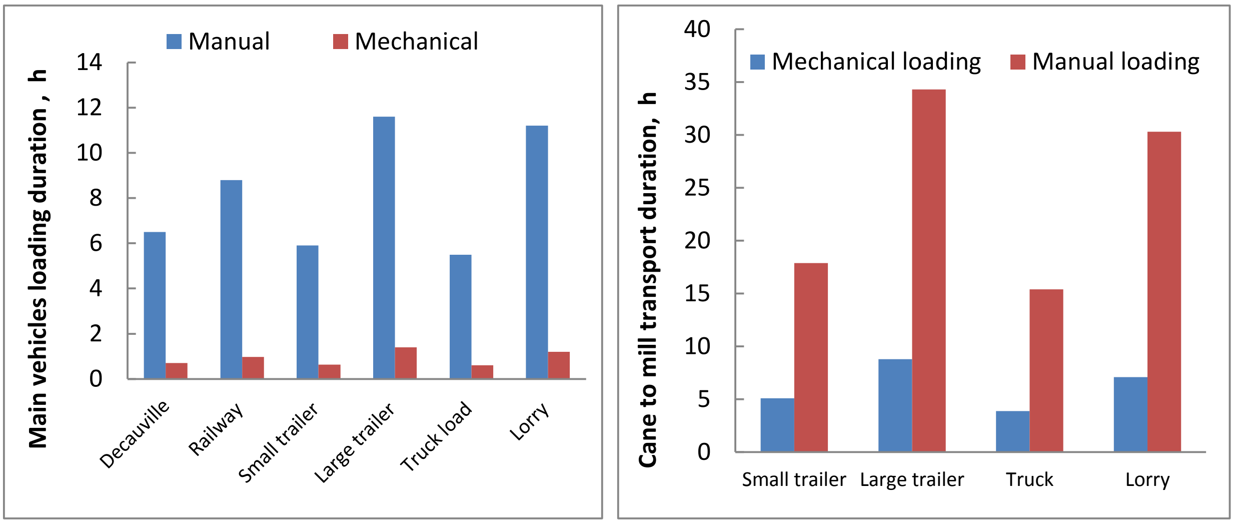

Figure 3. Main vehicle loading and transport duration.

Reduction of loading time and transport duration due to mechanical loading

Applying mechanical loading either in site and/or infield largely contribute for reducing the transport cycle time and transport duration of the system. Figure 4 illustrate the reduction of both vehicle loading duration and loading cycle time due to mechanical loading that computed as a ratio of difference between manual and mechanical loading time to the manual loading time of each vehicle. Figure 4 also shows the contribution of mechanical loading of sugarcane in reducing sugarcane transport duration.

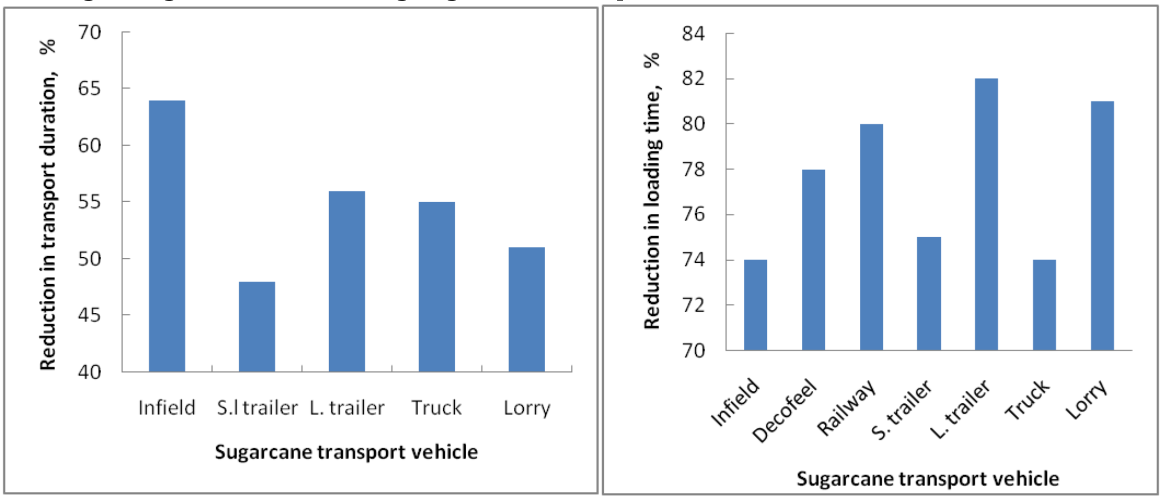

Figure 4. Reduction of loading and transport duration due to mechanical loading.

Delivery rate

Installing mechanical loading in the sugarcane delivery system may speed up the system where the main transport vehicle can transport more than one load from the trans-loading site to the mill within the diurnal operation period. Mechanical loading dramatically reduce the transport cycle time, improve efficiency and speed up the performance of the sugarcane delivery system. Figure 5 shows that only small trailers, trucks and lorries may successfully transport two loads per day. Consequently the quantity of sugarcane transported by these vehicles duplicated due to the application of mechanical loading. The rail transport systems represented in decauvelle and rail wagons designed to transport one load per day where no change in delivery rate per day when applying mechanical loading.

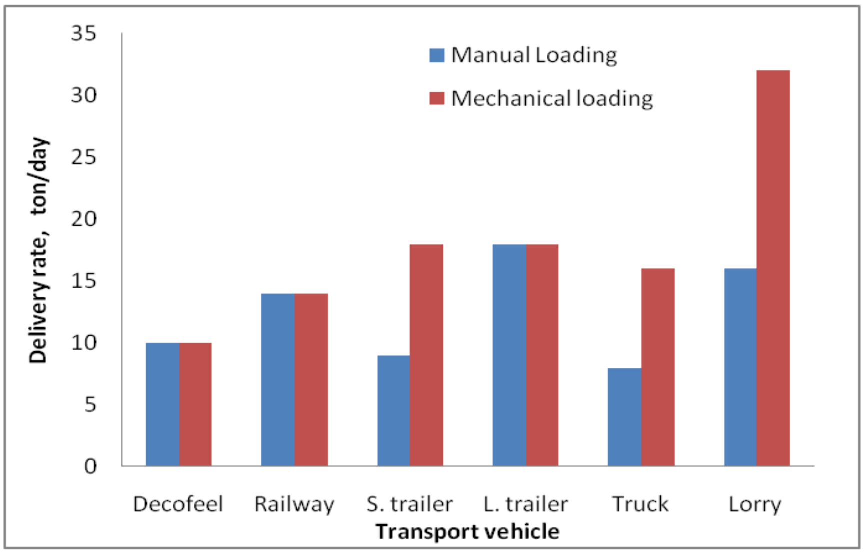

Figure 5. Sugarcane delivery rate (ton/day).

CONCLUSIONS

The following conclusions can be drawn from the study:

– Manual loading slows down the performance of sugarcane transport system that resulted in poor performance of transport equipment, lower delivery rate and delay of sugarcane to mill delivery.
– Mechanical loading reduces within 90% of the loading time for all the transport vehicle and contribute reducing up to 55% of the sugarcane transport duration that resulted in duplicating the delivery rate of the road transport equipment.
– Mechanical loading inside the field still performed at low rate because of slow maneuvers across furrows.
– Efforts should be exerted to develop a loader with swivel boom to avoid excessive maneuvering and speed up infield loading operation.

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