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Enhancing Field Mechanization in Oil Palm Management

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ABSTRACT

Advancements in field mechanization for the oil palm plantation industry have, over the years, involved the introduction of machines and implements that are adapted to local terrain conditions. A suitable choice of machines is dependant on land size, terrain conditions, management preferences and economic returns. Currently, mechanization approaches vary from plantation to plantation with the major aim of overcoming labour shortage. In the 1990s, due to restrictions in the importation of labour, many organizations embarked on mechanization. Various machines of different makes were field-tested by the plantations. Some were locally developed while others were imported. Some of these machines are still in commercial use. However, in the post-2000 era, labour availability for the industry has eased through government-to-government arrangements on foreign labour supply, with the result that the pace of mechanization has slowed down. Though in-field transportation of fresh fruit bunches (FFB) has progressed well, there is still room for improvement. This article discusses the intensification of work on mechanization in areas which mainly focus on in-field FFB evacuation and transportation of the harvested crop to the mill. Past and present experiences using various types of machines will be reported. On research and development, the article highlights some salient points to be considered to further intensify cooperation between the machine fabricator and the potential user, in the search for better machines for the future.

ABSTRAK

Kemajuan dalam bidang mekanisasi ladang telah berkembang dengan pesat di mana jentera dan alatan telah diperkenalkan serta diterimapakai bersesuaian dengan keadaan fizikal ladang di negara kita. Pemilihan jentera bergantung pada keluasan kawasan, keadaan fizikal ladang, kecenderungan pengurusan dan pulangan ekonomik sesebuah jentera. Dewasa ini, pendekatan mekanisasi walaupun berbeza tetapi bertujuan untuk mengurangkan tenaga buruh. Pada tahun 1990-an, banyak organisasi perladangan telah memekanisasikan operasi ladang mereka akibat kekangan terhadap pengambilan tenaga buruh. Pelbagai jenis jentera yang diimport atau dikeluarkan oleh pengeluar tempatan telah diuji di ladang. Jentera yang menunjukkan keberkesanan kos telah digunakan secara komersial. Walau bagaimanapun, pada era pasca 2000, proses membawa masuk tenaga buruh asing menjadi lebih mudah melalui persetujuan dengan kerajaan yang menyediakan tenaga buruh. Ini telah menurunkan kadar penggunaan mekanisasi di ladang. Mekanisasi pengangkutan buah tandan segar (BTS) walaupun telah berkembang dengan pesat, namun masih ada ruang untuk diperbaiki. Artikel ini membincangkan usaha-usaha intensif yang dijalankan dalam bidang mekanisasi terutama dalam proses pengangkutan dan penghantaran BTS ke kilang. Pengalaman masa lampau dan kini dalam penggunaan pelbagai jentera juga akan dibincangkan. Selain itu, artikel ini juga mengemukakan beberapa perkara penting yang boleh dipertimbangkan untuk memperbaiki kerjasama antara pengeluar dan pengguna jentera demi untuk memperkasakan penggunaan jentera pada masa akan datang.

Keywords: harvesting, in-field collection, mechanization.

INTRODUCTION

The oil palm industry is very dependent on labour. The industry requires many workers for its operations, ranging from planting to processing. It was reported that the total work-force in the plantation and smallholder sectors of the Malaysian oil palm industry in 2008 was 500 817 workers, with 73.7% or 369 000 of them made up of foreigners (Faizah, 2010). *Figure 1* shows the estimated total work-force involved in oil palm cultivation in Malaysia by category of work in 2008. It was found that harvesting activities required a largest

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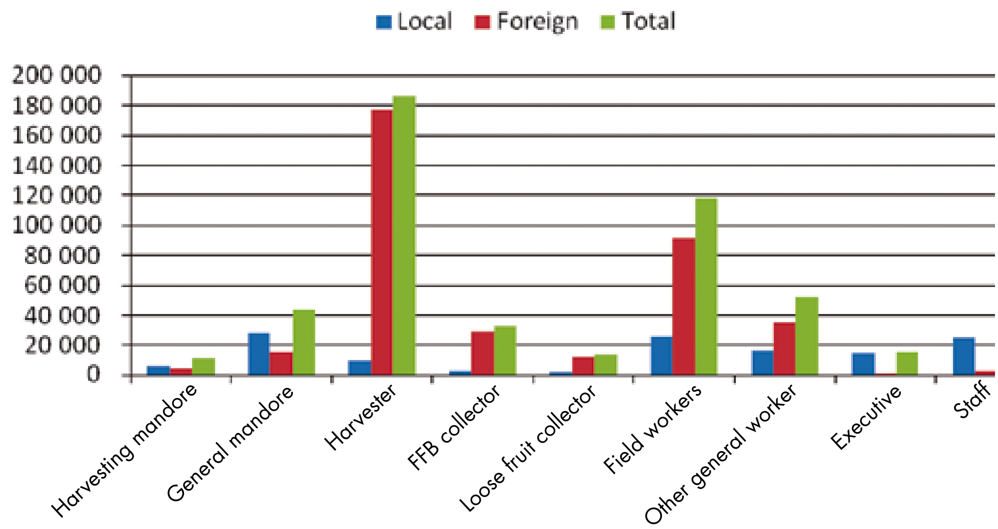

Source: Faizah (2010).

Figure 1. Estimated total work-force in oil palm cultivation in Malaysia by category of work in 2008.

proportion of the work-force, that is 37% or 186 473 workers. It also reveals that four categories of work in the oil palm plantation are totally dependent on foreign workers, namely those employed as harvester/cutter, fresh fruit bunches (FFB) collector, loose fruit collector and field worker.

Currently, mechanization practices in oil palm estates vary from plantation to plantation. The land conditions, as well as the operation, define the mechanization practices to be applied. Besides providing suitable machines for field operations, the preparation of infrastructure such as mechanization paths, the training of workers, supervisors and managers on mechanization, and obtaining firm commitment from top management are important. The plantation must be prepared to invest in the machines and accept a slight drop in productivity during the initial training period until full use and proficiency have been achieved. As mechanization is an investment, capital assets are necessary. It has been observed that the current practices of estates in which successful mechanization has been realized include the following six points:

- infrastructure preparation of mechanization paths or mechanization terraces, especially in hilly areas;
- participation of workers and their union;
- choice of the correct machine for the job and environment;
- use of demonstration plots to evaluate and develop the system;
- expansion of the system to cover the whole estate; and
- management commitment.

MECHANIZATION IN OIL PALM ESTATES

The oil palm industry is very dependent on labour. The industry requires many workers for its operations ranging from planting to processing. Unless this requirement is met, the performance of the industry will be severely affected. The problem of labour shortage is very acute. The reluctance of local workers to work in the plantation sector has resulted in the importation of foreign workers. Complete reliance on foreign workers is not the ultimate solution; it is only a temporary measure. Thus, the industry has to focus on the adoption of mechanization for increasing labour productivity, hence decreasing the dependency on human workers.

With the labour situation tightening but still manageable, due to a relatively relaxed foreign workers' policy, most plantation operators find that there is no urgency to rush into the introduction of mechanization. This is a luxury that may soon backfire considering the fact that the labour situation is definitely not going to get better. Competition with a neighbouring country with larger land and labour reserves means that dependency on foreign workers must be checked.

A common fallacy is that mechanization is all about reducing labour dependency. While this is true to a certain extent, more correctly, mechanization should be looked upon as a means for increasing productivity with the same number of workers. Taking this point of view, mechanization will not then be perceived as being evil (in displacing human jobs) and will hopefully be more readily accepted.

Several types of machines have been introduced into the oil palm plantation and evaluated for transporting FFB in the last 20 years. Generally, these machines can be classified into three-, four- and six-wheeler power carts, rubber and steel crawler-dumpers, but in this article the authors will only focus on the mini-tractor grabber system and machines that have been introduced recently.

HARVESTING

In an oil palm estate, the harvesting operation requires the most number of workers. The harvesting operation consists of the cutting activity (fronds and FFB), evacuating FFB to roadside platforms, loose fruit collection, and the cleaning activity (frond stacking and bunch stalk cutting). The harvesting of FFB from tall palms is currently not mechanized, as the cost of such technology is expensive.

Motorized Cutter (*Cantas*) for Short Palms

The chisel and sickle are the traditional tools used for harvesting oil palm fruit bunches. Harvesting with these tools is a job that requires skilled and energetic workers, who are expensive and hard to come by. Manual harvesting is slow, which means more workers are required. MPOB researchers have invented a motorized cutter (trade name being *Canta*s) for cutting oil palm fruit bunches from palms less than 5 m tall. The invention uses a rapid chopping method to perform the cutting. Less energy is thus needed in executing the cutting operation. With a 'C-shaped' sickle design, vibratios transferred to the operator are reduced. In a day's work, 300 to 900 bunches can be harvested, which cover 10 to 15 ha of plantation. For comparison, manual harvesting using the sickle may achieve 100 to 300 bunches a day. *Cantas* is the first motorized cutter that is well accepted by the industry with productivity and performance which are very satisfactory. It is envisaged that this machine will open up the development of new technology to mechanically-assisted harvesting operations that are more acceptable to the oil palm industry

Mechanical Harvester for Tall Palms

An ideal harvesting machine is one that is operated by a single worker and that can cut, collect and carry FFB to the roadside or collecting point. If these operations are done manually, the productivity is about 1.5 to 1.8 t per day. Hence, the mechanical harvester must at least be able to increase productivity by four to five times more than the manual system in order to be economically viable.

MPOB has been working with a Japanese firm in developing a harvesting machine. This mechanical harvester is based on a track-type undercarriage powered by a 31.5 hp, 4-cylinder diesel engine with 1732 c.c. capacity. The machine is made up of four basic modules, namely:

- undercarriage;
- boom;
- cutter and grapple; and
- bucket.

The booms are designed to achieve the intended height while maintaining the outreach to the minimum required. This is to ensure maximum stability of the vehicle during operation. The booms consist of vertical telescoping and articulating sections to which the cutter and grapple are mounted. The scissor-type cutter and grapple are hydraulically-driven. The maximum height that the boom can reach is 10 m. A grapple is provided to grab or hold the fruit bunch prior to cutting, and this eliminates bunch impact when falling on the ground. After cutting, the grapple will place the cut bunch into a bin. It was found that the machine takes between 2.5 to 3.5 min for a complete cycle which includes positioning the cutter, cutting the frond and setting the grapple to grab the fruit bunch, cutting the bunch and placing it in the bucket. In terms of productivity, the machine is able to harvest between 4 and 6 t FFB a day.

Mechanical Grabber

A mini tractor-trailer is the best system for FFB evacuation if accessibility is good for the machine. In this system, separate groups of workers are employed, namely, the cutter and the carrier groups. The cutter's job is to cut FFB and align them along the harvesting path. The carrier group comprises three workers – a driver and two loaders – who collect the cut FFB along the harvesting path and unload them by the roadside. The mini-tractor system serves about 200 to 250 ha per day, and six to seven cutters are required for cutting FFB as well as cutting and stacking the fronds. For loose fruit collection, another group is required to do this task. By having a separate group for each task, the overall worker productivity increases by at least 33% (Malek and Yaacob, 1988). As the groups become more proficient in their tasks, productivity will increase further, earning the workers a better take-home pay. The productivity of both harvesters and machine is expected to increase gradually as the machine operators become more skillful and familiar with the operations and road network. Full cooperation from participating contractors and workers is necessary for the success of this mechanization programme.

The former Palm Oil Research Institute of Malaysia (PORIM) introduced a mechanical loader to be fitted to the mini-tractors (Abd Rahim *et al.*, 1990). The introduction of this implement eliminated the need for the two loaders required in the mini tractor-trailer system. The system was further improved by the introduction of a mechanical grabber with a high lift trailer system for FFB in-field evacuation. One of the biggest benefits of the mini-tractor grabber with the high-lift system is its ability to load FFB collected from the harvesting paths directly into the main-line transport vehicle. Hence, the tedious and expensive operation of reloading FFB to the main-line transport vehicle was eliminated (Kamarudzaman and Mat Lani, 1996). In Ladang RISDA Bera in 2002, where the above system was used, one machine could evacuate an average of 18.5 t per day. With an area of about 1900 ha, six units of the mini-tractor with grabber and high-lift trailer system were required.

Compact Transporter

The compact transporter has been modified to make it suitable as an in-field transport vehicle. This single chassis machine with four low-pressure tyres provides good manoeuvrability in palm rows, on narrow terraces, over undulating terrain and in soggy areas. To a certain extent, this machine is more practical compared to a mini-tractor or other off-road vehicle as it can manoeuvre in all types of terrain and gradient, whilst leaving little impact on the ground.

Field trials on the modified compact transporter have been carried out at the MPOB/UKM Research Station and in smallholder areas, where the terrain was flat to slightly undulating. The machine is used to transport FFB from the palm base to the collecting point by the roadside. During the process of collecting fruit bunches, the operator drives the machine along the harvesting path and stops the machine at a convenient location to load the bunches into the bucket. When the bucket is full, the machine is brought to the roadside to unload FFB (*Figure 2*).

Five to seven tonnes of FFB with an average bunch weight of 22 kg can be evacuated per man-day. This is a three-fold increase in productivity compared to when using a wheelbarrow (*Table 1*).

The compact transporter has a single chassis with four wheels, so the stability and manoeuvrability of this machine in the oil palm field is much better compared to a bigger machine with a trailer. This machine is not only useful for smallholders but also for workers in a plantation. It has multiple uses, not only for FFB collection but also for carrying other materials *e.g.* fertilizer as well as herbicide and water for weed control. The machine is found to perform well under any condition such as on terraces, undulating terrain and in soggy areas.

Figure 2. Compact transporter collecting fruit bunches along a narrow path.

Battery-powered Wheelbarrow

The conventional wheelbarrow is a device with a simple function and low maintenance utilized widely in oil palm estates for FFB evacuation and other operations. This good old-fashioned device is hard to beat in terms of effectiveness and cost but the device has its own drawbacks, such as:

- the operator has to lift, push and balance the device all at the same time during operation, which needs a lot of energy;
- the operator has to lunge forward to set the load in motion, then quickly correct his posture to get the device under control if the load is heavy;
- to climb a slope is difficult and going uphill with a heavy load is impossible; and
- accidents may occur when there is a loss in momentum because of slope or when hitting an obstacle along the path.

To improve the concept, so as to further enhance the effectiveness of the device, a battery-powered wheelbarrow (BPW) was designed and fabricated. This BPW provides a labour-saving alternative to the conventional wheelbarrow. It will assist the harvester in carrying out in-field FFB evacuation from undulating areas.

TABLE 1. COMPARISON OF PRODUCTIVITY BETWEEN WHEELBARROW, MECHANICAL BUFFALO AND COMPACT TRANSPORTER

Type of transporter	Productivity (t per day)
Wheelbarrow	1.5 – 2.0 (average 1.75)
Mechanical buffalo	7 – 10 (average 8.5)
Compact transporter	5 – 7 (average 6)

Description of the machine. BPW is an improvement on the conventional wheelbarrow with the introduction of a DC motor to drive the wheel via a sprocket and chain, and powered by a rechargeable 36-volt battery (*Figure 3*).

To operate BPW the operator still needs to lift (as in the case of the conventional wheelbarrow). Carrying the load in motion and travelling is achieved by applying pressure to the thumb switch. As the operator does not have to thrust forward, he will be in better position to lift with his legs (not with his back), and he is then free to concentrate on guiding the load and reacting to changes in the terrain and ground conditions. The motor will assist in handling loads up to about 150 kg (*Figure 4*). The thumb switch is also used to control the speed of the device. Disengagement of the motor can be done by immediately releasing the thumb switch. It is advisable to turn the power switch to the 'OFF' position when the machine is idle as the battery will continue to drain when the switch is in the 'ON' position.

BPW has been designed and fabricated based on a standard sized conventional wheelbarrow. Although the same chassis as with a conventional wheelbarrow is used, the chassis has been reinforced to improve the durability and life-span of BPW. Other work carried out included the modification of the conventional wheelbarrow to incorporate a motor, sprocket and chain, and a compartment for the switch and the battery. The specifications of BPW are given in *Table 2*.

More than 50 units of BPW have been fabricated and sent to estates for evaluation. Data on the overall performance of the machine, which included its productivity, operating, repair and maintenance costs and the suitability of the machine for different types of terrain and ground conditions, were recorded. The system of the machine can then be further optimized to obtain maximum productivity.

Field trials have been carried out in estates, where the terrain varied from coastal flat to undulating and hilly inland. BPW was mainly used to transport FFB from the palm base to the collecting points by the roadside. The system used by BPW was similar to that of the conventional wheelbarrow in that the harvester pushed BPW along the harvesting path and stopped to load and arrange FFB in the bucket, and then continued to push BPW along the path heading to the collection point. When the bucket was full, the operator went on to unload FFB at the roadside collection point. Three to four tonnes of FFB could be evacuated per man-day, which is a two-fold increase in productivity compared to using a conventional wheelbarrow (*Table 3*).

Using BPW is more productive compared to using a conventional wheelbarrow. Thus, to realize its full potential, BPW should be utilized on a commercial scale. The operating cost is also quite low as the machine is powered by 3 x 12 V batteries, which

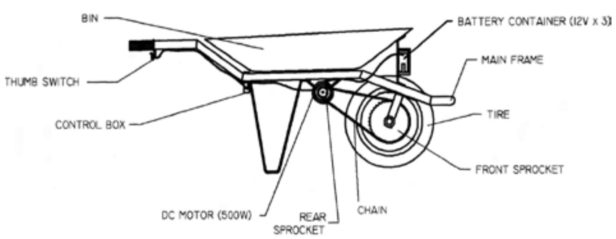

Figure 3. Configuration of the battery-powered wheelbarrow (BPW).

Figure 4. Collecting bunches using battery-powered wheelbarrow (BPW) along the harvesting path.

TABLE 2. SPECIFICATIONS OF BATTERY-POWERED WHELLBARROW (BPW)

Length	1400 mm
Width	710 mm
Height	580 mm
Weight	36 kg
Speed	0-5 km hr^{-1}
Motor power	500 Watts
Voltage	36 V, DC
Capacity	100-150 kg
Transmission	Sprocket and chain
Controller	Pressure-sensitive thumb switch
Tyre diameter	204 mm (8")

TABLE 3. COMPARISON OF PRODUCTIVITY BETWEEN A CONVENTIONAL WHEELBARROW AND BATTERY-POWERED WHELLBARROW (BPW)

Transporter	Productivity (t per man-day)
Conventional wheelbarrow	1.5 – 2.0
BPW	3.0 – 4.0

are rechargeable daily in about 6 hr. The machine being small (the same size as a conventional wheelbarrow) and lightweight, manoeuvrability in the oil palm field is much better compared to bigger machines. In addition, it has better accessibility to narrow paths or terraces and exerts lower ground pressure, which reduces the incidence of compaction and rutted paths. The machine is not only useful for transporting FFB but also for transporting fertilizers and seedlings.

Three-wheeler Power Cart (RIMAU 328)

The RIMAU 328 (3-wheel, 2-wheel drive, 800 kg capacity, 12 hp) is designed around the 3-wheel concept (*Figures 5a* and *5b*). Guthrie's (now Sime Darby Bhd) estates were selected for the trials when developing the RIMAU 328. During the first-quarter of 2000, a special committee was set up comprising a number of experts from Guthrie's estates and the mechanization department to oversee the development programme. This was to ensure that the demand and standards of the oil palm industry are met. The development programme ended in December 2001. After hundreds of hours spent at the drawing board and thousands more in the field trials, the RIMAU 328 was born. The RIMAU 328 is the product of vigorous testing and improvements. High standards had been set by the technical committee with the intention of ensuring peak performance and reliability. Evaluation and analysis of each problem in minute detail and a continuous improvement effort proved to be the core ingredient to the success of the project. From the first generation prototype to its current form, the machine has been transformed into a reliable, easy to handle and maintain, operator-friendly, cost-efficient and versatile machine.

Unique features

- The Vertilift or vertical lifting concept is the first of its kind for this application. It provides rigid, stable and smooth lifting. A double-acting cylinder ensures safe and reliable operation.

- Efficient transfer of power is achieved through direct coupling of the engine and transmission via a mechanical clutch. The clutch is well-protected from rain and dirt, therefore, allowing all-weather operation.

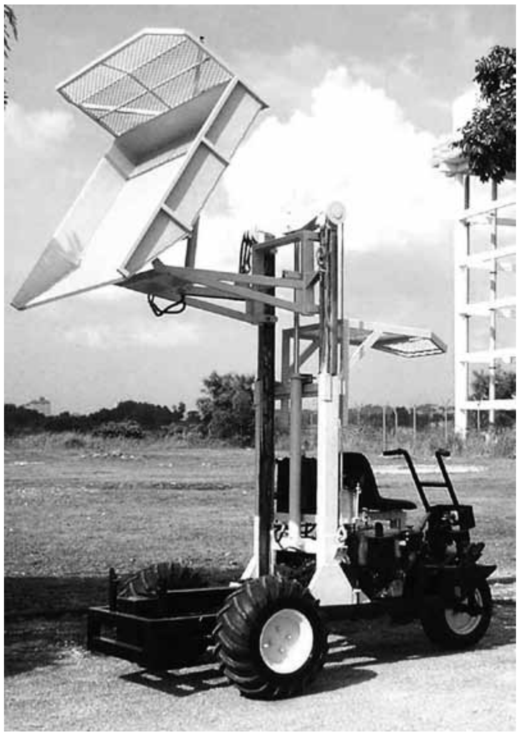

Figure 5a. High discharge point with a fork-lift concept of the 800 HP.

Figure 5b. Direct unloading of fruit bunches into a bucket using the 800 HP.

- The speed reducer (gear ratio 3:1) provides enough torque to the final drive while maintaining good speed. An added advantage of the speed reducer comes in the form of gear-braking – a feature which is most desirable when descending slopes under a heavy load, *i.e.* there is less dependence on the brakes. Hilly terrain is no longer impassable.

- The unique arrangement of the transmission-reducer-differential allows the wheel base to be kept to a minimum, thus giving optimum weight distribution and manoeuvrability.

- Based on the success of the 800 HL (High Lift) series, the 800 HP (High Pivot) series (*Figure 6*) inherits the same tried and proven features. The introduction of the 800 HP series is to cater for terraces and other applications, giving more choice to the user.

- Last, but not least, the machine has been designed for easy assembly and disassembly. The kit-form design not only benefits the production assembly process, it also allows for fast replacement and interchangeability of parts. Downtime can thus be kept to a minimum.

Four-wheeler Power Cart (RIMAU 4410)

The 4410 series – 4-wheel drive, 1000 kg capacity, 22 hp – was launched in August, 2006 (*Figures 7a* and *7b*). Its purpose is to cater for the demands of a much more difficult terrain and the need for higher payloads (upgradable to 1500 kg). The main design of the machine is similar to the 328 version with minor structural reinforcement. Valuable experience from the 328 series made its debut possible.

Eight-wheeler Power Cart

Various efforts are still being made to find suitable machines to assist in FFB evacuation in difficult terrains such as steep hilly areas. One of Guthrie's estates in Kulim is using a special unit 'eight-wheel mini-dumper' with a hopper capacity of up to 2 t to access a slope gradient of more than 30° in hilly areas (*Figure 8*). The use of this machine for FFB evacuation was found to be successful in eliminating manual labour (otherwise, workers would have to carry FFB on their shoulders). The average productivity of this machine was found to be 0.5 t hr^{-1}. Apart from fruit evacuation, this machine was also used for transporting fertilizer. Considering the extreme terrain conditions, this machine has proved to be very helpful in assisting the workers in taking out the fruit bunches. Further studies are being conducted to assess the technical superiority of the machine in the long run, and the outcome of this assessment might be of benefit to the plantation industry later on.

Figure 6. High pivot discharge mechanism of the three-wheeler power cart.

a

b

Figure 7. RIMAU 4410.

Loose Fruit Cleaner

FFB delivered to the mills have a high percentage of contamination, usually in the form of rocks, stones, sand, grass and weeds. The reasons for the need of having clean loose fruits before sending them to the mill is to get a higher oil extraction rate (OER). A large amount of trash will affect the mill productivity, as trash will absorb the oil, resulting in a reduction in OER. According to Ravi (2002), if loose fruits amount to 8% of the total crop and

Figure 8. Eight-wheeler power cart.

25% of which is trash, then for a mill processing 500 t FFB a day, trash alone can be as high as 10 t per day. If this weight is reduced from the total weight of FFB, OER will rise by about 0.5% (based on 20% OER). The average productivity of each loose fruit collector is 200-250 kg loose fruit per day, according to Ahmad *et al.* (1995). They also reported that the debris content in the raking activity can be as high as 60% by weight. Therefore, there is a need to minimize the amount of this trash from being sent to the mill by separating the debris from the loose fruits.

The separator machine is a mobile type which means it can be moved from one place to another (*Figure 9*). The separation will be carried out on a vibrating bed. In this development, the objective of the separating mechanism is to achieve zero debris and zero damage. The separating process is done via two methods of separation, *i.e.* with vibrating tables and a high velocity airstream created by twin fans. The upper vibrating table, lower vibrating table and the twin fans are coupled directly onto an engine via belt and pulley systems.

Figure 9. The air-assisted loose fruit separating machine.

Table 4 shows that the machine is able to separate an average of 30 kg of loose fruits in 1.5 min or an estimated 1.2 t hr^{-1}. The table also shows that the average amount of debris is 3.2 kg per bag or 10.5% debris weight per bag. This machine is able to clean the loose fruits to a level of 98.9%.

The study also indicates that the remaining debris left after using the separator machine is 0.3 kg or 1.1%. Most of the remaining debris was made up of small stones that have a similar size as the loose fruits. With only 1.1% debris remaining, this is even better than what was achieved by the manual-picking method, which had loose fruits containing 2.5% debris (Amirshah and Hoong, 2003).

By using the loose fruit separating machine, only 1% of the debris remained. The profit to be gained by the mill will be much higher as they do not have to pay the additional cost for the extra percentage of debris. Besides that, the cost for FFB transportation also can be fully optimized, as the entire transportation compartment will be filled up only with FFB and clean loose fruit.

Main-line Transportation

It is a common practice for FFB to be dumped by the roadside and then manually loaded into a truck or a tractor-trailer. Apart from manual loading, some estates also practise net loading. Collected FFB are dumped into these nets which have been laid out near the roadside, and the nets filled with FFB are attached later to a crane, fitted to a lorry or tractor, which will hoist them up and empty FFB into the lorry or trailer to be transported to the mill.

Damage to the fruits occurs during loading. With mechanical in-field evacuation, the use of a high lift trailer eliminates the handling of FFB at the roadside. Mini-tractors fixed with a high-lift trailer can now unload FFB directly into the main-line transport waiting by the roadside. The main-line transport could be a lorry or a trailer. With this system, no manual loader is needed and no loose fruits are scattered around as they are directly loaded into the transport vehicle. This system has been well-accepted by the oil palm estates.

Conventional bin system. Some estates have now successfully implemented an integrated system of FFB transportation. This system consists of a mini-tractor with a high lift trailer, a bin and a hook lift mechanism. This hook lift is an arm mounted to the lorry chassis which is able to pull up a bin filled with 8 to 12 t of FFB. With this system, an estate only needs to deposit the containers at predetermined locations along the roadside. Once the bin is full,

TABLE 4. SUMMARY OF PRODUCTIVITY AND LOOSE FRUIT CLEANLINESS STUDY

Trial No.	Before W_1 (kg)	Time completed T_1 (s)	After W_2 (kg)	After manually removing debris W_3 (kg)	W_1-W_2 (kg)	W_2-W_3 (kg)
1	30.7	143.0	28.0	27.6	2.7	0.4
2	32.0	126.0	28.0	27.7	4.0	0.2
3	29.1	108.3	26.3	26.1	2.8	0.2
Average	30.6	125.8	27.4	27.1	3.2	0.3

Note: W_1: weight of loose fruits before the cleaning process.
W_2: weight of loose fruits after the cleaning process.
W_3: weight of loose fruits after manual cleaning.
T_1: time to complete the cleaning process for one bag of loose fruits.

a lorry with a hook-on mechanism will then attach to the filled container and transport it to the mill. With this system, an estate has experienced a reduction of more than 50% in the use of trailers. A study done by an estate revealed that for an area of 1000 ha three mini-tractor grabbers with a high-lift trailer and a prime mover with hook-on system were required. The cost of main-line transport of FFB using this system is RM 4.30 t^{-1} of FFB. With this system, the labour requirement can be reduced by 90% (Samsudin, 2002).

Mini-bin system. This system, which requires minimal infrastructural preparation in-field, involves FFB being brought to the roadside platforms along the collection roads using current in-field collection systems, *e.g.* wheelbarrows, baskets and other manual collection systems. The crop is then unloaded directly into mini-bins (with a capacity of 1-1.5 t each). The mini-bins are then lifted up by a 2- to 4-t mini-hook lift equipment mounted on a scissors lift trailer. The trailer is then towed by a prime mover or tractor. FFB in the mini-bins are then transported along the collection roads to the main-line roads for the crop to be transferred into larger bins (of 8 to 10-t capacity). The crop transfer process is achieved by raising the mini-bins with the scissors lift trailer to a suitable height before tipping the crop into the larger bin. The crop in the larger bin is then transported by a bigger capacity hook lift for delivery to the mill.

The system has the following potential benefits:

- it does not disrupt the existing system of workers using wheelbarrows baskets and other manual in-field FFB evacuation methods;
- no in-field infrastructural preparation is required;
- there is a reduction in labour use; and
- there is a reduction in machine use.

PRIVATE SECTOR PARTICIPATION IN MECHANIZATION R&D

More private sector participation in R&D is required. A number of companies have either ceased to exist or have switched operations simply because they cannot sustain the heavy financial strain of R&D. What drives these private companies to be involved in R&D in the first place is the market potential for machine systems. However, the market potential is like chasing a mirage. A machine may take a few years to be developed and perfected, and several more years to market. Virtually no small privately owned companies have the staying power to see the machine through to the market-place.

Larger companies lack the desire, not because of financial limitation but rather due to the inherent complexity of R&D. The need to maintain development teams and the lack of experience have dampened the interest. Unlike small companies, larger organizations suffer bureaucratic handicaps. Decision-making is slow and not conducive to an R&D environment.

In recent years, the government through its Ministry of Science, Technology and Innovation (MOSTI) and the Small Medium Industry Development Corporation (SMIDEC) has allocated various funds and grants to encourage private sector participation. Many companies have benefited from these. So too will the industry.

However, most of these funds or grants support only the actual development work. There is still no guarantee that the product is saleable. A company cannot survive from project grants alone. The real gain is when the product is accepted by the market.

In order to achieve this, support from the industry, namely by MPOB and large plantation operators, is required: the former to scientifically identify design viability and the latter to be contractually committed. Only then can the grants be effective.

CONCLUSION

This article demonstrates that indeed there are researchable areas for equipment used in the in-field transportation or evacuation of FFB. As simple as it may sound, this poses a challenge in its own right. The past 20 years, maybe more, have seen various methods and modes of evacuation put to field test with varying results. From the primitive buffalo-drawn cart to the motorized wheelbarrow, others include the motorcycle-drawn cart, the mini-tractor with a high-lift trailer and grabber combination, the tracked vehicle and tractor, the well-known 3-wheeler, and the multi-wheel drive single chassis vehicle – just to name a few. Some of these made it to become industry standards while others died silent deaths.

The plantation sector, dominated by the oil palm industry, needs in-house technology to improve productivity as well as reduce costs. Foreign technology needs to be adapted to suit local requirements – such as the operators' technical level and the working environment. Malaysia being the industry global leader means that there is an opportunity to be the trend setter. Furthermore, oil palm is unique to this part of the world. Therefore, machines must be developed for the local conditions by local experts. With export potential, they can even become a revenue earner.

Currently R&D is undertaken by MPOB, various institutions of higher learning, large oil palm plantation operators and a few active private companies. Often there is duplication of development efforts. Duplication may be encouraged to a certain extent to promote positive competition. However, there is a need to establish a proper yardstick to measure machine performance so that the industry can assess the machine based on standards that have been agreed upon.

As a typical example, it may be claimed that a machine can handle 20 t of FFB per day. However, there are so many factors that may affect its performance, such as the terrain, the daily yield, the weather, the number of workers involved, the location of supporting vehicles or trailers, the distance from the point of loading to unloading, *etc*. In order to avoid confusion in translating these data, an industry standard is required to provide meaningful guidelines with which to measure performance.

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