

Innovative Machines for Compost Application in Oil Palm Plantations

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ABSTRACT

The palm oil milling processes produce by-products or wastes in the form of empty fruit bunch (EFB) (23%), mesocarp fibres (12%), shell (5%), boiler ash, decanter cake, sludge and palm oil mill effluent (POME) (60%) for every tonne of fresh fruit bunch (FFB) processed (Najafpour et al., 2005). These by-products can be utilised as renewable resources with present technologies in harmony with the ecological system. Some examples of these renewable resources are biogas and biomass for the energy sector and composting for soil amelioration, in tandem with sustainable development for the oil palm industry.

Composting is indeed a viable means of converting oil palm organic wastes into organic fertilisers and soil conditioners that can be used safely and beneficially to supplement inorganic fertilisers. However, most producers encounter problems related to compost handling and applications, resulting in the extensive use of workers and the deployment of other conventional methods of applying compost in the plantation. Presently, getting workers to carry out harvesting of FFB is already a problem and will be compounded with compost production, handling and applications in the oil palm plantations.

Realising the imminent issues confronting compost application, Sime Darby Plantations has adopted various mechanisation application methods covering up to 35% of the targeted total compost production capacity.

This article presents an overview of the various types of innovative machines used presently for the application of compost in Sime Darby plantations and their performances. The necessity to adopt various types of machines is simply to achieve larger coverage to accommodate the compost production

volume and to effectively distribute the compost to the fields.

ABSTRAK

Proses pengilangan minyak sawit menghasilkan bahan sampingan atau buangan seperti buah tandan kosong (BTK) (23%), serat mesokarpa (12%), tempurung (5%), abu dandang, kek dekanter, endapan dan efluen kilang minyak sawit (POME) (60%) bagi setiap tan buah tandan segar (BTS) yang diproses (Najafpour et al., 2005). Kesemua bahan sampingan ini boleh digunakan sebagai sumber boleh diperbaharui dengan teknologi masa kini seiring dengan sistem ekologi. Sebahagian daripada contoh sumber boleh diperbaharui adalah biogas dan biojisim untuk sektor tenaga dan kompos bagi penambahbaikan tanah, selaras dengan pembangunan kelestarian untuk industri sawit.

Pengkomposan adalah satu kaedah yang praktikal untuk mengubah bahan buangan organik sawit kepada baja organik dan perapi tanah yang selamat digunakan dan berfaedah sebagai tambahan kepada penggunaan baja inorganik. Namun, kebanyakan pengeluar menghadapi masalah berhubung dengan teknik mengendali dan mengaplikasi kompos, mengakibatkan penggunaan tenaga kerja yang ramai dan menggunakan kaedah konvensional lain untuk mengaplikasi kompos di ladang. Pada masa kini, mendapatkan pekerja untuk menjalankan penuaian BTS merupakan satu masalah dan apatah lagi dengan adanya pengeluaran, kendalian dan aplikasi kompos di ladang.

Menyedari hakikat yang perlu ditangani mengenai pengaplikasian kompos, Sime Darby Plantations telah menggunakan pelbagai kaedah mekanisasi yang meliputi kawasan sehingga 35% keluasan yang disasarkan untuk kapasiti pengeluaran kompos.

Artikel ini membentangkan pandangan menyeluruh pelbagai jentera inovatif yang

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digunakan masa kini untuk tujuan aplikasi kompos di Sime Darby Plantations serta prestasinya. Keperluan untuk mengguna pelbagai jentera adalah untuk mencapai keluasan yang besar untuk mengimbangi jumlah pengeluaran kompos serta pengagihan kompos yang berkesan di ladang.

Keywords: biomass, composting, soil conditioners, compost handling, mechanised methods.

INTRODUCTION

The challenges of today's oil palm plantation are not only confined to meeting all the compliances for sustainable development but also in ensuring that apart from preserving the environment, the results from managing the waste by-products from the milling operation will be economical and sustainable.

Composting of empty fruit bunch (EFB) with palm oil mill effluent (POME) has been acknowledged as a handling method closely related to the sustainable development of the environment for the oil palm industry. This would help in reducing the dependence on chemical fertilisers, as well as improving the content of the organic matter of the soil and its fertility. Good quality compost with the correct method and rate of application would increase oil palm yield between 12% - 19% (Ognyan Kostov, 2008). Producing compost from the palm oil mill waste has been advocated under the Malaysian Strategic Focus in developing renewable energy (RE) and by the attraction of the carbon credit under the Clean Development Mechanism (CDM), which act as a catalyst in the biomass-based RE along the palm oil production chain.

Nonetheless, in the compost production, the process chain will not be completed if the application method is done inefficiently and costly. At present, compost application is labour intensive as it is distributed manually to the fields. This is an issue to be reckoned with and is thus a setback to some compost producers and operators.

Chapter 9 of the National Key Economic Areas (NKEA) under the Economic Transformation Programme for Palm Oil states that although mechanisation had been gradually introduced over the years, it has yet to replace the high labour requirements in the upstream sector. Wherever it is introduced, mechanisation must meet the stringent criteria in reducing labour costs, increasing productivity and improving product quality. For this reason, one of the key challenges of the plantation segment is to scale up its level of mechanisation.

PRIORITIES FOR SUSTAINABLE DEVELOPMENT

In pursuing sustainability, generally for the biomass sector and specifically for compost, the focus must be clear as to the necessity to embark and implement the best and most economical methods to manage the mill waste and most importantly the effort towards environment conservations.

In Malaysia, biogas from POME and biomass energy from solid waste have been proposed as RE with their power potential maximised if palm biomass is utilised. But there is an obstacle to the acceleration phase for the biogas or biomass RE initiatives in the not so attractive feed in tariff (FiT) offered to the Green Independent Power Producers (IPP) (Er, *et al.*, 2010). The price variation is perhaps due to the location and connectivity infrastructure. However, the Ministry of Energy, Green Technology and Water (KeTTHA) has provided an indicative range of FiT for various RE technologies concerned, as well as the IPP duration and degression in an effort to optimise the utilisation of RE.

Composting, on the other hand has resulted in some carbon storage (associated with application of compost to agriculture soils), as well as minimal carbon dioxide (CO₂) emissions from transportation and mechanical turning of the compost windrow piles. As a result, it has become one of the preferred options by plantations due to its lower investment cost and reasonably good returns and savings as an inorganic fertiliser supplement. Nonetheless, the effective application method of compost to the fields with improved productivity and efficiency must be incorporated.

THE PHYSICAL PROPERTIES OF COMPOST FROM MILL WASTE

The nature of compost material presently produced by composting plants comes in many different forms. Some are fibrous (*Figure 1*), the rest bulky and voluminous (*Figure 2*), with different moisture content and some foul odour, whilst others are quite refined and dry depending on the treatment processes and the maturity period of the compost. The compost nutrient level will determine the quantity required per palm or per hectare, which has to be applied as soon as it matures to supplement the nutrient demand by the oil palm.

The composting process requires continuous supply of EFB from the mill, hence, it is imperative that all matured compost is delivered to the fields and applied immediately. Delay in distribution to the fields will result in a high compost stock-

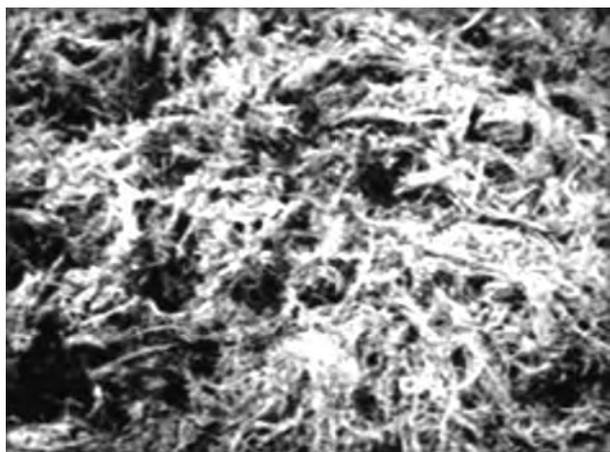


Figure 1. Matured compost.

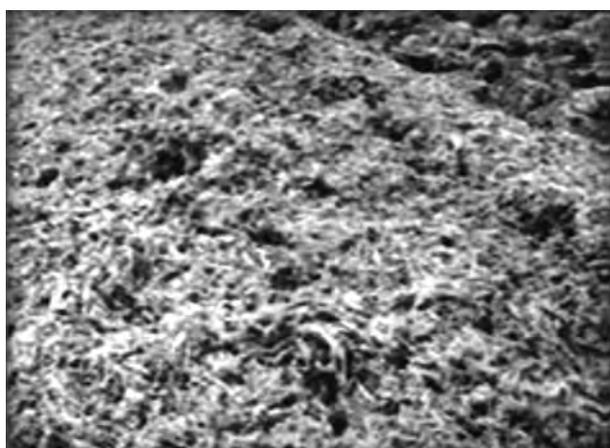


Figure 2. Compost windrows.

pile and will eventually cause a backlog of EFB. Prolonging delay in application would cause the nutrients to be leached out along the field roads instead of to the palm trees.

CURRENT PRACTICES FOR COMPOST APPLICATION

The current problem of labour shortages experienced by the plantation industry, especially in getting skilled workers for harvesting, will continue to become increasingly critical. As such, it would not make sense to divert labour to complete a compost application programme that requires a rate of about 50 or 100 kg per palm, which could result in increased yields but remains unharvested due to lack of labour. Thus, mechanised compost application for all suitable terrain will no longer be just an option but a necessity to relieve the scarce labour supply and be a supplement to inorganic fertiliser.

Manual Compost Application

It is a common practice today that most compost materials are manually applied with the use of ei-

ther wheel barrows or custom-made wheel carts by several workers especially in terrace areas. Whenever labour is very acute, machines such as backhoes, mechanical buffaloes (MB) and back-pusher tractors with buckets or tippers suitably modified according to the rate of application, are used on flat undulating terrain. The challenge is intensified for plantations in Sabah and Sarawak where high rainfall is one of the factors that impedes efficient distribution. As such, compost has to be placed in individual bags of 20 – 30 kg to facilitate easy handling and application to the fields. Furthermore, the hilly terrain and weather conditions can also have a compounded effect on manual compost applications.

Manual compost applications (Figures 3 and 4) require between 5 – 10 workers with a productivity range of 25 – 50 palms per man day for Sabah/Sarawak and 40 – 60 palms per man day for Peninsula assuming the application rate is about 100 kg per palm. The total average productivity ranges between 1.7 to 5.7 ha per day depending on the number of workers per group, terrain and accessibility. For a composting plant producing between 2000 – 3000 t per month will require an area of about



Figure 3. Manual application of compost.



Figure 4. Using the wheel barrow.

142 – 214 ha per month. With 10 workers applying about 5 ha per day, it will take between 28 – 43 days to complete the tasks on full time basis.

This becomes a challenge particularly for estates that can afford only the required number of workers to deal with the application. In view of this, Sime Darby Plantations which now operates 21 composting plants have no other alternatives plan to them except to explore how mechanisation can be utilised as a means to apply the compost.

The rate for manual compost application varies between RM 0.60 to RM 1.30 per palm depending on the type of terrain such as coastal, terraces and hilly areas. For these types of difficult terrain, it would be preferable if the areas are to be avoided unless all flat and undulating terrain for mechanised application has been exhausted.

Hence, the only way to mitigate the application problem is by adopting mechanised means to apply compost to the fields.

MACHINERY FOR COMPOST APPLICATION

Composting of EFB with POME is relatively a new practice in the Malaysian oil palm industry which was spurred by issues related to the sustainability of palm oil. This, however, will only partly resolve problems related to mill waste disposal. The approach in resolving these issues should be holistic in nature, such that the compost produced is well distributed and applied to the fields to realise the benefits as stated earlier.

Despite confronting the issues of handling mill processing waste by various methods, there are still very limited types of machines that can be used for compost application, considering the volume of production and the huge field area that the materials need to be applied to. As different terrains also pose another challenge in the selection and adoption of the right equipment, acquiring a machine that is very versatile and which would match all types of terrains in the oil palm plantation would be difficult.

Criteria for Machine Selection

Many factors have to be considered when selecting the appropriate machines for specific purposes in oil palm plantations. This is to ensure that productivity and efficiency will be achieved with the long-term utilisation of the machines.

The performance of the machines for compost application will be a function of several natural elements, including existing work methods in the plantations and the products to be applied such as follows:

Types of product/material – from palm oil mill waste. Compost being an organic material, is fibrous, lumpy and has tough physical properties even after treatment, and is in a decomposed state for more than six weeks. Upon maturity, it needs to be distributed immediately within the vicinity of the palm preferably on the frond stack avenues and between palms trees where the roots are.

Placement method. The way the compost material is to be placed will describe the type of discharge pattern on the designated point. This will in turn provide better efficacy of the compost that is to be decomposed and converted into organic soil matter and nutrient adsorption by the soil and eventually the roots of the palm trees.

Terrain and accessibility. The vital factors to be considered in order to establish the right selection of machine are horse power (hp), transmission capability and manoeuvrability. It is critical that the machine capability is matched with the requirement of the operation in ensuring that the desired performance is attainable. However, there are machines which can be used on terrace areas provided that new paths are prepared early, constructed and made accessible to facilitate the movement of machines in the fields.

Soil type and rainfall patterns. When machines are deployed in the plantation, it is imperative that they are operational most of the times. However, the soil type and rainfall patterns may deem some machines unsuitable due to the different traction requirements and gross weight of the machines themselves which may affect their performance.

Apart from the above, the distance of the composting plant which is usually close to the mill, also plays an important role in deciding the types of machines required. This is to minimise the logistic requirements for the delivery of compost into the field dumpsites.

The consideration of the above criteria and the operator's skills will enable the selection of the right machines for the compost application, hence, ensuring the desired productivity. The use of machines for the compost application is no longer an option because of the massive compost volume that

has to be delivered and applied within the shortest time possible.

Mechanised Compost Application in Sime Darby Plantations

With the increasing demand to mechanise various operations in the plantations, the Mechanisation Unit of Sime Darby Plantations was given the task to implement a suitable mechanisation system for the relevant operations such as fertilisers and compost applications. Over the years, the effort has been successful as evident in the Multi Bin Silo (MBS) system.

For mechanised compost application, the trials and testing of various types of machines were conducted in many stages with continuous modifications to ensure that the machines were practical and reliable for the intended purpose. Using the 'adapt and adopt' principle and with some innovative approach, the Mechanisation Unit had successfully adopted four different types of machines for the compost application.

Currently, these four types of machines are widely utilised in all Sime Darby estates having the composting facilities. They are to apply compost to the fields covering about 24 000 ha. Further expansion is possible and is being explored.

Compost application machines (CAM). The CAM was originally used for EFB application but with some modifications to the conveyor system it can now be used for compost application. The modification is necessary to accommodate the different material physical form of EFB, *i.e* in bunch form versus shredded form.

The trailer is designed with a payload capacity of up to 7 t with all tyres having a minimum of 10 ply rating to prevent punctures. The CAM productivity ranges up to 50 t per day for compost and can be as high as 70 t per day for EFB application depending on the distance from the composting plant/mill to the field.

The CAM will be suitable for inland estates application having flat undulating terrain without the moisture conservation pit (MCP) in the inter rows and preferably be within 8 - 10 km from the composting plant/mill.

The application efficiency using the CAM is based on the average hectare achieved, calculated from the payload over the rate per palm of which every load must be applied to the targeted number of palms. The obvious advantage using the CAM would be no requirement for the compost to be

delivered to the dump sites in the fields. This will avoid the double handling/loading of the material prior to application, hence the lower cost.

For large scale compost application of up to 1000 ha, it is also important to identify the suitable areas and the logistic requirements so that a combination of mechanised equipment may be used to maximise the coverage within the period of the total application programme.

The selection of at least a 90 hp tractor (*Figure 5*) is critical to ensure that the trailer can be manoeuvred comfortably over extreme ground undulations and depressions along the frond stack avenues. The tandem axle is designed to work independently on the ground surfaces and reduce the rolling resistance, thus preventing the trailer to bog down. The tractor speed and conveyor movement are of prime importance in ensuring an even material distribution over the targeted area and the number of palms. This will be made possible with a skilled operator who should be able to calculate the material volume and the number of palms the material to be applied to by synchronising it with the tractor and conveyor speed.

To achieve the rate of application, the machine has to be calibrated prior to commencement of the actual work. There are three speed components to be adjusted in order to attain the correct application rate. The trailer vertical and floor conveyor speed can be regulated via the individual hydraulic flow control valves which control the quantity of material to be discharged. This is then synchronised with the tractor speed to enable the material to be spread evenly, as shown in *Figure 6*. The operator's skill also plays an important role in this operation to ensure that the materials are well and evenly distributed.

Mini Tractor Grabber (MTG). The MTG is nothing new in Sime Darby Plantations as it is extensively used for infield crop evacuation. For compost application in coastal estates, the MTG equipped with Low Ground Pressure (LGP) tyres is found to be suitable due to the soft soil condition and subsidiary drainage system. The MTG can also be used for inland areas where the fields are not suitable for the CAM, due to the presence of field drains, Moisture Conservation Pit (MCP) or Closed Ended Conservation Trench (CECT).

For this method of application, the compost materials are first delivered to the fields by truck from the composting plant and dumped by the roadside. The MTG will then load the compost using the grabber which is suitably designed (*Figure 7*) to grab the material at the roadside heap



Figure 5. Compost application machine (CAM) with a 90 hp tractor.



Figure 6. Compost application on the frond stack avenue.



Figure 7. The compost grabber.

(Figure 8). Each compost heap varies from 5 to 10 t depending on the truck or tractor trailer capacity.

The trailer has a capacity of up to 1.5 t and is towed by a mini tractor with 29 hp. The MTG

moves on the path and the compost is applied based on spot application in between the palms as shown in Figure 9.

For compost application using MTG to be productive, a minimum area of at least 400 ha per machine should be established to ensure that maximum utilisation is achieved all year round. Application cost using MTG will have to include the transportation cost of the material delivered to the field either using tractor trailers or trucks. This application method is not restricted by the distance of which the compost has to be delivered to the fields.

Presently, for coastal compost application, the average productivity achieved is 28 t per day and 25 t per day for inland application. For inland compost application, the MTG can be utilised when MCP are scattered in the fields and other machines are not possible.

Coordination amongst the staff is vital for the planning and delivery of the compost at the roadside to ensure the heap is allocated adequately for the intended field.



Figure 8. Loading compost with the grabber at the roadside heap.



Figure 9. Application method using the Mini Tractor Grabber.

Compost trailer. The specially designed compost trailer as in *Figure 10* is unique whereby the spreader which is located at the rear end of the trailer and the floor conveyor, is powered mechanically by the tractor power take off (PTO). The floor conveyor speed is regulated by an index gear mechanism to facilitate the shifting of the material towards the rear end into the spreader which is rotated via a shaft from the indexing gearbox.

With this trailer, compost is required to be delivered to the roadside and a loading machine such as a backhoe will load up the trailer. This trailer having a capacity of up to 5 t is suitable for flat undulating terrain and areas far away from the composting plant. The compost will be spread evenly on the frond stack avenue (see insert in *Figure 10*) and will take less than 10 min to unload the material.

For flat undulating areas, the productivity achieved ranges between 60 – 80 t per day subject to the field accessibility and ground conditions which can affect the performance.

Compost Applicator for Terrace (CAT). Also known as the Advance Mechanise Field Applicator (AMFA), this machine is specifically designed for compost application commonly used in Europe for pastures cultivation. Built as a compact 40 hp 4-wheel drive machine with either a single chassis with front wheel steering (*Figure 11*) or articulated chassis model, the applicator has a trailer version which can be towed by a tractor (*Figure 12*) for infield application as an alternative to the MTG.

The applicator equipped with a special rotary discharge at the rear end can rotate 300° allowing the material to be discharged on the right or left side, thus making it versatile for terrace application. With its compact design, the machine is capable of moving around in terraces with at least 1.56 m (5.12 ft) and can turn around tight corners, especially the articulated version, thus making the machine very versatile for young palm areas with height up to 2.5 m (8.2 ft).

Two units of the AMFA are currently operational at the Sime Darby Plantations and perform very well at an average rate of 45 t per day on flat undulating areas and averaging about 25 t for wide terrace areas.

The AMFA machines will require assisted loading using a backhoe to maximise its performance and at least two machines are to be deployed for compost application. As declared by one of the concessionaire using the AMFA machine for compost



Figure 10. The compost trailer with applicator.



Figure 11. The Goldoni Transcar – compost applicator for terrace.

application at Kerdau Estate, the average productivity for one machine averages about 45 t per day and has since been carrying out the application for the estate for more than two years. The compost material can be evenly laid between palms on terrace areas or at the frond avenues (insert *Figure 12*) for flat undulating terrain.

The tractor-towed AMFA will be more suitable for flat undulating terrain as the overall length will need larger turning radius, hence, unsuitable for terrace areas. The tractor power required will be at least 35 hp to suitably match the applicator.

The above machine has demonstrated its versatility and has the capability to carry out compost application at various challenging terrains apart from the flat undulating areas. However, the capital



Figure 12. Tractor towed Advance Mechanise Field Applicator (AMFA).

investment for the AMFA is quite substantial being in the range of RM 171 000 per unit, whilst the trailer unit cost around RM 70 000 per unit excluding the tractor.

RESULTS AND DISCUSSION

Most planters who operate composting plants have acknowledged problems associated with the application of the compost material produced. Presently, it is largely done by manual labour, which is very demanding due to the large coverage and difficulty in handling the material, despite

having difficulty in obtaining the workforce to do the job.

With the introduction of various types of machines for compost application (Table 1), there will be several options available to mechanise compost applications for various terrain conditions. Therefore, it is crucial to select the right machines for the right terrain to maximise machine performance and provide the desired return on investment in addition to substituting manual labour for compost application.

TABLE 1. SUMMARY OF THE COMPOST APPLICATION MACHINES

Parameters	Compost Application Machine	Mini Tractor Grabber	Trailer Applicator	Advanced Mechanised Field Applicator
1 Distance (plant to field)	8 – 10 km	From 5 km & above	Above 10 km	From 5 km & above
2 Mode of application	FronD avenues	Between palms	FronD avenues	Between palms & frond avenues
3 Landscape	Flat undulating only	Flat undulating only	Flat undulating only	Flat undulating & terrace
4 Terrain	Inland	Inland/coastal	Inland	Inland/coastal
5 Transport to field	No	Yes	Yes	Yes
6 Assisted loading	No	No	Yes	Yes
7 Productivity (tonnes per day)	30 - 40	20 - 28	25 - 35	Up to 40
8 Minimum coverage (ha)	500	400	500	500
9 Cost per ha* (RM) excl. transportation cost	RM 220	RM 165	RM 200	RM 250
10 Capital investment/unit	RM 170K	Min. RM 82K	RM 115K	RM 171K

Note: Data as at September 2011.

*Inclusive of depreciation.

Transport cost ranging from RM 6 – RM 12 per tonne.

CONCLUSION

In order for the oil palm industry to sustain its biomass sector and continue its development particularly for composting of EFB, it is essential that mechanised application is implemented to achieve the desired productivity and efficacy. Today, it is a known fact that for the oil palm industry to be sustainable in the long run, labour substitution by mechanisation is inevitable hence enabling the industry to continue pursuing its waste to wealth objectives and meeting its 3P's requirements.

The availability of the various types of compost application machines as illustrated and discussed in this article will provide the industry with a mechanised solution, which can be widely implemented by oil palm plantations. This should not deter them to continue producing compost towards effective waste management in an environmentally and socially responsible manner.

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