

Aerial Fertilization of Oil Palm

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Today's technology is allowing for significant improvements in techniques associated with aerial fertilization. This article outlines the economic and nutrient efficiencies gained in an oil palm plantation currently operating a successful aerial fertilization program.

The dramatic expansion of the area planted to oil palm over the past 15 years has resulted in the development and reclamation of much marginal land, including peat soils and steeply sloping land. In some of these areas, in-field mechanization using ground vehicles is not possible because of steep slopes or poor drainage, or unacceptable soil and land damage caused by vehicles. Suitable areas for oil palm have been developed in remote locations where manpower is in short supply and it is difficult to maintain high standards of manual fertilizer application.

The oil palm requires large amounts of mineral fertilizer (500 to 1,000 kg/ha), usually carried into the field by hand or with a wheelbarrow. Each palm must receive the specified amount of fertilizer, usually applied by workers using calibrated containers to deliver the required amount to each tree. Poor supervision is one reason why fertilizer is often not applied properly and the application rate is reduced in the parts of the field most distant from the roadside. This results in spatial variability in the incidence of deficiency symptoms (as shown in the photo) and reduced yield and profitability. A second problem is fertilizer pilfering, due to the wide ratio between the value of fertilizer and the cost of labor.

Patches of light-coloured palms in the middle part of fields are caused by uneven manual fertilizer application.



Photo source: PPI/PPIC ESCAP

For immature palms, fertilizers are best applied within the drip circle because root development is quite limited during the first three years after field planting. In contrast, roots under mature palms branch throughout the entire soil volume to a depth of 40 to 70 cm. It is therefore not surprising that only small differences in yield were detected between treatments that compared the application of fertilizer over the soil in weeded palm circles with fertilizer broadcast over the inter row (Foster and Dolmat, 1986). Some older work showed that the loss of fertilizer nutrients by leaching is reduced when fertilizers are applied over a larger surface area (Ochs, 1965).

Mechanical fertilizer application using ground vehicles in mature plantations meets

most requirements in terms of even fertilizer application within fields, reduced labour requirements, and rapid application. Tractor-mounted spreaders can be used conveniently on flat mineral soils, but aerial fertilizer application is the only possible means for mechanical fertilizer application on peat soils and steeply sloping land where the cost of preparing the field for tractor access is too great.

Aerial fertilizer application has been used for years in the U.S., Australia, and New Zealand, but the first commercial trials for aerial fertilizer application in oil palm were implemented by FELDA in Malaysia (Wood et al., 1973; Tan et al., 1977; Lee, 1977). Several types of agricultural aircraft have been tested, with carrying capacities ranging from 800 to 1,000 kg. Some of the present models of agricultural aircraft have a capacity of 2,000 kg.

The main infrastructure requirement for aerial fertilizer application is a landing strip (one for every 3,000 to 5,000 ha), equipped with two fertilizer bins with capacity of 70 tonnes (t) each, for fertilizer loading and mixing. Equipment required for aerial fertilizer application includes the following: aircraft, loader, Global Positioning System (GPS), portable blender, and weighing equipment. A cement truck can be used to mix two or more fertilizers together to increase the rate of application and improve the efficiency of operation. A special loader, equipped with a hydraulic or cell weight gauge, provides sufficiently accurate records of the quantity of fertilizer applied.

Fertilizers that are to be mixed must be compatible in terms of physical and chemical properties (Table 1). Chemically compatible fertilizers may be mixed together without gaseous losses, decrease in nutrient availability, or caking due to chemical reactions. Physically compatible fertilizers have similar granule sizes and density so that segregation does not occur during transport (International Fertilizer Industry Association, 1992).

Table 1. Compatibility of fertilizer used in oil palm .

	Ammonium nitrate	Urea	Triple superphosphate	Diammonium phosphate	Rock phosphate	Potassium chloride	Kieserite	
	Red	Yellow	Green	Green	Green	Green	Green	Ammonium sulfate
		Red	Yellow	Green	Green	Yellow	Green	Ammonium nitrate
			Red	Green	Green	Yellow	Yellow	Urea
				Yellow	Green	Green	Green	Triple superphosphate
					Green	Green	Green	Diammonium phosphate
Red	Incompatible					Green	Green	Rock phosphate
Yellow	Limited compatibility ¹						Green	Potassium chloride
Green	Compatible							

¹ Denotes mix just before application
 Source: International Fertilizer Industry Association, 1992

Fertilizer can be transferred to the agricultural aircraft using a loader.



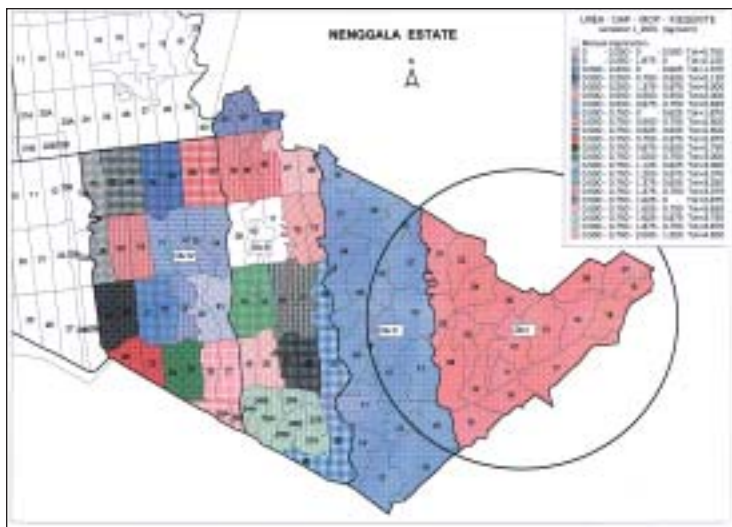


Figure 1. Fertilizer is applied by airplane in Division I and II where topography makes manual fertilizer application difficult and inefficient.

has replaced the use of ground flags to direct the aircraft. The system also provides a computerized record of each flight path including all the flight characteristics (swath, height, and speed) required for accurate fertilizer application mapping (Figure 2).

There are several advantages associated with aerial application. Fertilizers are evenly applied over the target area. Lateral distribution can be mastered by adjusting the swath width based on test runs where fertilizer is applied in an open area. A simple mathematical model can be fitted for each type of fertilizer, depending mostly on its specific guide number and uniformity index. Possibility of fertilizer theft is greatly reduced. Minimal field supervision is required because fertilizer is delivered to the airstrip bin. Application of fertilizer is supervised by reference to the aircraft's tracking record and through periodic checks in the field. The computerized recording system, together with the DGPS tracking guidance system, provide full performance accountability, as well as automatic and accurate guidance for the pilot to fly in parallel application lines. The amount of fertilizer applied is monitored using the weigh gauge fitted to the loading system. A fertilizer program can be completed in a shorter time compared with manual application. This may reduce losses as the timing of fertilizer application can be adjusted to local weather patterns.

By introducing aerial fertilizer application, workers are spared for specialized and highly paid tasks (e.g., harvesting) that have not yet been mechanized. This is very important in remote areas where manpower is scarce, or on steep terrain where manual fertilizer application is difficult to supervise.

Aerial application of fertilizer, properly done, does not have any adverse impact. Continuous monitoring of surface water and ground-water has shown that nutrient losses are small (Satyoso et al., 1997; Liwang et al., 2000) partly because a smaller amount of nutrient is applied per square meter, and thus nutrient losses due to leaching and

Geographic Information System (GIS) software is used to prepare maps showing the required application rate of fertilizer for each single estate field (Figure 1). These maps are required by the pilot to prepare a work program, and are more useful than tables showing fertilizer recommendations. Development of Differential Global Positioning Systems (DGPS) and related software for track guidance

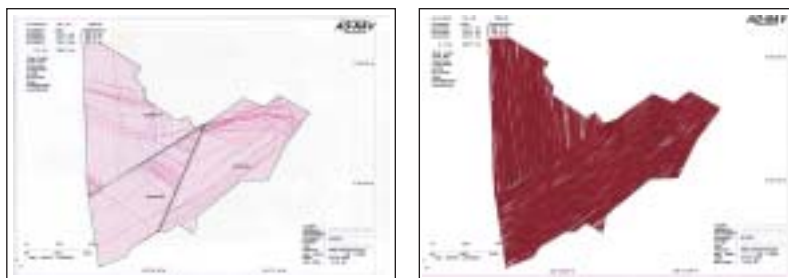


Figure 2. Computer printout showing airplane tracking details (left) and proportion of ground covered (right). The pilot has achieved good ground coverage using GPS.

surface run-off are reduced (Ochs, 1965).

Several factors are critical for successful aerial application. The entire fertilizer procurement process must be coordinated with the field application program. The physical quality of fertilizer materials must be optimized to ensure uniform distribution over the field. Quality granular fertilizers (e.g., urea, diammonium phosphate, potassium chloride) should be used. Blending must be monitored closely when two or more fertilizers are applied at the same time. Fuel and oil delivery and the provision of spare parts must be organized, thereby avoiding costly aircraft downtime. Administrative requirements for the pilot, aircraft, and airstrip, as well as flight authorization must be arranged.

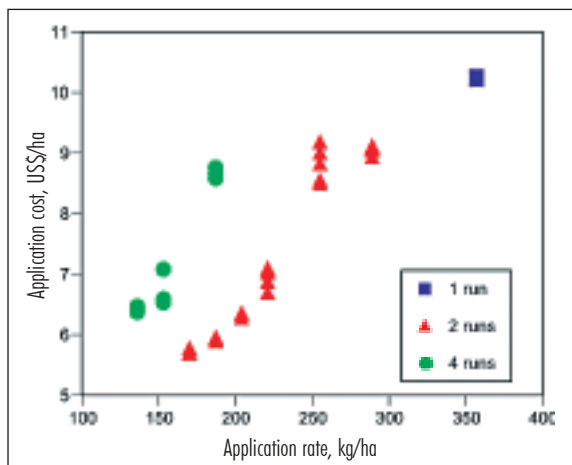
These requirements can be met with the following set-up: An aerial fertilizer coordinator, responsible for all operational logistics, the work program and coordination with estate management, the control of fertilizer preparation and application, the control of operational security, as well as progress reporting to estate and agronomy services; one senior engineer for aircraft maintenance and spare part inventory management; one experienced pilot per aircraft; loader and driver teams (one per aircraft). With a one tonne (t) loading capacity, an experienced pilot can apply up to 70 or 150 t per day, depending on the rate of application.

The cost of aerial application is two to five times greater than manual application, depending on currency value, local cost, and management.

This additional cost of application must be balanced by an increase in fertilizer efficiency due to a reduction in nutrient losses, without any adverse impact on yield, as observed by Loong et al. (1990).

Further, the cost of application and the aircraft output is related to application rate (Figure 3). High application rates applied in one-run over the working area results in a **relatively** lower cost. However, when the number of runs increases (from two to four for example) due to small application rates or small block sizes, the cost increases significantly.

Figure 3. Cost of fertilizer application and amount applied.



A compromise between the need to apply site-specific fertilizer recommendations (reducing the productivity of the aircraft) and the need to increase the aircraft's performance (by decreasing to an acceptable level of site-specificity of recommendations) is inevitable. In the near future, technological developments will improve the scope for aerial fertilizer application. Electronic flow meters are available for use with solid fertilizers and GPS companies are expected to integrate DGPS and GIS so that actual fertilizer recommendation maps can be uploaded to the aircraft's computer. These developments will make aerial fertilizer an attractive tool for precision plantation agriculture in the next few years. **BCI**

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References

- Foster, H.L. and Mohd. Tayeb Hj. Dolmat. 1986. The effect of different methods of placement and frequency of application of fertilizer to oil palm on an inland soil in Peninsula, Malaysia. *PORIM Bulletin*, 12, p. 1-11.
- International Fertilizer Industry Association. 1992. *IFA World Fertilizer Use Manual*. IFA, Paris, 632 p.
- Lee, A.K. 1977. Economics of large-scale aerial manuring of oil palm. (Preprint). *In Seminar on Agricultural Aviation*, January 6-8, 1977. Rubber Research Institute of Malaysia and Agricultural Institute of Malaysia.
- Liwang, T., S. Suyanto, and T. Widodo. 2000. Informasi terkini pengalaman penerapan teknik pemupukan melalui udara di perkebunan kelapa sawit PT SMART Tbk periode 1996-1999. *Seminar Kelapa Sawit 1*, PPKS, Medan, Indonesia, April 25-26, 2000. 14 p.
- Loong, S.G., M. Nazeeb, and A. Letchumanan. 1990. A Commercial Trial Showing the Promise of Aerial Application of Fertilizers to Oil Palms. *The Planter*, 66, p. 125-132.
- Ochs, R. 1965. Contribution a l'étude de la fumure potassique du palmier a huile. *oléagineux*, 20, (6), p. 365-501.
- Satyoso, H., S. Azhari, and E.S. Neo. 1997. Pemupukan kelapa sawit melalui udara, pengalaman penerapannya selama 1996-1997 di kebun PT SMART Corp. *Pertemuan technis kelapa sawit*, Medan. August 26, 1997. Pusat Penelitian Kelapa Sawit.
- Tan, K.Y., A.K. Lee, C.W. Leong, and A.H. Ling. 1977. Large scale aerial manuring of oil palm in FELDA. (Preprint). *In Seminar on Agricultural Aviation*, January 6-8, 1977. Rubber Research Institute of Malaysia and Agricultural Institute of Malaysia.
- Wood, B.J., C.J. Piggott, Phang Siew, and D.P. Nesbit. 1973. Aerial application in oil palms. *In Wastie, R.L., and D.A. Earp (eds). Advances in Oil Palm Cultivation: Proceedings of the International Oil Palm Conference*. Incorporated Society of Planters, Kuala Lumpur, Malaysia, November 16-18, 1972, p.167-183.