Nutrient reserves and recycling from oil palm trunks at replanting

Khan-Kiang Kee

Applied Agricultural Research Sdn. Bhd., Locked Bag 212, Sg. Buloh Post Office, 47000 Sg. Buloh, Selangor, Malaysia
Email aarsb@po.jaring.my

Abstract

When oil palms are replanted at about 20-25 years old, the biomass of the palm trunk alone comprised nearly 70 t dry matter/ha representing an enormous pool of nutrients that could be recycled. Nitrogen and K are the two most abundant nutrients in oil palm trunks, accumulated at 190 kg and 770 kg/ha, respectively. Concentrations of the nutrients are highest in the upper, and lowest at the basal, segment of the trunk. Results from a field experiment to determine the rate of palm trunk decomposition and nutrient release indicated that decomposition was most rapid in the upper, followed by the mid and basal, trunk segments. Only 57 and 37% of the initial total trunk dry weight could be recovered after six and 12 months respectively. Very little of the N, P, Ca and Mg stored in the palm trunk are released in the first 12 months after felling presumably due to nutrient immobilization by the microbial fauna and flora population involved in decomposition. Net release of these nutrients occurred mainly after the 12th month of felling. In contrast, K was rapidly "released" and leached out as cellular disintegration occur after felling. Over a period of 18 months nearly 80% (> 600 kg K/ha) of the K in the palm trunks was released. Although some of the nutrients may be retained by the soil, the standard practice of planting a fast growing legume cover crop soon after felling of the old palms will mitigate against potential nutrient losses by reducing surface soil erosion and nutrient immobilization.

Media summary

Oil palm trunks at replanting are rich with N and K reserves, which could be conserved and recycled to meet the requirements of the next generation of palms.

Keywords

Nutrient reserves, nutrient recycling, replanting, biomass decomposition, mineralization

Introduction

At the time of replanting, when the oil palm (*Elaeis guineensis* Jacq.) is about 20-25 years old, the trunks are usually 'chipped', windrowed and left to decay in the field. The palm trunks represent an enormous pool of nutrients particularly N and K. Quantitative data on how fast the nutrients immobilized in old palm trunks are released after felling is not available. It was therefore difficult to fully conserve and exploit this vast nutrient pool for recycling to meet the nutrient requirements of the next generation of palms. A field experiment was set up to determine the rate of mineralization and nutrients release from the trunk biomass after felling. Results from the experiment will enable more effective strategies to be developed for management of trunk biomass at the time of felling to maximize recycling and utilization of the nutrients released from the old palm trunks.

Materials and methods

Four palms were selected from a 23 year-old field due for felling. All fronds were pruned off and the position of leaf no. 40 was marked with paint. The palms were felled at ground level using a chain saw. The shoot was cut (at leaf no. 40) and discarded. The 10-11m long palm trunk was then divided into three equal parts, i.e. the upper, middle and basal, segments, and cylindrical sections, each about 45 cm in length, were taken from each of the three segments. These sections were further divided with a chainsaw, into eight wedges longitudinally, labeled and weighed. Sub-samples were taken for moisture and nutrient analysis. The trunk wedges were placed in bags made of fine nylon netting and laid out in four replicates (one palm per replicate) within the windrowed trunk chips in the field. Trunk wedges were recovered at 1, 3, 6, 12 and 18 months after felling and weighed. Sub-samples were collected at each sampling time, for moisture and nutrient analysis.

Results and discussion

Trunk dry weight and nutrient content at felling.

At the time of replanting, for a mean trunk length of 11 m, total trunk dry weight was 531 kg/palm (Table 1). The basal segment was heaviest accounting for > 42% of the total weight, while the upper and mid segments accounted for 28 and 30%, respectively. For the major nutrients N, P and K, concentrations were highest in the upper segment and decreased towards the basal segment. Trunk Ca and Mg concentrations however, increased marginally from the upper to the basal segment.

Table 1: Trunk dry weight (per palm) at felling and nutrient concentrations

Trunk segment	Trunk dry weight (kg)*	Nutrient concentrations (% dry weight) ? Std. Error				
		N	P	K	Ca	Mg
Upper	147	0.32?0.02	0.042?0.004	1.40?0.16	0.15?0.02	0.05?0.003
Mid	160	0.28?0.03	0.029?0.002	0.99?0.05	0.15?0.01	0.06?0.003
Basal	224	0.26?0.02	0.029?0.003	1.10?0.16	0.17?0.01	0.08?0.006
Total	531					

* reconstituted from mean dry weight of trunk wedges for 11 m trunk length.

At a palm density of 126/ha at replanting, total trunk biomass was estimated at nearly 67 t/ha (Table 2). The potential nutrient pool that could be recycled from the trunk biomass is enormous especially N and K at 189 kg and 770 kg/ha respectively. For a 30 year-old field, Chan et al (1980) estimated a dry trunk biomass of 75.5 t/ha with a potential nutrient pool of 368 kg N and 527 kg K/ha.

Table 2: Palm biomass and nutrient content per ha at felling

Trunk segment	Trunk biomass (t/ha)*	Nutrient content (kg/ha)				
		N	P	K	Ca	Mg
Upper	18.5	59.2	7.8	259.3	27.8	9.3
Mid	20.2	56.4	5.8	199.6	30.2	12.1

Basal	28.2	73.4	8.2	310.5	48.0	22.6
Total	66.9	189	21.8	769.4	106.0	44.0

*assuming a density of 126 palms per ha at replanting (85% of original density)

Loss of dry weight with time

Loss of trunk dry weight proceeded rapidly over the first three months, especially in the upper segment (Table 3). By the six month, only 50% of the initial dry weight could be recovered from the upper segment compared to nearly 62% from the basal segment. Thereafter, decomposition rate slowed down considerably. About 25% and 20% of the initial upper segment dry weight could still be recovered after 12 and 18 months respectively. In contrast, about 30 and 32% were recovered after 18 months from the mid and basal segments respectively. The basal segment has significantly higher Klason lignin content compared to the upper segment (Mansor and Ahmad 1991) due to higher number of thickened, lignified vascular bundles in the lower segment of the oil palm trunk (Lim and Khoo 1986). As the trunk tissues get older and more fibrous, they become more resistant to microbial decomposition.

Table 3: Mean remaining biomass (% of initial dry weight), N and K concentrations of trunk segments with time (months) after felling.

Time (months)	Remaining biomass (% of initial) ? Std. Error			
	Upper	Mid	Basal	Whole trunk
0	100	100	100	100
1	83.3?1.0	78.1?n.a.	89.3?8.3	84.6
3	57.1?2.8	61.9?9.7	64.4?2.5	61.3
6	50.5?3.9	55.9?4.1	61.8?2.6	56.9
12	25.2?4.6	37.5?2.3	44.4?3.6	36.7
18	19.8?1.6	29.6?2.5	32.1?5.4	27.8

Changes in nutrient concentrations with time

Nutrient concentrations in various segments increased with time after felling for all the nutrients until the 12^{th} month before stabilizing or declining at the 18^{th} month (Table 4). In contrast K concentrations reached a peak at the third month and declined thereafter with time. Nutrient concentrations were generally highest in the upper and lowest in the basal segment of the trunk.

Table 4: N, P, K, Ca, Mg concentrations (% dry weight) in trunk segments with time after felling.

Time months	Upper segment					Mid segment					Basal segment				
	N	P	K	Ca	Mg	N	P	K	Ca	Mg	N	P	K	Ca	Mg
0	0.32	0.042	1.40	0.15	0.05	0.28	0.029	0.99	0.15	0.06	0.26	0.029	1.10	0.17	0.08
1	0.58	0.064	1.85	0.25	0.07	0.31	0.037	1.21	0.17	0.07	0.36	0.040	1.39	0.24	0.11
3	0.75	0.077	2.26	0.31	0.10	0.53	0.057	1.71	0.29	0.12	0.49	0.045	1.40	0.26	0.12
6	0.83	0.092	2.27	0.39	0.14	0.47	0.049	1.32	0.26	0.10	0.46	0.043	1.03	0.23	0.11
12	1.32	0.111	1.44	0.67	0.28	1.03	0.083	1.46	0.45	0.19	0.83	0.065	0.69	0.31	0.16
18	1.03	0.074	0.70	0.68	0.14	1.05	0.077	0.95	0.56	0.11	1.01	0.070	0.89	0.52	0.10

Fig. 1a: N recovery

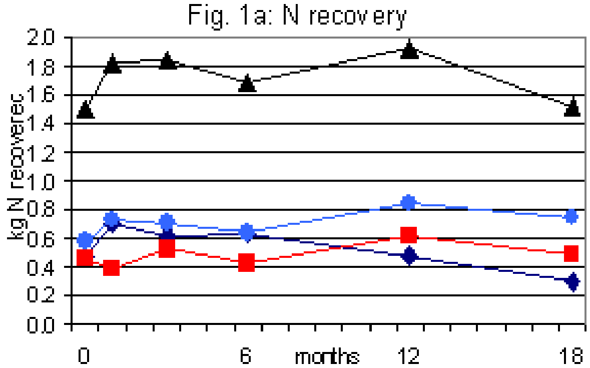


Fig. 1b: P recovery

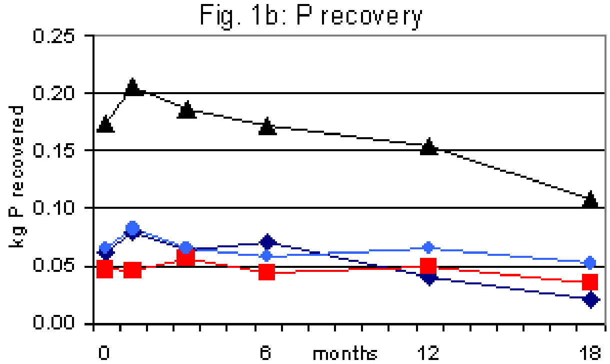


Fig 1c: Ca recovery

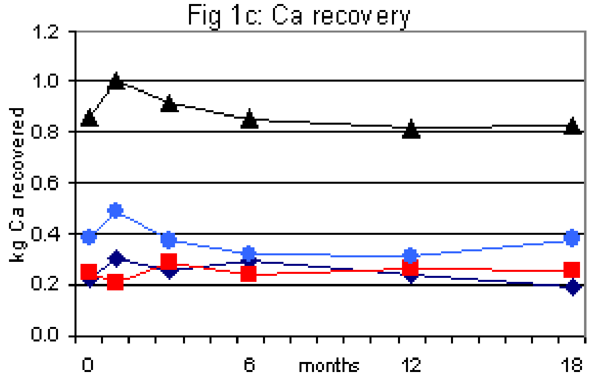
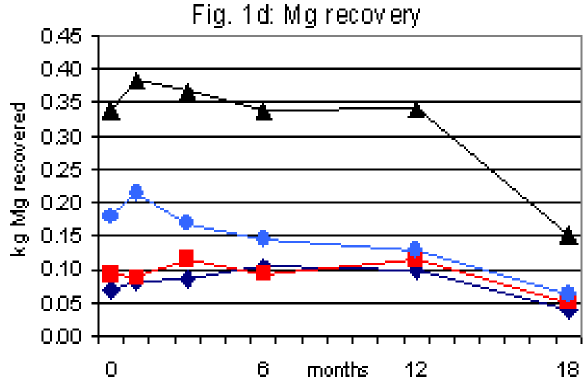


Fig. 1d: Mg recovery



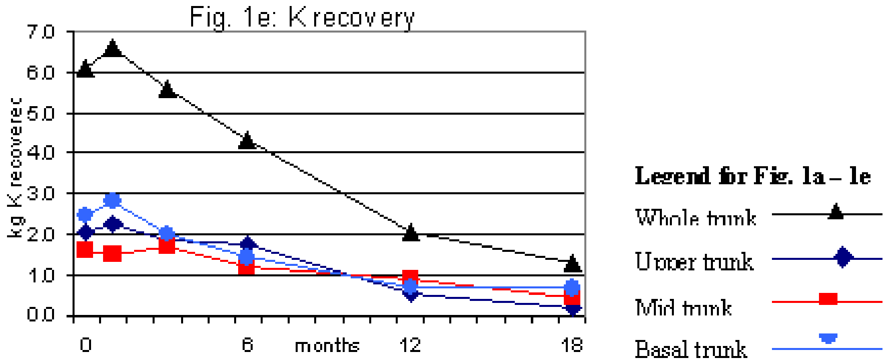


Fig. 1: Nutrient recovery (kg) from oil palm trunk with time.

Nutrients released from trunk decomposition

For all five nutrients analyzed there was a net increase in nutrient recovered at one month after felling (Fig. 1a to Fig. 1e). Thereafter for P, Ca and Mg, nutrients recovered declined gradually until the 12th month (Fig. 1b, 1c and 1d), with very little net release after the 12th month. For N, there was a large net increase in N recovered with time (Fig. 1a). This phenomenon has been attributed to translocation of N from the surrounding medium by fungal colonies, N-fixation by microbes stimulated by availability of carbon sources, migration of small fauna into the decomposing substrate as well as inputs from wet and dry deposition. Net release of N from the trunk segments was low even at 18 months after felling. Nitrogen, and to a lesser extent P, Ca and Mg, is an essential component of proteins and cell structures. Thus, despite the net loss of trunk biomass with time, the nutrients remained “immobilized” by the microbial population involved in decomposition, with very little “released” in the process.

In contrast K recovery declined rapidly and there was a net release of K by the 3rd month (Fig 1e). At the 12th month, only about 30% of the trunk K was recovered. K occurs mainly in the ionic form in the cytoplasmic fluids within the structural cells of the palm trunk. As cellular disintegration occurs, K is rapidly “released” and leached out. Thus over a period of 18 months nearly 80% (or >600 kg K/ha) of the K in the palm trunks was released. Sampling of the soil to a depth of 30 cm under the windrowed trunk biomass showed a sharp increase in soil exchangeable K at 6 months and in total N and P and exchangeable K and Mg at 12 months after felling (Khalid *et al* 1996). This is consistent with the nutrient disappearance pattern from this study and suggests that there is some retention and buildup of these nutrients in the soil. This study also showed that except for K, recycling of N, P, Ca and Mg from the trunk is slow in the first 12 months. The very rapid and large quantities of K released from the trunk biomass greatly exceed what can be absorbed by the new planting and stored in the soil. The standard practice of planting a fast growing leguminous cover crop soon after felling of the old palms will mitigate against potential nutrient losses by reducing surface soil erosion and immobilizing some of the nutrients especially K from being leached out of the system.

Conclusion

The oil palm trunk biomass, estimated at nearly 70 t/ha at the time of felling for replanting contained an enormous pool of nutrients equivalent to 189 kg N, 22 kg P, 769 kg K, 106 kg Ca and 44 kg Mg/ha. Loss of trunk dry weight was rapid with only 57% recovery at the 6th month and 28% at the 18th month after felling. Despite the rapid rate of decomposition, there was very little net release of N, P, Ca and Mg within the first 12 months after felling. Nitrogen, and to a lesser extent P, Ca and Mg, is an essential component of proteins and cell structures and thus remained “immobilized” by the microbial population. Recycling of all nutrients except K was slow in the first 12 month after felling. In contrast, K was rapidly “released” and leached out of the trunk tissues by the third month after felling. Over a period of 18 months nearly 80% of the K in the palm trunks was released, equivalent to > 600 kg K/ha. Planting a leguminous cover crop after felling will mitigate against potential nutrient losses by reducing surface soil erosion and nutrient immobilization.

Acknowledgement

The author thanks Messrs Applied Agricultural Research (AAR) Sdn. Bhd. and their principals Messrs Boustead Holdings Bhd and Kuala Lumpur Kepong Bhd. for permission to present this paper. The assistance and cooperation of the Manager and Staff of Tuan Mee Estate is also gratefully acknowledged.

References

Chan KW, Watson I and Lim KC (1980). Use of oil palm waste material for increased production. In: Proc. Conf. On Soil Sc. and Agric. Dev. in Malaysia. Malaysian Soil Science Soc, KL. pp. 213-242.

Khalid H, Zin ZZ and Anderson JM (1996). Management of palm residues using various replanting techniques in oil palm plantations. In: Proc. 1996 Int. Palm Oil Congress. PORIM, KL. pp. 241-253.

Lim SC and Khoo KC (1986). Characteristics of the oil palm trunk and its potential utilization. The Malaysian Forester 49 (1): 3-22.

Mansor H and Ahmad AR (1991). Chemical composition of the oil palm trunk. In: Proc. Nat. Seminar on oil palm trunk and other palmwood utilization. Min. Primary Industries, Malaysia, pp. 335-342.