Guidelines for the Implementation of the ASEAN Policy on Zero Burning

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- Malaysian Palm Oil Board - *Alternative technique - young palms planted directly to residue piles.*
- Applied Agricultural Research Sdn Bhd - *EnviroMulcher mounted to the end of the excavator's boom*

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Message from the Secretary-General of ASEAN

In April 1999, the ASEAN Environment Ministers adopted the policy on zero burning and agreed to promote its application by plantation companies, timber concessionaires and other relevant parties in the region. The ASEAN Agreement on Transboundary Haze Pollution signed in June 2002 calls for the development and implementation of legislative and other regulatory measures, as well as programmes and strategies to promote zero burning policy.

The Guidelines for the Implementation of the ASEAN Policy on Zero Burning reflects ASEAN's commitment in containing land and forest fires and the resulting transboundary haze pollution. Apart from techniques on zero burning, the Guidelines also highlight the benefits, prerequisites as well as constraints in implementing zero burning practices. I hope that these Guidelines will generate further research and dissemination of other environmental friendly practices on land clearing and management in general.

I congratulate the ASEAN Senior Officials on the Environment-Haze Technical Task Force and the Government of Malaysia for taking the lead in developing the Guidelines. Our appreciation also goes to the Global Environment Facility/United Nations Environment Programme and East Asia and Pacific Environmental Initiative/US Department of Agriculture Forest Service for providing financial support, and all those who have contributed to the development of the Guidelines.

ONG KENG YONG
Secretary-General of ASEAN

Message from the Chairperson of ASOEN-HTTF

On behalf of the ASEAN Senior Officials on the Environment - Haze Technical Task Force (ASOEN-HTTF), I am happy with the development of "*Guidelines for the Implementation of the ASEAN Policy on Zero Burning*", which was prepared for the ASEAN member countries. The development of the Guidelines was based on the spirit of cooperation among the ASEAN member countries in addressing land and forest fires and transboundary haze pollution within the Southeast Asian region.

I hope that the Guidelines could become a reference guide for the ASEAN member countries in implementing the Policy on Zero Burning in their respective countries. The application of the Guidelines will depend on the circumstances in each member country. Therefore, there is a need to have some adjustments to make the Guidelines in line with the needs and situation of each country. However, I believe that the Guidelines can contribute to the efforts on controlling land and forest fires.

While the implementation of the Guidelines may be limited for the plantation companies, particularly oil palm plantations in dry land and peat land, but in principle the application could be applied for new plantation development and replanting in forest plantations.

Under the framework of ASEAN's cooperation, exchange of information and experiences in implementing the Guidelines by every member country should be promoted, so that its effectiveness could be further evaluated.

Finally, I would like to express my gratitude to all who have contributed in the development of the Guidelines, particularly Mr. Teoh Cheng Hai, the consultant from Total Quality and Environment Management, Malaysia and the ASEAN Secretariat. I hope that the Guidelines can be useful for the decision makers to further develop technical guidance on zero burning for land managers in Southeast Asia.

LIANA BRATASIDA
Chairperson, ASOEN-HTTF
Deputy for Environmental Conservation
Ministry of Environment
REPUBLIC OF INDONESIA

Message from the Chairperson of SRFA-Borneo

I am pleased to be given the opportunity to jointly present the "Guidelines on the Implementation of the ASEAN Policy on Zero Burning". The publication of the Guidelines is indeed welcomed as it addresses the 6th ASEAN Ministerial Meeting on Haze's decision, in Brunei Darussalam, for ASEAN to adopt a zero burning policy and to promote its application among plantations owners and timber concessionaires.

It has been recognised that the foremost underlying cause of the catastrophic fires in Southeast Asia in 1997 and 1998 was the use of open burning techniques for conversion of forestland to other land uses particularly as plantations and other commercial purposes. Therefore, the Guidelines I believe can serve a very useful purpose in offering advice on the application of zero burning techniques in plantations.

The timing of the publication is also appropriate as we celebrate ASEAN Environment Year 2003 with the theme "Together Towards Sustainable Development". The theme is apt as it also reflects on the need for involvement, participation and commitment of everyone to stamp out the undesired and sometimes catastrophic effects of open burning in the pursuit of development. At the same time it also reflects our desire to reap the benefits from zero burning such as no more smoke pollution, reduced greenhouse gas emissions as well as economic and ecological sustainability. Hence, I sincerely hope the Guidelines will be used and the advice it offers be applied by plantation owners, managers, supervisory staff and contractors.

I do believe a lot of effort and time has been put in producing the Guidelines. Therefore my sincere appreciation and heartiest congratulations goes to everyone involved in producing such as beneficial document.

HAJI MOHD. JUMIN BIN HAJI MARSAL
Permanent Secretary
cum Chairman of ASEAN Sub-Regional Fire-fighting Arrangement for Borneo
Ministry of Development
BRUNEI DARUSSALAM

Message from the Chairperson of SRFA-Sumatra

The development of the Guideline for the Implementation of the ASEAN Policy on Zero Burning is yet another milestone in our effort towards combating haze in the ASEAN region. I am pleased to note that the good practices of zero burning already being implemented in certain parts of the region is now documented to provide guidance to other members seeking for best practicable and economical solution to the problem arising from the traditional practices of open burning in agriculture activities.

Although zero burning may not be the only solution to the problem, it is an alternative method in line with the concept of sustainable environmental practices. Whenever possible the technique could be a better way of disposing large volume of biomass while at the same time conserving the quality of the environment.

I wish to encourage all the ASEAN member countries to adopt and adapt the strategies and recommendations presented in this guideline to suit each country's requirement and customary practices. The region's healthy environment depends greatly on our cooperation and concerted effort.

HAJAH ROSNANI IBARAHIM
Director General
cum Chairperson of ASEAN Sub-Regional Fire-fighting Arrangement for Sumatra
Department of Environment
MALAYSIA

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1. Introduction

1.1. In response to the land and forest fires that affected the ASEAN region in 1997/98 the ASEAN Senior Officials on the Environment-Haze Technical Task Force (ASOEN-HTTF) formulated the Regional Haze Action Plan (RHAP) that was adopted in December 1997. At the 6th ASEAN Ministerial Meeting on Haze in April, 1999, the ASEAN Environment Ministers agreed to adopt the policy on zero burning and to promote its application by plantation companies and owners and timber concessionaires in the region.

1.2. In principle, the zero burning could be applied for development of various plantation crops and forest plantations. To-date, research and commercial experience on the zero burning approach have been focused mainly on oil palm plantations. As substantial areas in the region have been projected to under replanting or new plantings for this crop, these guidelines have been developed to provide advice to plantation owners, managers, supervisory staff and contractors on the application of the zero burning technique for development of oil palm plantations.

1.3. These guidelines, which are based on commercial scale experience of plantation companies in Malaysia and Indonesia, are not intended to be prescriptive. They provide the basis for implementation of the zero burning policy on plantations. Actual practice adopted by specific companies could vary according to ground conditions, vegetation and resources and policies of the individual companies.

1.4. These guidelines may not applicable to smallholders[1] as they may not have the necessary resources or economies of scale to implement the zero burning technique.

1.5. The approach taken for the development of these guidelines is given in Appendix.

2. Overview on the Zero Burning Technique

2.1. Definition:

The zero burning technique is a method of land clearing whereby the tree stand, either logged over secondary forests or an old area of plantation tree crops such as oil palm are felled, shredded, stacked and left *in situ* to decompose naturally.

[1] 'Smallholders' are independent owners or legal occupiers of small areas of agricultural land; the formal definition would vary with countries. For instance, in Malaysia, a smallholder is the owner or legal occupier of land that is less than 40.5 ha (100 acres) in size.

2.2. Benefits of Zero Burning:

- An environmentally sound approach as it does not cause air pollution.
- Zero burning reduces greenhouse gas (GHG) emission, particularly CO_2.
- Through recycling of plant biomass, the zero burning technique improves soil organic matter, moisture retention and soil fertility, particularly in areas that have been planted with more than one generation of plantation crops. This reduces the overall requirement for inorganic fertilizers and minimizes the risk of water pollution through leaching or surface wash of nutrients.
- The agronomic benefits can be enhanced if the oil palm seedlings are planted directly on to the residue piles rather than on bare soil. Through this approach, higher levels of total nitrogen, exchangeable potassium, calcium and magnesium can be obtained and the nutrients are released over a longer period.
- Unlike land clearing by burning, the zero burning technique is less dependent on weather conditions.
- The zero burning technique has a shorter fallow period than clearing by burning; crop plants and legume covers can be planted within two months of felling and shredding; the latter provides faster coverage of the ground and minimizes soil loss and pollution through run-off.
- As the zero burning technique involves progressive felling, application of the technique oil palm to oil palm replanting would result in additional revenue from continued harvesting of the palms until they are felled. The revenue could offset any additional expenses incurred. Overall, the cost of applying the zero burning technique for replanting oil palms with a new generation of palms is comparable to or cheaper than land clearing by burning.
- In the long run, analyses of experience to-date have indicated that approaches that do not involve the use of fire and removal of biomass would ensure economic and ecological sustainability.

2.3. Potential Problems Associated with the Zero Burning Technique

- In replanting of oil palm, pests such as the rhinoceros beetle (*Oryctes rhinocerous)* and the Basal Stem Rot disease caused by *Ganoderma boninense* can cause serious losses to the new oil palm stand, unless appropriate preventive measures are undertaken before and during application of the zero burning technique. *Oryctes* beetle damage and *Ganoderma* disease can be particularly damaging in coastal estates where these problems had been endemic. In some situations, a severe attack of *Oryctes* could predispose the palms to further damage by the Red Stripe weevil (*Rhychophorus schach).*
- In logged-over forests and peat swamps, zero burn areas have been found to be

more susceptible to attacks by termites, a heavy attack of *Coptotermes curvinaathus* could kill the young oil palms while *Macrotermes gilvus* could disturb the root system of the palms.

- The stacked timber or biomass of the preceding plantation crop could provide a breeding ground for rats. Whereas rats are forced to migrate in situations where land is cleared by burning, they remain and breed in the heaps of timber or trunk chips in windrows where zero burning technique is practised.

- In general, the zero burning technique is more expensive to implement for forest clearing, particularly in areas with a high volume of biomass. Furthermore, the technique requires heavy machinery which may not be readily available to smaller plantation owners.

- During prolonged dry weather, the decomposing heaps of biomass could dry out and become sources of accidental fires.

- Resistance to change could be a problem among managers, supervisors and contractors who are unfamiliar with the new technique. For those who are accustomed to the clean and almost bare field created by burning, the 'untidy' and rather messy appearance of areas with heaps of decaying vegetation in the interrows of zero burn areas may not be readily acceptable.

3. Pre-Requisites for Effective Implementation of the ASEAN Policy on Zero Burning

3.1. A number of factors must be given due consideration when preparing to implement the ASEAN Policy on Zero Burning, among which are corporate and government commitment towards implementation of the policy, training of all concerned on the new technique, and provision of appropriate support and monitoring services.

3.2. The adoption of the ASEAN Policy on Zero Burning by ASEAN Environment Ministers is a clear demonstration of the commitment to zero burning at the regional and national levels. However, it is vital that this commitment is communicated and cascaded down to all levels of administration. Effective implementation of the policy would require diligent monitoring on compliance of regulatory requirements and remedial actions against cases of non-compliance. At the company level, top management must show its commitment towards the implementation of the policy and it should provide the necessary resources and training to all concerned, including contractors, to ensure that they have sound understanding of the policy and have the ability to implement the zero burning technique. The company's commitment to the policy must be reflected in written corporate policies, manuals or standard operating procedures as well as in contracts for land clearing. It should also put in place a system for monitoring the level of compliance of the zero burning policy.

3.3. Considering that the zero burning technique is more complex than clearing by

burning, appropriate training must be given to all concerned within the company and its contractors, before commencement of felling operations. For those implementing zero burning for the first time, it would be desirable to establish demonstration plots to provide the opportunity for hands-on experience with the technique. Field visits to companies that have experience with zero burning is also an effective way for learning.

3.4. Implementation of these guidelines is based on the assumption that the project proponent or plantation company has already undertaken appropriate land use planning, which could include the conduct of an Environment Impact Assessment, as required by the respective national environmental regulations. Potential environmental impacts from the development would have been identified and appropriate mitigation measures have been developed. As a general rule, development should not be undertaken in High Conservation Value Forests (HCVFs). According to the Forest Stewardship Council, HCVFs are defined as "forests" of outstanding and critical importance due to their environmental, socio-economic, biodiversity or landscape values".

3.5. Heavy land clearing vehicles and machinery such as bulldozers, excavators for felling and shredding/chipping of trunks and other operations are necessary for the zero burning technique. Large plantations are likely to have them as standard vehicles/machines for land clearing operations but smaller estates (1000 ha or less) may face problems with their availability.

4. The Zero Burning Technique – Replanting of Plantation Crops to Oil Palm

4.1. The Zero Burning Technique for Replanting Oil Palm to Oil Palm

The main steps in the zero burning replanting of an old oil palm planting with a new generation of palms are summarized in Figure 1.

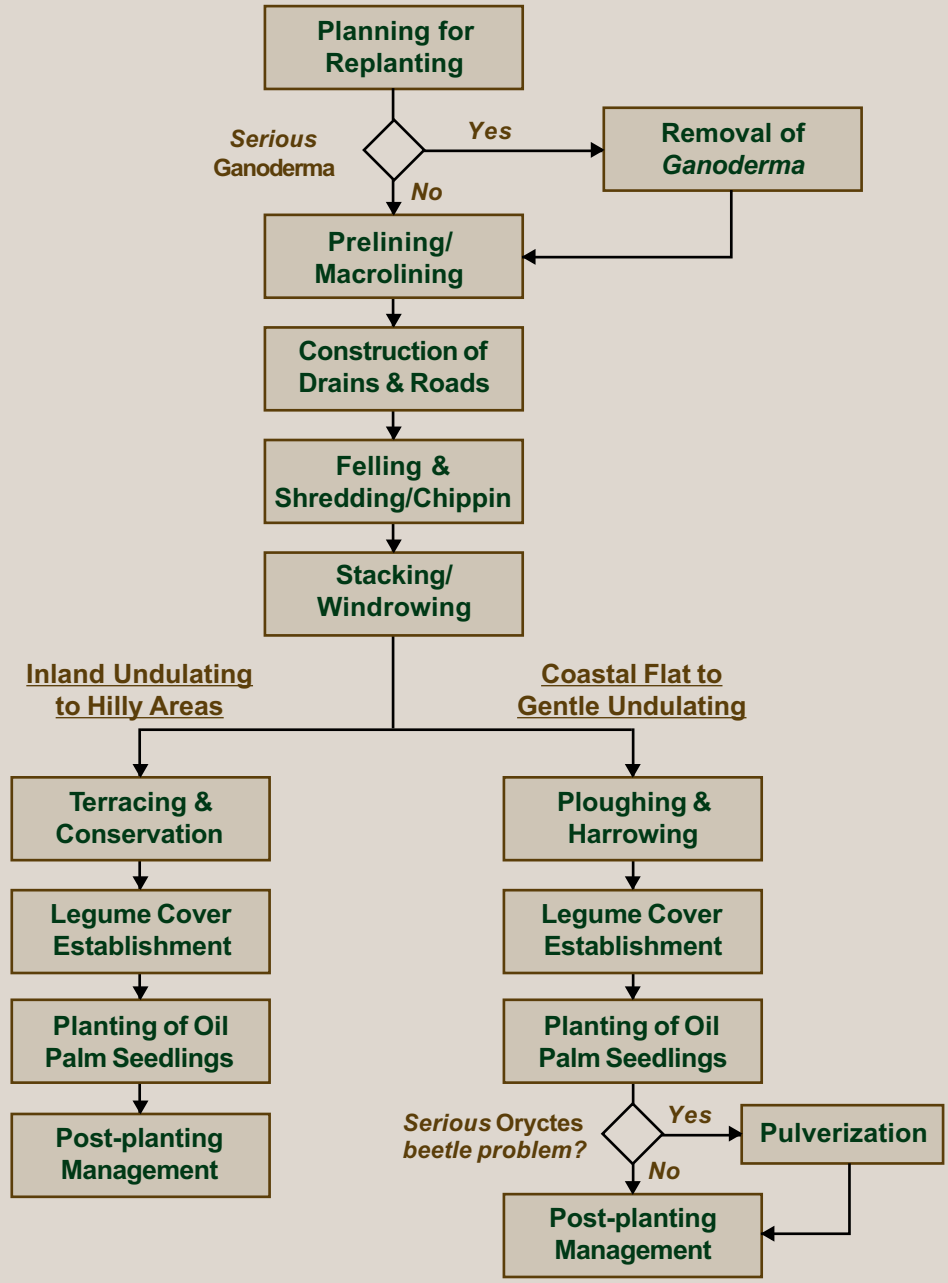
4.1.1. Planning for Replanting

i. In planning for zero burning replanting, a proper design of the estate is essential. Consideration would have to be given to the scope of work, availability of appropriate machines and equipment, timing of operations and budget.

ii. If personnel from the plantation company and or their contractors do not have previous experience with the zero burning technique, a training or practice session should be conducted. If possible, a study field trip to a plantation that has undertaken replanting by zero burning would be beneficial.

iii. Replanting provides the opportunity to rectify any physical problems or inadequacies that have been encountered in the previous crop. For instance, the need for realignment of the road or drainage systems must be identified during the planning stage.

Figure 1: Process Steps for Zero Burning Replanting Oil Palm to Oil Palm



iv. If the area to be replanted has a history of severe infestation of *Ganoderma boninense*, which causes Basal Stem Rot, a higher initial planting density ought to be considered, particularly in coastal areas (both on clay soils and peat soils) and the requirement for oil palm materials from the nursery and the field layout would have to be raised accordingly.

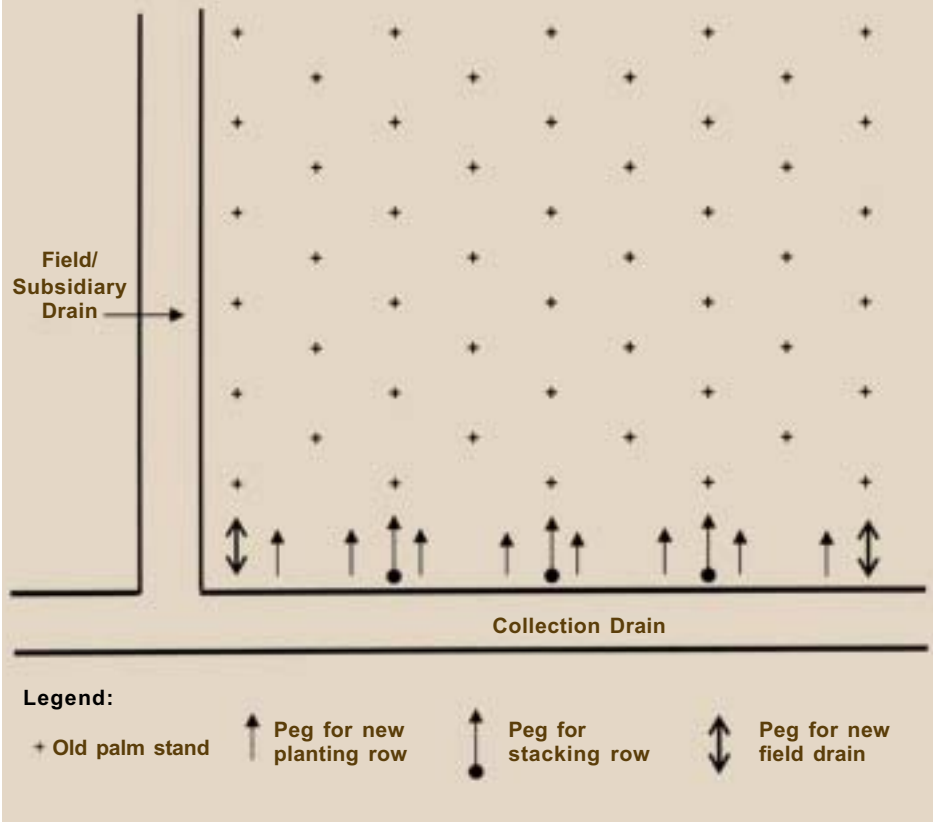
4.1.2. Removal of *Ganoderma* Diseased Palms

i. In areas with a high incidence of Basal Stem Rot, a detailed census of *Ganoderma* diseased palms should be undertaken. Vacant points should also be recorded as they are likely to be due to *Ganoderma*.

ii. Diseased palms should be felled ahead of the replanting operations and the palm bole and the adjoining root mass should be removed by an excavator and placed in the interrow, away from any new planting points. The bole and root mass should also be shredded.

iii. The palm trunks are left behind for shredding along with the rest of the old palm stand during the replanting operations.

Figure 2: Prelining of Planting Rows, Stacking Rows and Drains



4.1.3. Prelining

i. Prelining or macrolining is done to identify the new planting rows, roads, harvesters' paths and drains as shown in Figure 2 for replanting on flat to undulating terrain. Prelining on hilly terrain would have to follow the land contours. This operation facilitates the placement of the shredded materials and other field operations.

ii. The tips of lining pegs should be painted with colors to identify various field operations.

iii. In order to minimize the risk of *Ganoderma* infection in coastal areas, new plantings rows are placed in between the previous rows.

4.1.4. Construction of Roads and Drains

i. The construction of collection and field or subsidiary drains can be done before or immediately after felling of palms.

ii. In situations where the old field drains do not fall in place with the new field layout, they are filled up with soil and new drains that were prelined earlier are constructed. Where the existing drains can be retained, they are desilted and until they are of the same depth as the new drains.

iii. In coastal areas, field drains are constructed every fourth or eighth palm row while the collection drains are placed in the center of two field roads.

iv. A double rotary ditcher can be used for the construction of new drains.

v. Bulldozers or excavators are suitable for construction of new roads, which should be cambered up to a height of about 30 cm in the center to ensure adequate drainage and all-year road access to vehicular traffic.

4.1.5. Felling and Shredding/Chipping

i. The old palms are directionally felled using an excavator's hydraulic boom that is fitted with a chipping bucket.

ii. For effective shredding, the chipping bucket's cutting edge should be made of high tensile carbon steel.

iii. The palm trunk is cut at an angle of 45° - 60° into 5-10 cm thick slices of about 0.8 to 1.0 m in length. (Plate 1); thinner slices of trunk tissues would hasten the

Plate 1: Shredding of the oil palm trunk.

Photo by Golden Hope Plantations Berhad

rate of disintegration and decomposition. The shredding or chipping operation normally commences from the basal end of the palm trunk. Bole tissues and the adjoining root mass should also be shredded.

iv. A 120 HP track-type excavator is capable of felling and shredding 50 to 80 palms, depending on the height of palms, ground conditions and ground conditions.

4.1.6. Stacking/Windrowing

i. In straight-lined plantings on flat to undulating terrain, the shredded materials are stacked as follows:
   a. In an area where the field drain intensity is 1 in every 4 palm rows, the shredded materials are stacked in the center avenue of 4 palm rows between the two field drains. (Figure 3A and Plate 2)
   b. In an area where the field drain intensity is 1 in every 8 palm rows, the shredded materials are stacked at alternate avenues except along the drain avenues (Figure 3B)

Plate 2: Shredded palm materials in the avenues.

Photo by United Plantations Berhad

ii. In hilly areas, the shredded materials are spread out evenly on the inter-terrace slopes.

4.1.7. Ploughing and Harrowing in Coastal Areas

i. After completion of felling, shredding and stacking, ploughing and harrowing are done along the new planting strips to produce a friable and level planting surface.

4.1.8. Construction of Terraces in Inland Undulating to Hilly Areas

i. On land with slopes exceeding 10°, planting terraces of about 4 m width should be constructed, except on shallow soils where narrower terraces are made to avoid cutting into parent materials/rocks. The terraces should follow contour lines.

ii. In areas where the slope is between 5-10°, soil conservation terraces should be constructed, the distance between terraces is about 30 m.

Figure 3A and 3B: Stacking Patterns for Shredded Palm Debris

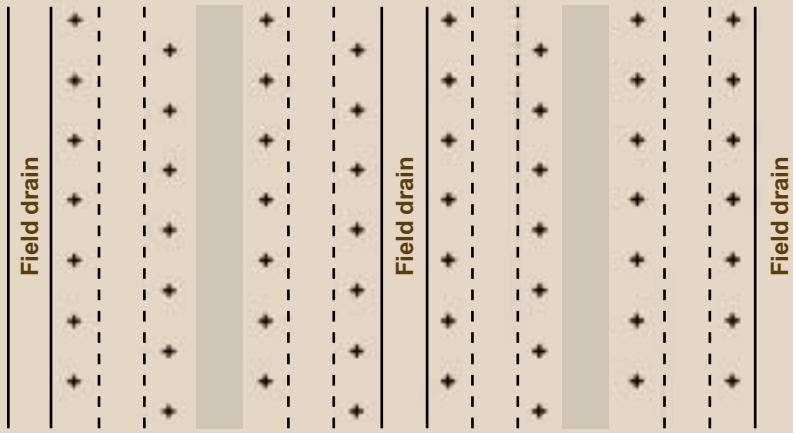


Figure 3A: 1 field drain in every 4 palm rows

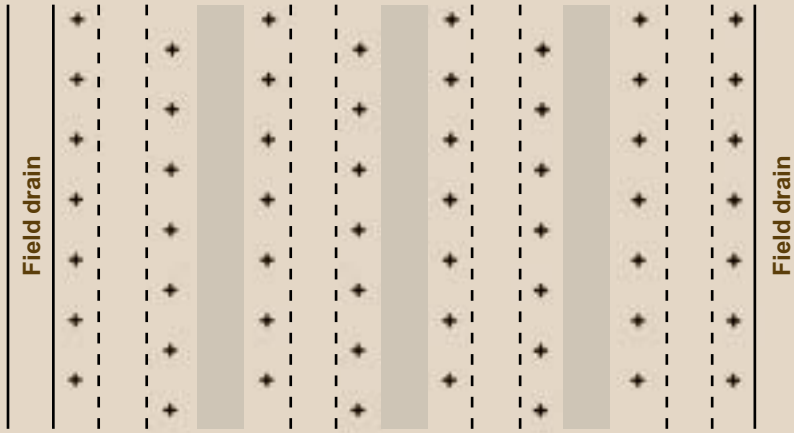


Figure 3B: 1 field drain in every 8 palm rows

Legend: + Old palm stand | Harvester's path | Shredded material

4.1.9. Establishment of Legume Covers

i. Leguminous cover crops (LCC) should be planted as soon as land preparation is completed to ensure rapid coverage of the bare ground and to hasten the decomposition of the shredded palm biomass (Plate 3). A vigorous legume cover over the wood stacks could reduce the risk of fires, reduce the breeding of *Oryctes* beetle in the debris and also suppress weed growth. Legume covers improve the physical and chemical properties of the soil, particularly through nitrogen fixation.

Plate 3: Well-established leguminous cover crops.

Photo by United Plantations Berhad

ii. Commonly used LCC species include *Pueraria javanica, Calopogonium mucinoides* and *Calopogonium caeruleum.* The last cover species is more shade tolerant and fixes a higher quantity of nitrogen than the other two legumes. *Mucuna cochinensis* and *Mucuna bracteata* could also be considered, as they are vigorous and fast growing species that could provide rapid ground coverage.

iii. The legume seeding rate and planting patterns would depend on soil type and terrain. In general, two drills are planted on either side of the planting row in coastal areas while the compressed band system, planting of 4 to 5 drills of legumes in the interrows and other approaches are used for inland situations.

4.1.10. Lining, Holing and Planting of Oil Palm Seedlings

i. Lining, holing and planting of oil palm seedlings could commence soon after completion of land preparation. Holing could be done mechanically using a conventional post-hole digger.

ii. Depending on its availability, empty fruit bunches (EFB) could be applied as mulch around the newly planted palms.

4.1.11. Pulverization

i. The need for pulverization of the shredded palm materials depends on the risk of attack by the *Oryctes* beetle. In areas where *Oryctes* outbreaks are likely, particularly in coastal areas, pulverization should be done between two to six

months after felling and shredding to accelerate the decomposition of plant tissues which provide an ideal breeding site for the beetles.

ii. Pulverization can be carried out using a modified a heavy-duty rotary slasher or a mulcher mounted on to a 80 to 100 HP tractor. Two or three passes, along and across the heaps of shredded materials would provide satisfactory pulverization.

4.1.12. Post-planting Management

i. Among the post-planting field operations, particular attention should be given to the management of pests and diseases, particularly in replantings on coastal soils. The introduction of zero burning from oil palm-to-oil palm replanting (as well as cocoa/coconut-to-oil palm replanting) can caused serious damage of the newly planted palms by the *Oryctes* beetle (Plate 4), if appropriate preventive or remedial measures are not taken. The heaps of decaying palm tissues provide a conducive environment for the breeding of *Oryctes.* During the first year after planting, damage to palms is caused mainly by beetles flying in to nest/ breed while the emerging generation of beetles from the field could inflict heavy damage from about 12 to 24 months after planting. In areas where *Oryctes* beetles are expected to be problematic, it is advisable to carry out mass trapping of adult beetles in aggregation pheromone (*ethyl 4-methyloctanoate*) vane traps at the intensity of one trap per two hectares. Trapped beetles could be inoculated with natural biocontrol control agents, a baculovirus that is an indigenous enemy to *Oryctes* and the fungus, *Metarhizium anisopilae.* The inoculated beetles are then released to infect other adult beetles.

Plate 4: The Oryctes beetle *(Oryctes rhinoceros)*.

Photo by Golden Hope Plantations Berhad

Photo by Golden Hope Plantations Berhad

Photo by Golden Hope Plantations Berhad

Under high pest populations, the young palms can also be protected by fortnightly spraying of synthetic pyrethroids such as cypermethrin at 0.1% active ingredient (a.i.).

ii. The heaps of decaying palm biomass also provide refuge and breeding ground for rats. Routine monitoring of the incidence of rat damage to the immature oil palm is advisable and baiting with appropriate rodenticides should be done when a significant increase in the rat population is detected.

iii. In the zero burning replanting of oil palms, the ripe fruitlets from the remaining fresh fruit bunches could germinate and give rise to volunteer oil palm seedlings (VOPS). These should be treated as weeds and removed at regular intervals.

iv. Through the zero burning technique, the plant nutrients are recycled and there will be a lower requirement for chemical fertilizer inputs. However, these nutrients are released slowly as the biomass decomposes and they may not be immediately available soon after planting. Thus, it is advisable to review and revise the fertilizer schedule accordingly.

4.2. The Zero Burning Technique for Replanting Oil Palm to Oil Palm: Alternative Approach #1 – Zero Burning by Pulverization

4.2.1. In the effort to address the potential problems of high palm damage from *Oryctes* beetle and rats arising from the zero burning technique described in Section 4.1, two large plantation companies in Malaysia have adopted a new method of clearing the old oil palm stand by extensive pulverization. Application of the technique has reduced the incidence of *Oryctes* beetle and rat damage to economically insignificant levels. It has also resulted in more effective distribution and utilization of recycled nutrients by the new oil palm stand. It has facilitated better field access for other operations and could reduce the fallow period to less than two months.

4.2.2. Instead of felling, shredding and stacking, this alternative approach uses a specialized machine known as the *EnviroMulcher* (Plate 5) to pulverize the standing palms. The machine consists of a rotary steel drum with 75 or 111 tungsten carbide knives bolted on in a spiral arrangement. The drum is mounted to the end of the boom of a conventional excavator and is driven by the hydraulic system of the latter. The excavator with the EnviroMulcher cuts a standing palm into two, after which the rotary drum pulverizes the standing lower half of the palm. The upper section with the crown and fronds is shredded by

Plate 5: *EnviroMulcher* mounted to the end of the excavator's boom.

Photo by Applied Agricultural Research Sdn Bhd

another excavator fitted with a conventional chipping bucket. The shredded biomass is windrowed in trenches in every 4th interrow. This new technique enables more than 80% pulverization of the palm trunk and spreads the fine chips evenly throughout the field.

4.2.3. Experience with this new zero burning replanting technique is described by Ooi *et al* (2001) and the relevant reference is listed in Section 7 (Page 23).

4.3. The Zero Burning Technique for Replanting Oil Palm to Oil Palm: Alternative Approach #2 – Windrowing without Shredding of Palms

4.3.1. P.T.P.P London Sumatra Indonesia Tbk practices the windrowing system of zero burning which is cheaper and has a lower requirement for heavy machines. The approach involves felling and stacking of the oil palm trunks in avenues in a north-south direction at the intensity of one avenue per two palm rows. After felling the planting rows are ploughed, followed by two rounds of harrowing. In hilly areas, the palm trunks are placed across the contours to minimize soil erosion.

4.3.2. While the windrowing method is much simpler and cheaper to implement than the technique described in Section 4.1, caution should be exercised in areas where there is likely to be a high incidence of *Ganoderma* infection or attacks by the *Oryctes* beetle.

4.4. The Zero Burning Technique for Replanting Oil Palm to Oil Palm : Alternative Approach #3 – Planting of Young Palms on Residue Piles

4.4.1. The Malaysian Palm Oil Board is promoting the idea of planting the new oil palm seedlings on to the residue piles to improve the accessibility and efficiency of nutrient utilization (Plate 6). Compared with the standard practice of planting palms on bare soil in between residue stacks, oil palms planted according to the new technique have better growth and higher yields. This is largely attributed to improved soil physico-chemical properties and better synchrony between release of nutrients from the residual biomass and nutrient uptake by the oil palm seedlings.

Plate 6: Alternative technique - young palms planted directly on to residue piles.

Photo by Malaysian Palm Oil Board

4.4.2. While the felling and shredding/chipping operations are similar to those described in para 4.1.5, operators following the new method are required to required to clear an area of about 1.5 m square in between the old stands for the new planting points. The shredded materials are spread evenly at about 3 m - 4 m width to avoid the formation of thick residue piles.

4.4.3. Further information on this alternative approach of zero burning is given in MPOB Technology No 25 (December 2002) entitled "*Crop residue management during oil palm replanting*". (See 'Selected References' in Section 7 (Page 23)).

4.5. The Zero Burning Technique for Replanting Rubber to Oil Palm

4.5.1. The following methods can be considered for zero burning replanting of rubber, the choice being dependent on the location, terrain, machines and the need for extraction of marketable rubberwood:

- Uproot rubber trees and stack biomass in the new interrows;
- Uproot rubber trees and stack biomass beside ravines;
- Chain saw rubber trees, leave root boles in the ground and stack biomass in the new interrows;
- Chain saw rubber trees, leave root boles in the ground and stack biomass beside ravines.

4.5.2. Rubber trees are directionally felled at an angle to the existing planting rows so that the trees fall within the new interrows. Where there is market demand, the usable rubber timber should be extracted immediately after felling. Rubber has a high biomass and even after commercial extraction, more than 50% of the residual biomass by weight would remain in the field. In the absence of burning, this would have to be distributed systematically in the field.

4.5.3. The management of the residual rubber biomass would depend mainly on the terrain. On flat to undulating terrain where straight line planting of oil palm seedlings is feasible, the plant remnants are stacked in about 3m wide strips in alternate interrows. On hilly terrain, construction of terraces commences from the top of the hill. Residual plant biomass that lies on the contour of the proposed terraces would be pushed by bulldozers or excavators into the inter-terrace avenues.

4.5.4. It should be noted that the Malaysian Palm Oil Board does not recommend planting of oil palms on ex-rubber areas where zero burning has been adopted as it could aggravate the *Ganoderma* problem. Recent research findings have indicated that *G. boninense* and *G. zonatum,* which are pathogenic to oil palms, have been isolated from rubber stems and stumps.

4.6. The Zero Burning Technique for Replanting Cocoa-Coconut Areas to Oil Palm

4.6.1. The approach for replanting monoculture cocoa and cocoa/coconut interplanted areas is broadly similar to the zero burning technique for oil palm-to-oil palm replanting, except for the method of clearing the old crop stand. In monococoa areas, *Gliricidia* shade trees are poisoned in advance of removal of the cocoa trees. A second round of poisoning may be necessary to kill any surviving *Gliricidia* trees. The cocoa and *Gliricidia* trees are then uprooted using an excavator bucket and stacked in the interrows. The biomass from four rows of cocoa is heaped into one stacking avenue.

4.6.2. In cocoa/coconut interplanted areas, the process begins with the uprooting of the cocoa trees and stacking of the plant remnants in the stacking avenues (four rows of cocoa trees to one avenue). The biomass is compressed while being stacked using the excavator bucket to reduce the stack height. Felling of coconut palms is done progressively as the cocoa stands are being cleared and stacked. The method of felling and shredding the coconut is similar to that described in Section 4.1.5 for oil palm-to-oil palm replanting. The shredded materials should be heaped on top of the cocoa biomass wherever possible. In situations where there is a practical use for the coconut trunks e.g. for piling and construction of bridges or where there is a market demand, they should be removed as soon as possible from the field. Remnants of the coconut bole tissues and root mass should be dug out completely and shredded into small pieces.

4.6.3. As the decaying vegetation in the stacked heaps is also conducive for the breeding of the *Oryctes* beetle, proactive action should be taken to minimize the possibility of pest outbreaks. The establishment of vigorous leguminous cover crops could suppress *Oryctes* activity in the new replants while the use of aggregation pheromone trapping and the release of trapped beetles inoculated with an *Oryctes*-specific baculovirus or with spores of *Metarhizium anisopliae* could reduce the adult beetle population. Application of synthetic pyrethroid insecticides would be necessary when *Oryctes* damage to young palms exceeds an economic threshold level.

5. The Zero Burning Technique for Development of New Oil Palm Plantings

5.1. Macro Planning for Development of New Oil Palm Plantations

5.1.1. Development of oil palm plantations could involve opening of large areas of new land. As such, it is important that holistic planning is undertaken to ensure sustainability of the project in respect of economic, social and environmental considerations. Plantation companies and project proponents should conduct Environmental Impact Assessments (EIAs) according to their respective national regulatory requirements, to identify the potential environmental impacts that could arise from the development and to devise appropriate mitigation measures to address them.

5.1.2. Environmental assessment is particularly relevant for development that involves forest conversion. As a general guideline, plantation development should not be undertaken in areas classified as High Value Conservation Forests (HCVFs). These are defined by the Forest Stewardship Council as ”forests of outstanding and critical importance due to their environmental, socio-economic, biodiversity or landscape values”.

5.2. The Zero Burning Technique for New Plantings from Secondary or Logged-over Forests on Flat to Undulating Terrain

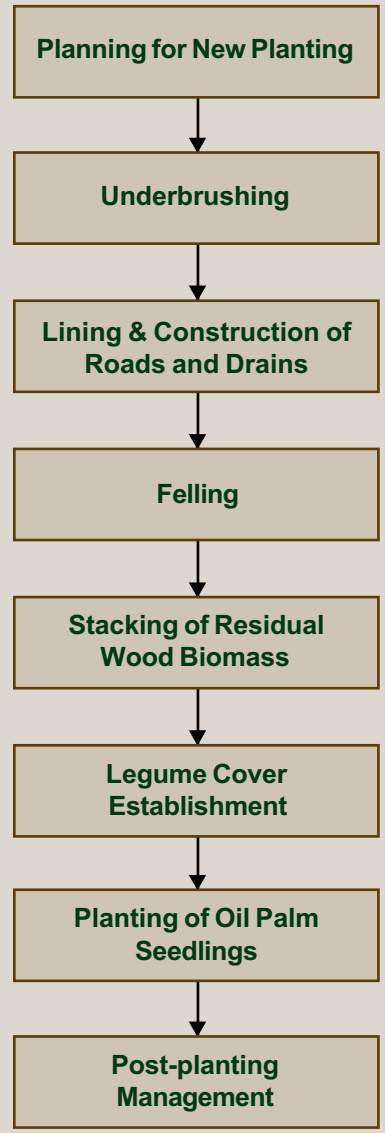
The main steps for the zero burning technique for development of new plantations from secondary or logged-over forests on flat to undulating terrain are summarized in Figure 4.

5.2.1. Planning for New Planting

i. Initial planning requires the development of an integrated plan or design of the estate which takes the following aspects into consideration:
   - Size of the estate;
   - Size of each block or field;
   - Terrain;
   - Soil type;
   - Road system and FFB transportation;
   - Soil and water conservation measures;
   - Plans for future operational needs e.g. mechanization of field practices.

ii. A site survey should be undertaken to confirm the location and perimeter of the land. This is followed by demarcation of the planting blocks, with due consideration to the terrain, soil types, road systems, etc. For example, an estate could be divided into 100 ha blocks which are divided into 25 ha sub-blocks (1000 m x 250 m). Each sub-block is surrounded by main roads and collection roads

Figure 4: Process Steps for the Zero Burning Technique for Planting Oil Palm from Secondary Forest on Flat to Undulating Terrain



iii. To facilitate planning for the implementation of zero burning, it is desirable to classify the ground vegetation in each block as light, medium or heavy according to size and relative population per ha. Any large trees with usable timber should be extracted ahead of the zero burning to reduce the amount of residual wood that would be left to decompose in the field.

5.2.2. Underbrushing

i. Underbrushing is carried out to remove small woody growth and scrub. This operation could be done manually using a cutlass or an axe.

ii. Where sheet *lalang* or *alang-alang* (*Imperata cylindrica*) is present, it should be slashed to the ground and the regrowth should be subsequently eradicated by spraying of herbicides such as glyphosate and sulphosate.

5.2.3. Lining and Construction of Roads and Drains.

i. Road construction should be done as soon as possible to facilitate zero burning operations. On flat to undulating terrain where the area is divided into regular size blocks and sub-blocks, the roads are constructed around the blocks, forming a grid pattern. The main roads could be aligned in the north-south direction while smaller fruit collection roads traverse the east-west direction. Roads should be as straight as possible and the surface should be properly cambered.

ii. The drainage system, comprising large collection drains connected with smaller field drains, should also follow a grid layout, in line with the road system. The drain intensity depends on the soil type and water table and it could range from one field drain for every two rows of palms to one per eight rows of palms.

iii. Drains are usually constructed mechanically using an excavator. A double rotary ditcher can also be used.

iv. Lining of planting rows and stacking rows is also done at this stage.

5.2.4. Felling

i. Felling of residual trees is done either with chain saws or mechanically by bulldozers or excavators. The latter is preferred as it is faster and also ensures complete uprooting of the stumps. It also facilitates other subsequent field operations. However, where there has been no previous experience with mechanical felling, operators and supervisors must be given appropriate training on the proper techniques of operating the machines.

ii. Wherever feasible, tree stumps should also be uprooted. Where they are large stumps, they should be cut with a chain saw to the lowest level from the

ground. The chain saw should also be used to long trunks and branches into more manageable lengths.

iii. Riparian reserves or 'buffer strips' along streams should not be cleared in order to minimize runoff of soil sediments into the river, prevent erosion of river banks, and preserve the natural riverine habitat. The width of the reserves to be left undisturbed varies with the size of the rivers and it is often specified in the relevant national regulations. For instance, the Water Enactment of Sarawak in Malaysia requires the maintenance of at least 20 m width on either sides of permanent waterways. To ensure observance of the regulatory requirements, the riverine reserves should be clearly demarcated before felling.

5.2.5. Stacking of Residual Wood Biomass

i. On flat to undulating terrain, the placement of residual timber would depend on the drainage intensity. In situations where there is one field drain for every four palm rows, the wood biomass should be stacked in the center avenue of every four palm rows. Where there is one field drain for every eight palm rows, the timber is stacked in alternate avenues. This is similar to the approach for oil palm-to-oil palm replanting as shown in Figures 3A and 3B. (Plates 7 & 8)

Plate 7: Mechanical stacking in progress (Sumatera Selatan, Indonesia)

Photo by Technopalm Runding Sdn Bhd

5.2.6. Legume Cover Crop Establishment

i. Leguminous cover crops (LCC) should be planted as soon as land preparation is completed to ensure rapid coverage of the bare ground and to hasten the decomposition of the residual wood and debris. A vigorous legume cover over the wood stacks could reduce the risk of fires and also suppress weed growth. Legume covers improve the physical and chemical properties of the soil, particularly through nitrogen fixation.

Plate 8: Stacked rows of wood biomass (Sumatera Selatan, Indonesia)

Photo by Technopalm Runding Sdn Bhd

ii. Commonly used LCC species include *Pueraria javanica, Calopogonium mucinoides* and *Calopogonium caeruleum.* The last cover species is more shade tolerant and has fixed a higher quantity of nitrogen than the other two legumes. *Mucuna cochinensis* and *Mucuna bracteata* could also be considered, as they are vigorous and fast growing species that could provide rapid ground coverage.

iii. The legume seeding rate and planting patterns would depend on soil type and terrain. In flat and undulating terrain, the LCC seeds could be sown in two rows on both side of the oil palm planting row.

5.2.7. Planting of Oil Palm Seedlings

i. Lining, holing and planting operations are similar to those for the zero burning technique for oil palm replanting. Planting could commence within two months of felling on stacking of the previous vegetation.

5.2.8. Post-planting Management

i. Where an Environmental Impact Assessment has been conducted and appropriate mitigation measures have been identified, an environment management plan must be drawn up to ensure effective implementation of these measures. Regular monitoring of environmental quality, particularly water quality, is also necessary. Senior management of the company should review the progress of the implementation of the environment management plan as an integral part of their routine assessment of the development and performance of the plantation.

ii. During dry weather, the stacks of residual wood and debris could become fire hazards and could be the source of accidental fires. The plantation should be in the state of preparedness to handle any fire outbreaks. A fire management policy and response plan should be established and personnel should be trained to execute the plan.

iii. Termites can be a problem on zero burning oil palm areas developed from secondary forests. The stacked wood and debris provide a good environment for breeding of termites. A high pest population could inflict serious damage to young palms. Control measures include spraying of affected palms with termiticides to the palm spear as well as a soil drench around the base of the palm. Application of termiticide at the palm base isolates the termites on the palm from the rest of the colony and it also prevents termites from outside to cause further damage. Termite population can also be controlled by destruction of nests and the removal of the queen. However, this approach may be less practical as termite colonies are usually subterranean. The latest technique for termite control is baiting using insect growth regulators such as hexaflumuron.

iv. The stacked wood residues may also be conducive for the breeding of rats. Routine monitoring of rat damage should be done and baiting with rodenticides should be carried out when economic threshold levels of damage are recorded.

5.3. The Zero Burning Technique for New Plantings from Secondary or Logged-over Forests on Hilly Terrain

5.3.1. The zero burning process is broadly similar to that shown in Figure 4 except that

Plate 9: Zero burning on hilly terrain from secondary forest (Sarawak, Malaysia)

Photo by Golden Hope Plantations Berhad

contour terracing would have to be done prior to the stacking of the residual timber and debris. In general, terraces are constructed when the gradient of the land exceeds 10°. Lining of planting rows, stacking avenues and the terraces should be completed before terrace construction commences. Standard land survey equipment such as compass and the *Theodolite* should be used to ensure that terraces are cut along contour lines. Compass readings should be rechecked regularly to minimize errors and ensure that planting rows do not fall into stacking rows.

5.3.2. Bulldozers are usually used for construction of terraces of about 4m in width and an inward slope of 10° to 15°. However, on shallow soils narrower terraces could be made to avoid cutting into parent materials/rocks. Terracing should start from the top of the hill. The intensity of contour terracing would depend on the topography and desired planting density. It is important that all terraces are connected to field roads to facilitate other field operations and eventually, for evacuation of the fresh fruit bunches.

5.3.3. As the cutting of the terrace progresses, the bulldozer should push the residual timber and debris in its path and stack them into the stacking avenues between terraces. (Plate 9). Large tree trunks that could obstruct the bulldozer operation should be cut into more manageable size with chain saws.

5.3.4. Leguminous cover crops should be established as soon as possible to provide early coverage of the exposed ground and reduce the risk of soil erosion. In addition, other soil conservation measures, such as the construction of silt pits, should be implemented.

5.4. The Zero Burning Technique for New Plantings on Peat

5.4.1. Development of plantations on peat areas is more challenging from the operational as well as environmental perspectives. Peat lands in the tropics usually cover extensive areas and they perform vital hydrological and ecological functions for the entire landscape. In view of this, it is critical that a comprehensive environmental impact assessment is conducted to ensure that the proposed plantation does not have significant adverse impact on the ecosystem.

5.4.2. Although the zero burning technique for peat areas would follow the same process of felling and stacking of the residual plant biomass and planting of oil palm as

that for planting or replanting of oil palm on mineral soils (Plate 10), the inherent nature of peat would demand additional management inputs, particularly in respect of water management, land preparation and fertilization of the crop. Consequently, the cost of oil palm development on peat can be expected to be significantly higher than that for areas on mineral soils.

Plate 10: Zero burning on deep peat (Sarawak, Malaysia)

Photo by Golden Hope Plantations Berhad

5.4.3. Water Management: In their natural state, peat areas have a high water table and are often waterlogged. Effective water management holds the key to the successful development of oil palm on peat areas. During the land preparation phase, excess water has to be removed to lower the water table. However, drainage must not be too rapid as fast drying of the surface peat layer could make it difficult for subsequent reabsorption of water. An effective drainage system comprising main and subsidiary drains in a grid pattern that is integrated with the road system should be put in place before land preparation and zero burning operations commence. The intensity and dimensions of the drains would depend on the water level, land gradient and physical properties of the peat, particularly depth. The aim is to maintain a consistent water table level of between 50 to 75 cm below the soil surface.

5.4.4. Felling and Stacking: Tress with usable timber should be extracted ahead of felling of the rest of the area. Felling using an excavator should be done soon after construction of drains and roads. Bulldozers are not suitable for this operation on account of the soft ground conditions. Trees should be pushed over and uprooted wherever possible, and the trunks and branches cut into manageable size by chain saws. The residual timber and debris should be stacked at the intensity of one windrow for every two palm rows.

5.4.5. Soil Compaction: Upon drainage and drying out, soils would naturally shrink and subside. As peat has a low bulk density, soil compaction along the planting rows and harvesters paths is necessary to provide a proper stratum for palm root development and anchorage as well as to facilitate mechanization of various field operations. Planting of oil palms on areas that have not been adequately compacted would result leaning of the palms and exposure of the roots. Compaction could be done by excavators about three to four weeks after construction of subsidiary drains.

5.4.6. Holing and Planting of Oil Palm: As peat areas are inherently less fertile, consideration should be given to planting palms at a higher density; for example at 160 palms per ha compared with 136 –148 palms normally adopted for mineral soils. In view of soil subsistence following drainage, deep planting of oil palm

seedlings is advisable. This is achieved by the 'hole within a hole' method whereby a large hole with a 1.5 m diameter is dug to 25 – 30 cm depth at the planting point, followed by making a smaller hole of about 40 cm diameter and depth which will serve as the actual planting hole. Holing can be done mechanically using a *puncher* attached to the boom of an excavator. The *puncher* is an implement with a square top section and a conical bottom section to make the 'hole-in-hole'.

5.4.7. Post-planting Management

i. As mentioned earlier, effective water management is vital for successful cultivation of oil palm on peat areas. It is desirable to maintain a consistent water table level at about 50 – 75 cm below the surface.

ii. Compared with mineral soils, peat is inherently less fertile and a higher fertilizer regime will be necessary. Application of micronutrients such as boron, zinc and copper is also essential.

iii. Termites can be a major pest and are capable of causing serious damage to young palms on peat soils. Monitoring of pest incidence and application appropriate treatment should be an integral part of post-planting management.

iv. During dry periods, the wood residues in the stacks as well as the peat layers above the water table are fire hazards. Appropriate response plans at the plantation level should be put in place and activated immediately wherever there is a high risk of outbreaks of fires.

6. Alternative Approaches to the Zero Burning Technique

6.1. Although the zero burning technique has been applied as a standard plantation practice on a commercial scale, particularly for replanting of oil palms for many years, there are situations when the technique might not be entirely appropriate. Major constraints that could render the technique ineffective and/or uneconomical include:

- Areas where there is a high incidence of damage by the *Oryctes* beetle and application of zero burning could provide a conducive environment for further proliferation of the pest;
- In areas where *Ganoderma* disease is endemic and the risk of occurrence of the disease in oil palm-to-oil palm replanting is very high, especially in coastal areas;
- On steep terrain where mechanical clearing of trees and stacking of biomass can be problematic;
- In deep peat areas where access by heavy machinery is difficult; and
- Non-availability of heavy machinery to carry out the zero burning operations.

6.2. An alternative approach for replanting oil palm without burning is

UNDERPLANTING of a new generation of oil palms under senescing palms which are poisoned and removed progressively as the new palms become established (Plates 11 & 12). Correct timing of the removal of the old stand is a critical aspect of the underplanting technique. Although this practice was commonly done in Africa and Malaysia in the 1950s and 1960s, it not widely adopted currently because of the risk of spread of *Ganoderma* from the old stand as well as the possibility of *Oryctes* damage. Underplanting is not recommended for areas which have a history of *Ganoderma* disease infection or areas where there is likely to be a high population of the *Oryctes* beetle. As a policy, the Malaysian Palm Oil Board does not recommend underplanting of oil palm.

Plate 11: Underplanting of oil palm

Photo by Consolidated Plantations Berhad

Plate 12: Underplanting - after final round of poisoning of old palms

Photo by United Plantations Berhad

6.3. Where adoption of the zero burning technique has been found to be impractical, controlled burning approaches could be considered for specific situations, subject to the regulatory provisions under the respective national environmental legislation. If controlled burning is approved, implementation should follow the *"Guidelines for Implementation of Controlled Burning Practices"*

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Appendix

Process for the Development of the Guidelines for the Implementation of the ASEAN Policy on Zero Burning

APPROACH

The main steps taken in the development of the guidelines on zero burning were:

- Conduct of a survey of zero burning practices;
- Literature search and review;
- Follow up contact with some survey respondents to seek clarification or additional information;
- Preparation of the draft guidelines;
- Presentation of the draft guidelines to the 12th Joint Meeting of the Working Groups on Sub-Regional Fire-Fighting Arrangements (SRFAs) for Sumatra and Borneo on 16th January, 2003; and
- Revision and submission of final guidelines to the ASEAN Secretariat.

SURVEY ON ZERO BURNING PRACTICES

Through the Director-General, Department of Environment, Malaysia, a survey on zero burning techniques and practices was conducted between 10th and 31st December, 2002. The information requested from respondents is given in Attachment. The following were invited to participate in the survey:

- 19 plantation companies in Malaysia;
- Felda Plantations Sdn Bhd;
- Industry organizations in Malaysia –Malaysian Palm Oil Association (MPOA), Malaysian Palm Oil Board (MPOB) and East Malaysia Planters' Association (EMPA);
- Industry organizations in Indonesia - Indonesian Palm Oil Research Institute (IOPRI) and Gabungan Pengusaha Kelapa Sawit Indonesia (GAPKI);
- Haze Prevention Group;
- WWF/IUCN Project FireFight South East Asia; and
- Global Environment Centre.

Eleven companies/organizations, representing 39% of the total invited, responded to the survey.

LITERATURE SEARCH AND REVIEW

A *Google* search was undertaken on 01.01.03 for references on 'zero burning'. The main results were as follows:

Key words	No. references
'Zero burning' + ASEAN	249
'Zero burning' + technique + ASEAN	77
'Zero burning' + 'Golden Hope'	25
'Zero burning' + PORIM	18
'Zero burning' + MPOB	11
'Zero burning' + IOPRI	8

However, most of the references cited did not contain detailed information on the zero burning technique or procedure. Several company or organizational reports and Press reports cited made general statements pertaining to zero burning concept or policy. Technical information on zero burning was obtained from publications such as the Planter and proceedings of conferences on plantation agriculture and on oil palm. Effort was also made to obtain relevant information form the websites of selected companies, MPOB and IOPRI.

REVIEW OF DRAFT GUIDELINES

With the concurrence of the Chair of the SRFA Sumatra, Puan Hajah Rosnani Ibarahim, the draft guidelines were sent to the four major organizations representing the oil palm industry in Malaysia and Indonesia for their review and comments. Responses were received from MPAO, MPOB and GAPKI and wherever appropriate and relevant, their comments and suggestions were incorporated in the final edition of the guidelines.

The draft guidelines were presented to the 12th Joint Meeting of the Working Groups on Sub-Regional Fire-Fighting Arrangements (SRFAs) for Sumatra and Borneo on 16th January, 2003. The meeting agreed that the guidelines would serve as a reference for countries to implement zero burning practices according to their national circumstances.

The 20th ASOEN-Haze Technical Task Force Meeting in February 2003 agreed to publish the Guidelines for the Implementation of Policy on Zero Burning. The 10th ASEAN Ministerial Meeting on Haze in March 2003 supported the publication of the guidelines and encouraged member countries to use the guidelines based on their national circumstances and wherever applicable.

Attachment

Survey of Zero Burning Practices in the Plantation Industry for the Development of Guidelines for the Implementation of the ASEAN Policy on Zero Burning

Malaysia has been requested by the ASEAN Secretariat to develop the "Guidelines for the Implementation of the ASEAN Policy on Zero Burning", in view of our vast experience in the implementation of zero burning, particularly by the plantation industry. We propose to use the collective experience of the industry to develop the guidelines. Towards this end, we are conducting a survey on zero burning techniques and practices. It would be appreciated if you could support us in this effort by giving us your experience and recommendations on zero burning for various planting/replanting situations under the following headings:

A. ZERO BURNING TECHNIQUE FOR VARIOUS PLANTING/REPLANTING TECHNIQUE

A.1. Zero burning for new planting from secondary forests to oil palm
A.2. Zero burning for new planting from peat areas to oil palm
A.3. Zero burning for replanting oil palm areas to oil palm
A.4. Zero burning for replanting areas under other plantation crops to oil palm

Please provide detailed description for each of the planting/replanting situation that you have experience in under the following headings:

- Land preparation*
- Lining *
- Felling*
- Shredding*
- Stacking*
- Pulverisation*
- Planting of covers*
- Planting of oil palm*
- Post planting management, especially pest and diseases.

*) Please provide diagrams/pictures where appropriate

B. BENEFITS OF ZERO BURNING

- Economic benefits

- Agronomic benefits
- Environmental benefits

C. PROBLEMS ASSOCIATED WITH ZERO BURNING

Please describe the major problems you have encountered with zero burning and the action you have taken to manage them.

D. SITUATIONS WHEN ZERO BURNING MAY NOT BE APPLICABLE

D.1 Please indicate any situations/circumstances when it may not be possible to implement the zero burning technique.

D.2 For these situations, please indicate appropriate alternative methods new planting and replanting.

It would be appreciated if you could send your return to the following address by **31st December, 2002**:

Director General (Attention: En Patrick Tan)
Department of Environment,
Level 3-7, Block C4,
Federal Government Administrative Centre,
62662 PUTRAJAYA
Telefax: 03-8889 1042

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- Respondents to the survey on zero burning practices – Consolidated Plantations Berhad, East Malaysia Planters' Association (EMPA), Kumpulan Guthrie Berhad, Kuala Lumpur Kepong Berhad, IOI Corporation Berhad, Malaysian Palm Oil Association (MPOA), United Plantations Berhad, Indonesian Palm Oil Research Institute (IOPRI) and WWF/IUCN Project FireFight South East Asia;
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GEF

UNEP

EAPEI
East Asia and Pacific Environmental Initiative

UAS

ASEAN Haze Action Online
www.haze-online.or.id