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Farmers' perspectives on slash-and-burn as a land clearing method for small-scale rubber producers in Sepunggur, Jambi Province, Sumatra, Indonesia

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Abstract

On September 10, 1997, Indonesian President Soeharto renewed a ban on the practice of burning forests to clear land. At that moment a thick haze caused by land-clearing related fires in Kalimantan and Sumatra, Indonesia, blanketed large parts of Indonesia, Malaysia, Singapore, Brunei, the Philippines and Thailand. These fires, aggravated by the El Niño weather pattern and described as the worst in Southeast Asian history, renewed a long-term debate on slash-and-burn (S&B) as a method of land clearing.

Acceptable alternatives to S&B should address both the problems and the benefits of the use of fire. In depth knowledge and a clear diagnosis of the problems that rise with S&B and its alternatives are needed. A social/economic/agronomic survey was therefore conducted among 37 small-scale rubber producers in Sepunggur, Jambi Province, Sumatra, Indonesia. Our objectives were to: (1) characterize S&B techniques; (2) characterize farmers' perspectives on land clearing methods related to agronomic/economic factors (soil fertility, plant growth, production); and (3) evaluate alternatives to S&B that would be acceptable to individual farmers at present and in the near future. Small rubber producers (average farm size $\approx$5 ha) were selected because rubber gardens are the major land use type in this area, small producers are the main contributors, and most of the forest that is presently converted for agricultural use is being planted with rubber seedings.

Farmers generally start slashing in March and burn in the month of August. Burning takes place in two steps: broadcast burn followed by pile-and-burn. The five advantages of using fire as mentioned by the farmers were: (1) burning creates space (51%); (2) ash acts as a fertilizer (23%); (3) burning improves soil structure enabling faster establishment of seedlings (15%); (4) burning reduces weed/tree competition (5%); and (5) burning reduces the occurrence of pests/diseases (3%).

Alternatives to S&B should be economically acceptable. Mulching does not provide an alternative to any of the benefits of burning. Slash-and-remove-wood addresses only the first advantage and requires a tremendous effort in labor. If forced to accept either alternative, farmers expect a reduction in income due to difficulties in establishing new rubber gardens, reductions in yield, and an increase in labor costs.

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At present, small quantities of wood with economic value are sold on the local market. Slash-sell-and-burn is an alternative that could maintain the advantages of using fire while supplying the farmer with extra income and the initiative to remove and not burn the trees. Even though forest is rapidly being converted to rubber gardens, land clearing will remain in practice to rejuvenate the old rubber gardens or to convert them to other land use systems. By selling rubberwood, farmers could cover costs of land clearing and earn enough to cover some of the costs of buying higher-yielding clones for rubber planting. This alternative has benefits similar to using fire and could significantly reduce pollution problems, but a change in local trade regulations and taxes is required for its successful adoption.

Keywords: Slash-and-burn; Shifting cultivation; Fire; Farmer's survey; Social/economic/agronomic survey; Small rubber producers; Jambi Province; Sumatra; Indonesia

Introduction

A thick haze, caused by land-clearing forest fires in Kalimantan and Sumatra, blanketed not only large parts of Indonesia but also Malaysia, Singapore, Brunei, the Philippines and Thailand last year. The fires caused Indonesian President Suharto to renew a ban on the practice of burning forest on September 10, 1997.

Fire has been a traditional means to clear land for agricultural production in Indonesia. Shifting cultivators practice field rotation by slashing and burning a new plot of land after the existing plot has lost its fertility. The old plot is followed (abandoned) to allow tree regrowth and the replenishment of soil fertility. Due to increasing population pressure, shifting cultivation is no longer a sustainable land use in Sumatra. At present, farmers do not shift the locations of their plots but seek ownership of the remaining forest for conversion to permanent gardens. In addition, the reduction in average farm size forces farmers to cultivate economically valuable crops (cash-crops) such as rubber trees or oil palms. Fire is still widely used by smallholders to convert the remaining forest to rubber gardens and to rejuvenate these gardens. Slash-and-burn (S&B) hence refers to a technique for land clearing and no longer to an agricultural production system (Tomich et al., 1998b; Van Noordwijk et al., 1998). On a much larger scale, fire is also used by large companies to clear vegetation for establishing oil palm or timber plantations. It is these land clearing related fires that caused the tremendous pollution problems that started in August of 1997. Fire is used as a tool, but also as a weapon in the social conflicts which accompany forest conversion (Tomich et al., 1998a). Estimates of the total area burned range up to 3 M ha (Yves Laumonier, personal communication).

The ban on the use of fire in 1997 was a renewal of a ban that was initially enacted in 1984. It is now clear that officially banning fire is not the solution. Farmers S&B because alternatives that do not include the use of fire (such as slash-and-much) only address the environmental problems associated with S&B and do not offer any compensation for the benefits associated with the use of fire. If alternatives imply a decrease in yield, increase in risk of crop failure, and/or increase in labor and capital investment, they will not likely be adopted. Developing alternatives requires a basic understanding of the combination of social, economic, agronomic, and environmental factors that determine land clearing management practices at the farm household level.

A survey was conducted among 37 small rubber producers in the Sepunggur area (Jambi Province, Sumatra, Indonesia) in order to: (a) characterize S&B practices as exercised by farmers in the Sepunggur area; (b) determine reasons behind farmers' management decisions related to establishing new fields for agricultural production; and (c) establish the importance of S&B as a land-clearing method for rubber producers in this area, now and in the near future. Small rubber producers were selected because rubber gardens are the major land use in this area, small producers are the main contributors, and most of the forest and bush fallow that is presently being converted (slashed-and-burned) for agricultural use is being planted with rubber seedlings.

2. Materials and methods

The S&B-Survey was conducted in the Sepunggur administrative area (102° 14′E, 1° 29′ S) which is located 31 km southeast of Muara Bungo, the capital

Fig. 1. Sepunggur (102° 14′E, 1°29′S) is located in Jambi Province, Sumatra, Indonesia.

of subdistrict Muara Bungo in Bungo Tebo district, Jambi Province, Sumatra (Fig. 1). The average rainfall is nearly 3000 mm, with a monthly average rainfall of around 300 mm during the months of November to April and an average rainfall of 130 mm in the driest months of June and July (Fig. 2). A characterization of climate, vegetation, soils and land use were given by Van Noordwijk et al. (1995) and Van Noordwijk et al. (1998). The total population of Sepunggur amounts to 3038 people (1539 male, 1499 female) grouped in 632 families (Profil Sepunggur, 1997). In 1995, 42% of the population was younger than 14 years of age (Fig. 3). The Sepunggur administrative unit comprises 158.39 km^2 (BPS Muara Bungo, 1995). Of this total area, 0.2% is used for wet rice production, 1.0% for home gardens, 30.2% for cash crop gardens (rubber, fruit trees, oil palm etc.), and 41.0% for forests, while a total of 27.6% is used for other purposes (houses, roads, communal areas, etc.) (BPS Muara Bungo, 1995). The 'forest' category includes old jungle rubber which is no longer productive. The average farm size is 5 ha with most households owing and/or operating farms between 2 and 5 ha (Fig. 4). The average rubber area per farm is 4 ha and rubber provide 60% of the total income of the farmers (Kelfoun and Penot, 1997).

In total 37 farmer families (6% of all households in Sepunggur) were interviewed in the months August and September, 1997. All respondents had in common the fact that their main occupation was farming and that they owned at least one new (less than five years of

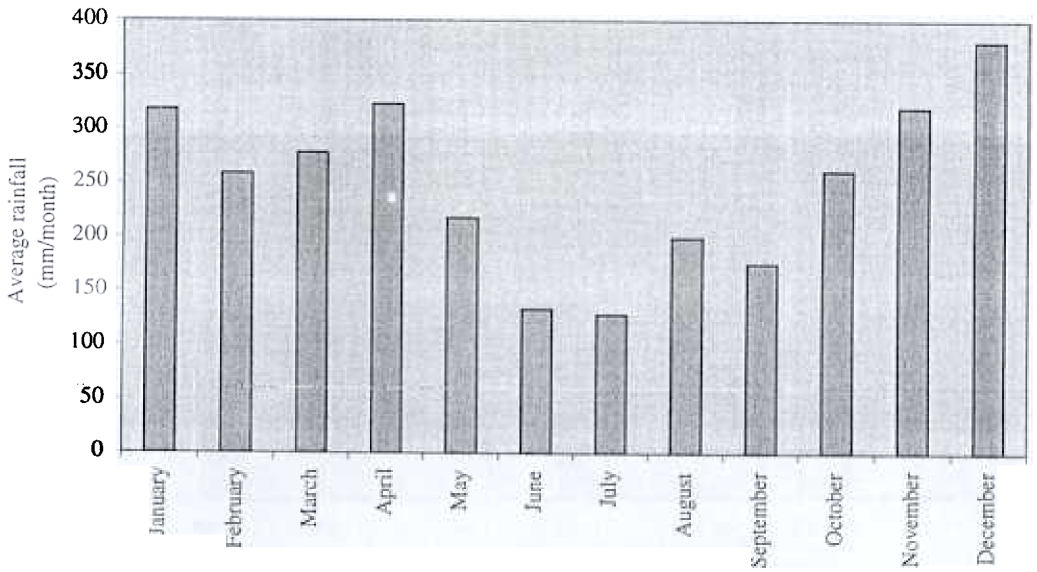

Fig. 2. Average monthly rainfall (mm) for three stations in the lowland peneplains of Jambi Province: Tanuh Tumbuh, Rantau Panjang, and Bangko (Van Noordwijk et al., 1995).

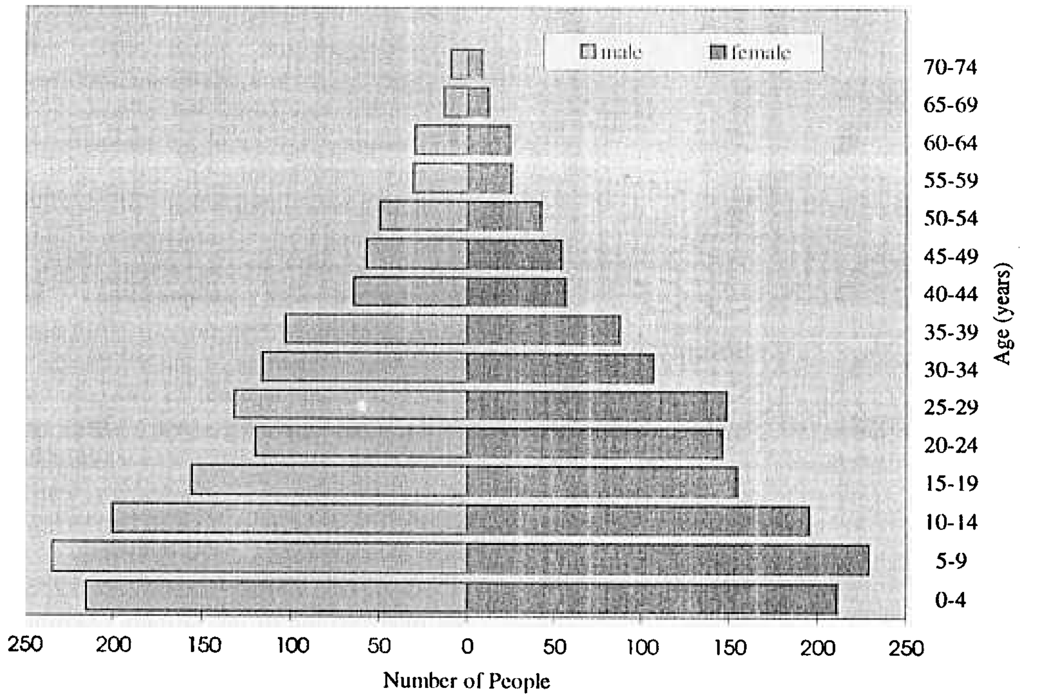

Fig. 3. Population distribution in Sepunggur, Sumatra, Indonesia (Source: BPS Muara Bungo, 1995)

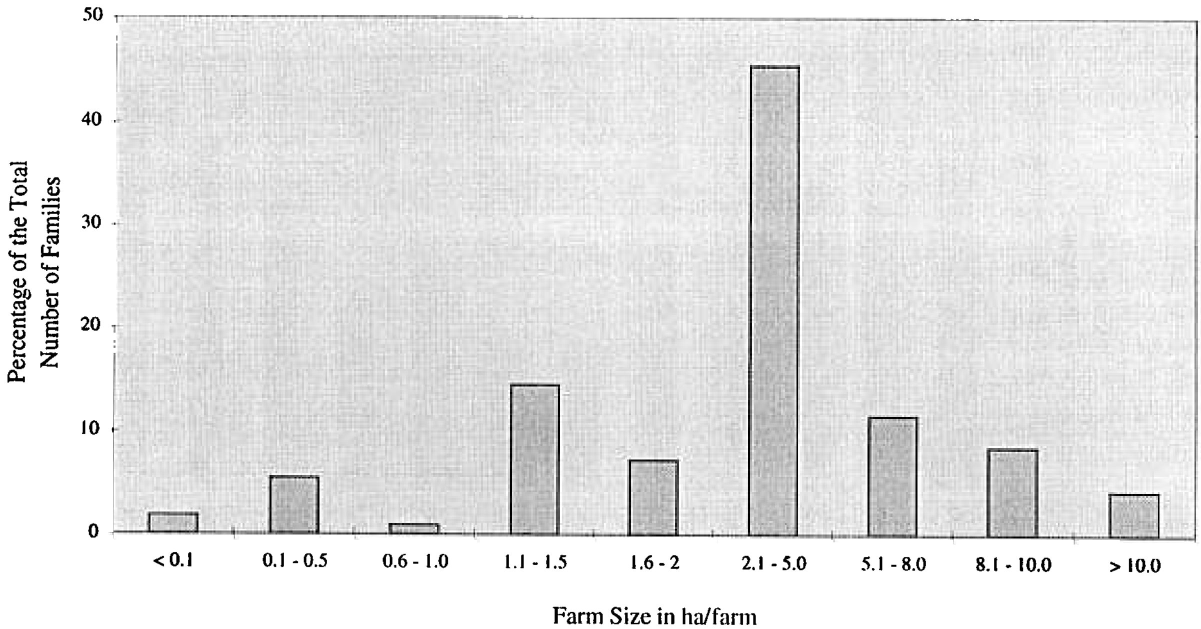

Fig. 4. Farm size distribution in Sepunggur, Sumatra, Indonesia (Source: Profil Sepunggur, 1997).

age) rubber garden. The latter criterion was used so detailed questions could be asked about the land clearing method of the most recently opened field. The survey was conducted during the dry season which proved exceptionally long and severe; there was hardly any rainfall between June and October 1997.

The survey consisted of questions on: (a) farm characterization; (b) farm characterization of the slash phase (including land selection); (c) general characterization of the burning phase; (d) characterization of the S&B methods of the most recently opened rubber garden; (e) farmers' perspectives on the importance of S&B as a land-clearing method; and (f) farmers' perspectives on alternatives to S&B. All interviews, which generally took 2 to 3 h per respondent, were conducted on an individual basis.

Data were entered and analyzed in $\text{WinStat}_{\text{IC}}$ version 1.0 (1996), a Windows operated software package for data entrance and statistical analyses of social economic and agronomic research developed by CIRAD (Centre Coopération Internationale en Recherche Agronomique pour le Développement) and (L' Institut Technique des Céréales et des Fourages).

The exchange rate of the Indonesian rupiah (Rp) to the US dollar declined dramatically in the second half of 1997. All price information given here refer to the period prior to this, when 1 US$ was worth ≈Rp 2400.

3. Results

3.1. Slashing

Most farmers started slashing to open new fields in March, towards the end of the wettest part of the year, and continued slashing until the month of August (Fig. 5). Twelve of the 37 farmers that were interviewed indicated that they had cleared their most recently opened field with a chainsaw. The cost of renting the chainsaw (Rp 35 000 per day) prevented other farmers from doing likewise. Prior to cutting the big trees, farmers removed the undergrowth of shrubs and bushes using a machete and beliung (an axe-like hand tool). Cutting one ha of secondary forest undergrowth generally took three-to-five days for one person. The daily income of a laborer for this type of work was either Rp 5000 (male) or 3000 per day (female). Hence, cutting 1 ha of secondary forest in the Sepunggur area, including chainsaw rental and labor to cut the undergrowth costed a farmer ≈Rp 60 000. The average area cleared amounted to 2 ha per household.

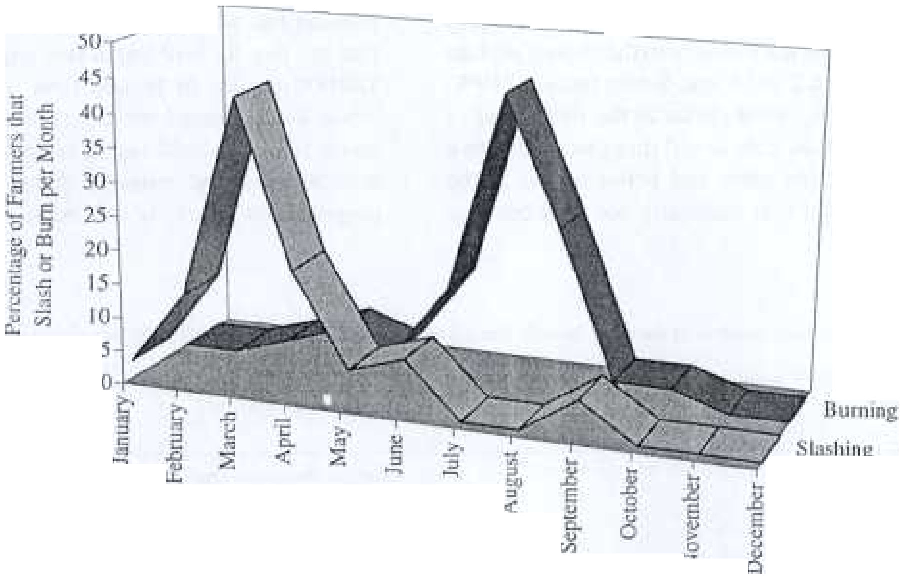

Fig. 5. Most farmers in the Sepunggur area, Sumatra, Indonesia, start slashing in March and burn fields in August.

Table 1
Wood species and local prices when sold/bought by farmers in Sepunggur (n = number of respondents). Prices are expressed as Indonesian rupiah per cubic meter planks. One US dollar equaled ≈2400 Indonesian rupiahs in September 1997

Wood species local name	Wood species, scientific name	n	Price per m^3 (1997)	Price per m^3 (1992)
Rubber	*Hevea brasiliensis, Euphorbiaceae*	2	12 500	12 500
Kulim	*Scorodocarpus borneensis, Olacaceae*	29	180 000	80 000
Tembesu	*Fagraea spp., Loganiaceae*	8	300 000	150 000
Mersawa	*Anisoptera spp., Dipterocarpacae*	13	150 000	80 000
Meranti	*Shorea spp., Dipterocarpaceae*	35	140 000	75 000
Kempas	*Koompassia malaccensis, Caesalpiniaceae*	2	90 000	40 000
Jelutung	*Dyera costulata, Apocynaceae*	1	60 000	30 000
Medang	Many species from many genera, *Lauraceae*	4	100 000	60 000
Sepat	*Vatica maingayi, Dipterocarpaceae*	4	125 000	60 000

3.2. Wood use

The price of most wood species in Sepunggur has doubled in the past five years (Table 1). Five respondents sold wood from their most recently burned field. Species sold were *Hevea brasiliensis*, *Shorea spp.*, *Koompassia malaccensis* and 'medang' which can contain species of 36 genera of the *Lauraceae* family. Total income from selling wood for these five farmers ranged from Rp 200 000 to 1 050 000 per cleared field (Table 2). No more wood was sold either due to a lack of material with economic value (68%), or high investment costs (hiring a chainsaw and/or labor and transporting the wood to the market) (30%). The distance to the nearest market (in Muara Bungo) was 24 to 31 km, and the distance to the closest asphalt road varied between 2 and 9 km. Seven farmers (19%) indicated that if they lived closer to the main road or market, they would be able to sell more wood due to a reduction in operating costs and better access to the buyer. Rubber wood was generally not sold because the investment costs and taxes outweighed the extra income earned (see Suyanto, 1997 for an analyses of the restrictions of existing government policies on the sale of rubberwood). Farmers that did sell rubberwood could cover all land clearing and planting costs.

Although pigs form a big threat to the successful establishment of a new rubber garden, only 27% of the farmers built a fence around their fields. The majority (86%) indicated that they built a field house in the newly opened field and used that location as a watchtower for pigs, goats and monkeys. At present, farmers that do not have enough wood to build a fence and still would like to do so can use wood from secondary forest or jungle rubber fields of neighbors with permission but without payment when available. Those that did pay for building a fence spent on average Rp 120 000 per ha of fenced land. A small amount of wood was collected for use as fuel for cooking. Since wood for household use is not scarce at present, the amount of wood removed from the fields for this purpose was generally limited to a few cubic meters.

Table 2
Farmer's income from selling wood from the most recently cleared field. One US dollar equaled ≈2400 Indonesian rupiahs (Rp) in September 1997

Original vegetation type	Age (years)	Area size (ha)	Wood species sold	Total earned amount (Rp)
Secondary forest			*Koompassia malaccensis*	250 000
Secondary forest			*Shorea spp.*	200 000
Secondary forest			*Koompassia malaccensis Shorea spp.* Medang	1 050 000
Jungle rubber			*Hevea brasiliensis*	300 000
Jungle rubber			*Hevea brasiliensis*	250 000

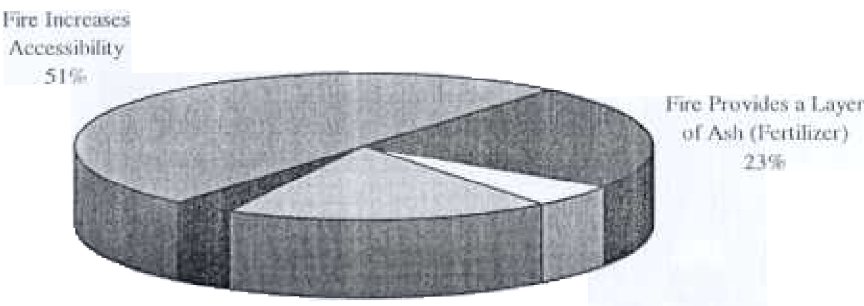

Fig. 6. Reasons why fire is being used as a land clearing method by Sepunggur farmers, Sumatra, Indonesia.

3.3. Burning

The main reason for using fire as a land clearing method was the fact that fire is a very cheap means to increase accessibility for planting and management of the new garden (Fig. 6). Other advantages were the addition of wood-ash, an improvement of the soil structure, a reduction in weed and tree re-growth, and decreased occurrence of pests and diseases.

Slashed fields are generally burned in the months of May through September with most fields being burned in the month of August (Fig. 5). The actual time of burning depends on the state of dryness of the slashed vegetation. Farmers estimated that one month was enough to dry cuttings which were less than 10 years old. A forest between 10 and 30 years took, on average, a minimum of two months to dry, whereas, the period of drying could be extended to three months for older forests. The average period of drying for the most recently opened fields was considerably longer than what farmers considered necessary, averaging three months for all vegetation types.

Burning takes place in two steps: a broadcast burn followed by pile-and-burn of the remaining wood. The second step is omitted if, after the broadcast burn, the field is considered clean enough for planting. When a second burn is conducted (generally within one week after the first burn), farmers collect wood in heaps of 200–400 kg stacked on a space of 3 to 4 m diameter. This second burn leaves a field with clearly recognizable, circle-shaped charcoal and ash spots over reddened topsoil. Out of 37 farmers, 19 burned twice (broadcast followed by pile-and-burn), 16 burned only once (broadcast), and one burned three times (twice broadcast followed by pile-and-burn).

Fields are generally burned in the afternoon when the wind is not so strong as to inhibit control but strong enough to let the fire continue on its own. Broadcast burning is a group activity in which the neighboring farmers participate. Occasionally, the borders of the newly opened field are cut clean to act as a fire break. No other precautions are usually taken apart from selecting the right time to burn.

When a fire entered a neighboring rubber garden and no prior agreement with the neighbors was obtained, the farmers, who burned the field had to pay for the damage (compare with Wibowo et al., 1997). Generally, the payment amounts to Rp 1000 per seedling for one-year old rubber, Rp 2000 per seedling for two-year old rubber, topping out of Rp 5000 per tree for five-year or older rubber trees. With a planting distance of 3*6 m per ha, the destruction of 1 ha of one-year old rubber garden would amount to total damages of Rp 560 000. Rubber trees that were more than 10 years old generally survived wild fires with a delay of a few months in production.

3.4. Crop selection and planting

All of the most recently opened fields (within the past five years) were planted with rubber seedlings at

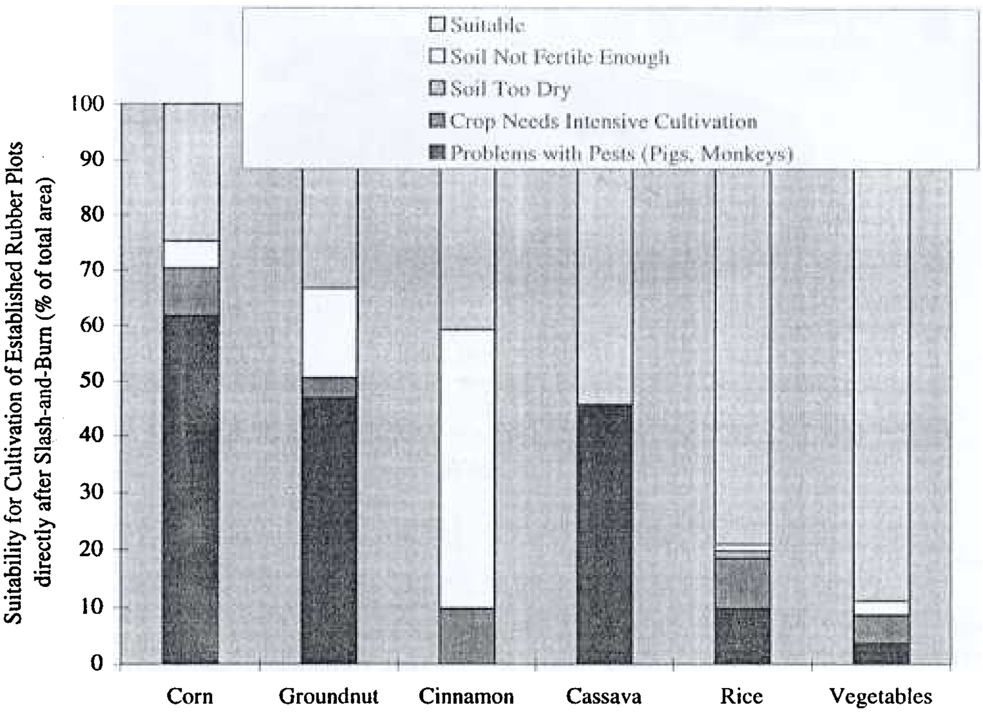

Fig. 7. Initial suitability assessment for crop cultivation of recently opened field (within the last five years) by the 37 respondents in Sepunggur, Sumatra, Indonesia. All fields were planted with rubber seedlings with or without intercropping with other crops during the first 2–3 years. Initial suitability percentages indicate which percentage of the fields was perceived to be suitable for other crops and which percentage was considered unsuitable due to either a low soil fertility status, too dry environmental conditions, high labor demand, or problems with pigs and monkeys.

fixed planting distances (3*6 m, 560 trees/ha). Only seven farmers planted their fields with clonal rubber. Four of the seven farmers received the clones in polybags free-of-charge from the Rubber Smallholder Agroforestry Project (SRAP) (a description of the project can be found in Penot, 1995). Farmers recognized that clonal rubber can produce up to three times more latex per ha per year. However, the high costs of planting material (≈Rp 700 per tree at the farmgate) prohibited all but three of the farmers that did not participate in the SRAP from planting improved clonal rubber seedlings.

Farmers were asked if the plots they opened during the past five years directly after slashing and burning would have been suitable for corn (*Zea mais*), peanut (*Arachis hypogea*), cinnamon (*Cinnamomum zeylanicum*), cassava (*Manihot esculenta*), rice (*Oryza sativa*), and vegetables. The initial suitability of six indicator crops described in the order: vegetables, rice, cassava, groundnut,, and corn (Fig. 7). Main constraint to the cultivation of corn, groundnut and cassava were problems with pigs and monkeys. Major constraint for the cultivation of cinnamom as indicated by the farmers, was the initial soil fertility. Although cinnamon is known to all farmers and has been planted in recent years, it is not very well suited to the lowland peneplain. It is interesting that farmers perceive it to be an indicator of soil fertility, rather than poor adaptations to the local climate.

Annual crops such as upland rice, corn, and vegetables were planted within the young rubber trees by 70% of all farmers. Cultivating annual crops longer than 2–3 year was considered uneconomical because, by then, rubber trees cause too much shade for successful cultivation of annual crops (37%), the soil is not fertile anymore (26%), there is too much weed competition (21%), or there are too many problems with pigs and monkeys (16%).

Table 3
Micro-scale comparison of farmers' perspectives on *Oryza sativa* response to differences in burning intensity: unburned soil, once burned soil (black and white ash), and soil exposed to high temperatures in a second burn (red soil deprived of organic matter).

Oryza sativa (Upland rice)					
Time until first production			Yield		
	Black/ash soil	Red soil	Unburned soil	Black/ash soil	Red soil
Longer 35	Control	Longer 27	Higher 0	Control	Higher 0
Same 2		Same 9	Same 1		Same 14
Shorter 0		Shorter 0	Lower 36		Lower 22
Don't know 0		Don't know 1	Don't know 0		Don't know

3.5. *Farmers' perceptions of the effects of burning on soil fertility and plant responses*

Fields are rarely homogeneously burned. Slash-and-burn generally leaves a patchy pattern of unburned litter and biomass, ash, charcoal, blackened (burned) soil and red (combusted) soil. Tables 3 and 4 show farmers' perceptions of the soil fertility status of these patches (micro-scale) for upland rice and rubber, respectively. For an annual crop like upland rice, almost all respondents indicated that black burned soil covered with ash was more fertile and resulted in faster growth and higher production levels as compared to unburned soil. For latex production, 84% of the farmers expected a delay in time until the first production and 59% expected a yield decline. The main reason for the delay in production and yield reduction in non-burned soil as compared to black burned soil was the fertilizer effect of wood-ash. Completely combusted red soil was considered less fertile (41%) and was described as not being able to hold water (37%) in addition to containing less ash (23%). For these reason, several farmers indicated that it was less desirable to burn a second time (pile-and-burn methods). Still, 20 respondents (54%) indicated that they had burned more than one. Obviously, the benefits of burning all wood from the field (easier planting and management of the newly planted trees) outweighed the expected localized decrease in soil fertility and water holding capacity of the soil.

Although farmers recognized these micro-scale differences in soil fertility after burning, not a single farmer redistributed the wood-ash or planted his crops specifically in the burned area. The advantages of planting the rubber seedlings at fixed planting distances (faster growth, easier management, less root competition and hence stronger roots resulting in less problems with wind) obviously outweighed the advantages of the anticipated shorter time until first production and higher yields when crops were planted in locations with black soil and ash (as compared to unburned and/or red soil) or when wood-ash was redistributed.

On a field-scale farmers expected a delay and/or decline in yield for the most commonly cultivated crops if no burning was used (Fig. 8). The expected decline was larger for annual crops than for perennial and woody species. Although the main reason for

Table 4
Micro-scale comparison of farmers' perspectives on *Hevea brasiliensis* response to differences in burning intensity: unburned soil, once burned soil (black and white ash), and soil exposed to high temperatures in a second burn (red soil deprived of organic matter)

Hevea brasiliensis (Rubber)					
Time until first production			Yield		
Unburned soil	Black/ash soil	Red soil	Unburned soil	Black/ash soil	Red soil
Longer 31	Control	Longer 27	Higher 0	Control	Higher 0
Same 6		Same 9	Same 15		Same 14
Shorter 0		Shorter 0	Lower 22		Lower 22
Don't know 0		Don't know 1	Don't know 0		Don't know

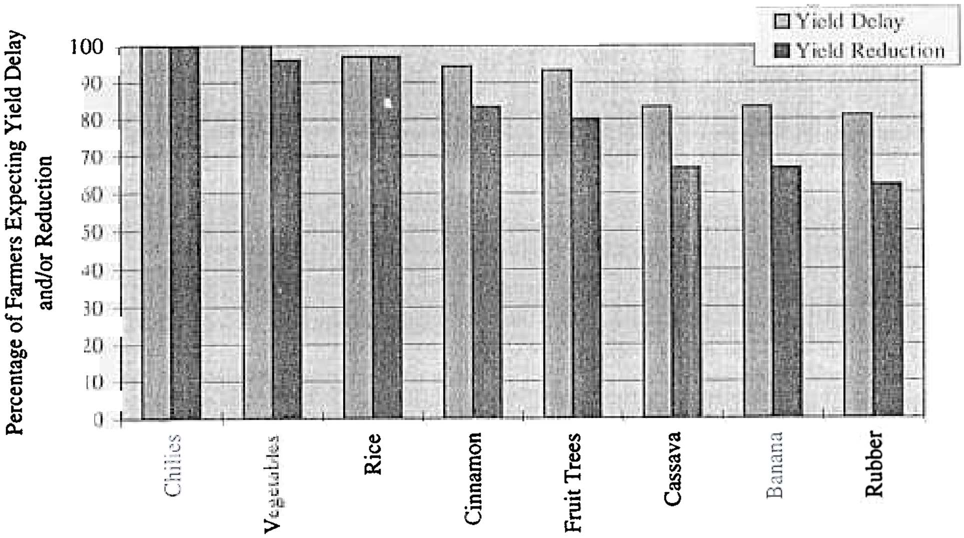

Fig. 8. Percentage of farmers expecting a delay and/or reduction in yield of frequently cultivated crops in the Sepunggur area if no burning takes place.

burning was to reduce the amount of biomass on the field allowing easier planting and management of the new garden, free fertilizer in the form of wood ash was believed to contribute most to the increase in yield when fire was used as land clearing tool (Fig. 9).

3.6. Future field selection

Most farmers indicated that if they had a choice they would select old forest (>30 years) for burning, mainly because the soils supporting mature trees were consi-

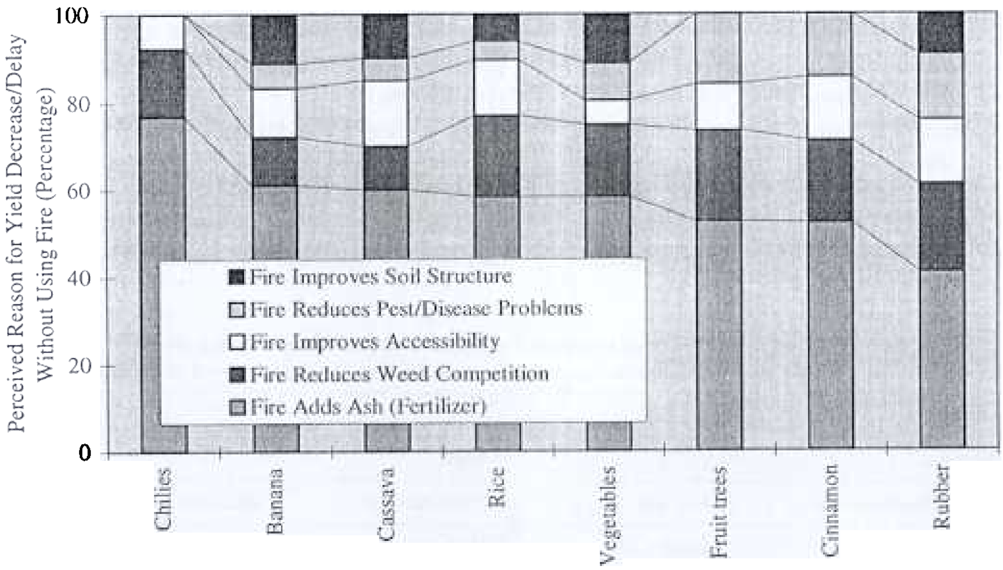

Fig. 9. Perceived reasons for an expected increase in crop yield and/or decrease in time until (first) production of frequently grown crops in Sepunggur if burning takes place.

:d more fertile. Seven farmers preferred <10 years secondary forest since slashing was easier. In addi- , farmers preferred flat fields over sloped fields ier to tap and keep clean) and dry fields over fields were waterlogged for one week to one month (esta- hment of rubber is restricted in a waterlogged field).)espite this clear preference for field selection, ners can no longer select which vegetation to There has been no community owned and oper- l forest since 1990. There is neither a primary :st nor any >30-years old secondary forest and only mall area of >30-years old jungle rubber left. ›unggur is surrounded by governmental transmi- tion areas and cannot extend its area any further. ped land, previously untouched, is now being ;hed and burned and converted to rubber gardens. [hose farmers that still own secondary forest or :h fallow (24 farmers) intend to S&B the remaining a, a total of 95.5 ha, within the next five years.

Future crop selection

At present, rubber is the most important crop in the ɔunggur area. As indicated before, all newly opened lds in the past five years have been planted with :ally obtained rubber seedlings. The farmers that ll own forest and/or bush fallow intend to plant ɔber seedlings.

Although governmental promotion of oil palm cul- ation is likely to cause the conversion of some of the ɔber gardens into oil palm gardens, only two respon- nts in Sepunggur believed that oil palm would come more important than rubber in the next 10 ars. Rubber cultivation was introduced into the area rly in the 20th century (Gouyon et al., 1993; Van ɔordwijk et al., 1995) and has been part of the rmers' lives and existence ever since. Farmers know ›w to cultivate rubber and can remain independent. ;tablishing rubber gardens involves little cost, hereas establishing an oil palm garden means a large vestment in the planting material and continued :pendency on a single oil palm factory which acts the nucleus of a plantation project area.

8. Alternatives

An enforced ban on burning would force 21 ɜpunggur farmers to slash-and-mulch. Eight farmers would slash and remove the wood from the field if S&B was no longer permitted. Five farmers indicated that they would burn smaller areas at a time (step-by-step burning) noting that it would never be possible to ban the use of household fires. All farmers indicated that not being permitted to burn would severely and negatively affect their economic status.

4. Discussion and conclusions

Farmers mentioned five advantages of S&B as a land clearing method: (1) residual wood ash acts as a fertilizer; (2) weed and tree competition is reduced due to the burn; (3) burning creates space to plant and walk; (4) burning reduces the occurrence of pests and diseases; and (5) burning improves soil structure enabling faster establishment of seedlings. Burning old stumps is recommended for phytosanitary reasons: to reduce the incidence of white root rot disease in rubber. Mulching not only makes management of the field more difficult and time consuming, it, in addition, does not provide a positive alternative to any of the benefits of burning. Slash-and-remove-wood without the option of selling it addresses only the third advantage and requires a tremendous effort in labor. Farmers would not contribute to air pollution with either alternative but they would expect a reduction in income due to difficulties in establishing new rubber gardens (increased occurrence of pests and diseases, especially white root rot disease), reductions in yield (lower soil fertility status due to absence of wood ash) and/or increases in labor costs (more time needed for removing the wood, planting and for weeding). An increase in poverty would be expected if burning was banned and slash-and-mulch was the only alternative. Neither alternative is likely to be acceptable, and it is therefore not surprising that the 1984 ban on burning could not be enforced.

The dry weather and atmospheric condition brought on by El Niño aggravated the air pollution problems in the region in 1997. As it is still not known what triggers El Niño events, El Niño years can not be predicted ahead of time, but early warning method are improving. In 1997 the first indications of El Niño were reported in Indonesia in May, but it is not likely that this influences farmers' decisions to clear land; fc the large scale operators, however, the prospects c easy clearing in a long dry season may have stimulated clearing decisions. Where the El Niño effects on wind directions and inversions imply a much stronger effect of fires on haze than in normal years, decision on burning times and methods might be adjusted in the future to reduce the damage (Tomich et al., 1998a). Regulating land clearing and burning practices (restrictions on burning when atmospheric conditions are unfavorable for quick smoke dispersion), would be an alternative that could prevent further disasters from happening. Some farmers supported this alternative by suggesting step-by-step burning of smaller areas. Regulated burning would require an effective monitoring system and enforcement mechanism which is possible for large plantation operations but not for small producers, whose activities can neither be monitored nor enforced.

Another possible alternative is a replacement of S&B by slash-sell-and-burn. Removal of the largest pieces of wood from the field prior to burning can reduce smoke development while still maintaining, to a certain extent, the benefits of fire. By selling wood, farmers can earn enough to cover the costs of land clearing and the purchase of higher-yielding clones for rubber replanting (Suyanto, 1997). Even after all forested land has been converted to rubber plantations (which is expected to happen within the next 10 years) some form of land clearing will still remain necessary to rejuvenate the rubber gardens or to convert them into other land uses. Slash-sell-and-burn would then be an alternative only when rubber wood can be sold. At present, only two farmers interviewed in this survey indicated they had sold rubberwood. Promoting the sale of rubberwood and other timber requires a change in local trade regulations and taxes. At present, a high export levy and local trade regulations severely restrict the sale of rubberwood and other valuable timber species by small producers.

The farmers that were interviewed in this survey largely depend on latex production for their income (Kelfoun and Penot, 1997). The results of this survey indicated that alternatives to S&B that do not include the use of fire are expected to increase the poverty of small rubber farmers in the Sepunggur area. Alternatives such as slash-and-mulch and slash-and-remove wood can therefore not be considered acceptable and a ban on the use of fire will be impossible to enforce. This survey also showed the potential for farmers to sell (more) wood if regulations and taxes would permit it and the willingness of farmers to burn in smaller amounts of biomass at a time if that means fire can still be used. These alternatives reduce air pollution and address the needs, and perceptions of the farmers and are therefore more likely to be acceptable as an alternative to the traditional S&B method of land clearing than a ban on the use of fire in Indonesia.

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