Intercropping Practices in Cacao, Rubber and Timber Plantations in West Java, Indonesia

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Abstract Intercropping practices enable to increase income levels and reduce social disturbances around plantations. However, detailed aspects relating to intercropping practices in West Java have not been fully studied. The objective of the present study was to identify the characteristics of intercropping practices in cacao, rubber and two teak plantations in West Java, Indonesia. Interviews with managers and farmers revealed that plantation companies allow farmers to cultivate crops for 3-4 years after tree cutting. Therefore, farmers change lands every 3-4 years. Farmers cultivate profitable and marketable crops on intercropping lands to earn income. They earn 57-72% of their income through intercropping activities. For sustainable production of cash crops over many years in intercropping, it is necessary to identify crops that fetch a high price and are tolerant to shade conditions, and to determine whether the cultivation of these crops under the mature canopy of tree crops might affect tree growth.

Key Words: banana, pineapple, pine tree, sustainability, teak

Introduction

Intercropping is a common agricultural practice in tropical regions. It has been recognized that farmers can achieve more profit per unit area of land by adopting intercropping systems without adverse effects on the environment (Osei-Bonsu et al., 2002; Nissen et al., 2001; Rodrigo et al., 2001), and that intercropping can stabilize socio-economic conditions and alleviate poverty. Pratiwi (1997) has stated that the involvement of villagers in intercropping programs can contribute to the preservation of forests, while Tomich et al. (1998) have reported that small-scale farmers are more concerned with profitability, food security, labor availability and agronomic sustainability than with forest conservation and the loss of biodiversity.

Crop and forestry plantations in Indonesia are estimated to cover about 4 and 45 million hectares, respectively. Most plantation companies are confronted with social and environmental issues related to high population pressure, high unemployment rates and limited land resources. Many conflicts occur between villagers and companies because villagers often invade plantations. Timber forests in Java covered 1.9 million ha in 1999, and timber production from about 0.3 million ha was lost due to illegal logging (65%), encroachment (17%), grazing of cattle and sheep (4%) and fire (2%) (Adjji, 2000).

Plantation companies provide two community development programs, i.e., land-based and non-land based programs. Non-land based program includes financial support to communities to install pipes for drinking water and to construct public facilities such as roads, hospitals and mosques. Companies finance farmers for the purchase of cattle, chickens and beehives, and for the establishment of cooperatives. In the land-based program, companies recommend that farmers adopt intercropping systems to increase their income. This program which was started as a national food security program in the 1980s changed to ‘The Pembinaan Masyarakat Desa Hutan’ (Rural Forest Community Development), a program for increasing the general income of villagers around forest companies, in the 1990s. However, both programs failed to satisfy the companies. Rodrigo et al. (2001) stated that problems associated with pests and diseases were the major reasons for the discontinuance of intercropping.

Intercropping in plantations in Indonesia is usually performed temporarily because it involves the use of lands for 3-4 years after tree planting.
If farmers want to derive long-term revenue in the same area, they need to grow shade-tolerant crops such as *Amorphophallus muelleri* under mature tree canopy in plantations (Santosa et al., 2003). However, intercropping systems using shade-tolerant *Amorphophallus muelleri* are implemented only in East Java. The objectives of the present study were to analyze intercropping practices in plantations in West Java, and to determine why farmers do not grow shade-tolerant crops under mature tree canopy in West Java.

**Methods**

Research was conducted in four plantation companies, i.e., the Rajamandala cacao (Bandung District), the Cikumpay rubber (Purwakarta District), the Purwakarta (Subang District) and Sumedang (Sumedang District) timber plantations in West Java, Indonesia, in July 2003 (Fig. 1). In each plantation, one village was selected based on the recommendations of the managers.

The Rajamandala cacao plantation is located at a distance of about 35 km from Bandung. The government allows the company to use 549.7 ha. The first planting was carried out in 1977 and the last planting in 1991. Productive cacao trees (*Theobroma cacao*) cover an area of 435.4 ha. In addition to cacao trees, some areas are planted with rubber (37.2 ha) and pine trees (4.5 ha), and some areas are reserved lands (38.1 ha). The company produces dried fermented seeds as end-products.

The Cikumpay rubber plantation is located at a distance of about 19 km from the Purwakarta District and 30 km from the Subang District. The government allows the company to use 3,173 ha. Productive rubber trees (*Hevea brasiliensis*), which are 4 years old or older, are planted on 2,608 ha. The plantation manages a well-equipped processing factory that produces concentrated latex, crepe rubber, smoked rubber sheets and crumb rubber.

The Purwakarta timber plantation is spread over three districts, i.e., Purwakarta (21,740 ha), Subang (17,229 ha) and Karawang (17,860 ha) along the northern coast of West Java at a distance of 10-60 km from the center of each district. Production forests and conservation forests cover areas of 52,611 ha and 4,218 ha, respectively. The company sells teak (*Tectona grandis*), pine (*Pinus merkusii*) and mahogany (*Swietenia macrophylla*) wood mainly for the domestic market.

The Sumedang timber plantation covers an area of 37,293 ha, with 22,734 ha for teak and 14,559 ha for pine tree forests. Production forests occupy 27,685 ha, while 8,626 ha and 982 ha are allocated as conservation forests and reserved lands, respectively.

We interviewed company managers in order to determine whether or not companies allow farmers to use the forest floor, and to obtain general information about intercropping systems if farmers use the forest floor. We interviewed ten farmers in each village to gain information about their agricultural activities, economic conditions and social background. Field data, such as plant productivity and performance, were also collected.

**Results and Discussion**

**Company policy**

Managers determined whether areas were suitable for the introduction of intercropping programs in terms of topography, the desire of farmers and their degree of poverty, if they wanted to implement intercropping programs in the plantations. Managers selected participants based on the distance from their houses to the intercropping sites; closer villages received a higher priority than distant ones. The distance...
ranged from 0.5 km for the Rajamandala cacao plantation to 3.0 km for the Sumedang timber plantation. In addition, the personality of the farmers, their contribution to the maintenance of company's properties, income level, farm size and recommendations from village authorities were important criteria for the selection of participants.

Before the intercropping program began, all the companies discussed the conditions for intercropping with the farmers and administration authorities in the villages, sub-districts or districts in order to achieve benefits for both the companies and farmers. The contracts, which were made between the timber companies and individual farmers with the endorsement of the head of the farmers' group, were usually effective for 3 years, and could be extended for another 3 years. In the Rajamandala cacao and the Cikumpay rubber plantations, the companies concluded contracts for 2 to 3 years. The contract of agreement stated the responsibility of the farmers, and prohibited farmers from transferring land use rights to other parties. The farmers’ groups provided planting materials and were responsible for marketing. Companies financed the groups at a low interest rate to procure basic input such as fertilizers or pesticides.

According to the managers, companies allowed intercropping under the canopy of trees that were 4 years old or younger. Therefore, farmers had to change intercropping sites every 3 to 4 years according to the cutting schedule. In 2001, the areas used for intercropping covered 710 ha in the Cikumpay rubber plantation, 4,874 ha in the Sumedang timber plantation, 1,000 ha in the Purwakarta timber plantation, and 2 ha in the Rajamandala cacao plantation, accounting for to 22%, 13%, 2% and less than 1% of the total area, respectively.

Timber plantation companies sometimes allowed farmers to utilize the forest floor under the canopy of mature trees (5 years old or older), but the Rajamandala cacao and the Cikumpay rubber plantation companies prohibited this practice because they considered that intercropping disturbed tree growth. The manager of the Rajamandala cacao plantation stated that tillage causes soil erosion in the rainy season and severe drought in the dry season. The Rajamandala cacao plantation also prohibited farmers from cultivating tuber crops and perennial crops such as cassava and fruit trees.

In order to increase farmers’ income, timber companies changed their policy in 1994 to allow farmers to grow pineapple and banana in addition to legumes and grain crops. Furthermore, the timber companies were planning to change the initial planting density of trees from $3m \times 1m$ to $3m \times 3m$, $3m \times 6m$ or $2m \times 6m$. Companies expected that farmers would cultivate crops in the same areas for more than 3 to 5 years by adopting a low planting density. However, it has been pointed out that a low planting density may decrease the yield of tree crops (Ekanade and Egbe, 1990; Midmore, 1993; Prawoto, 1997; Nissen et al., 2001; Osei-Bonsu et al., 2002).

**Background of participants**

The age of the farmers participating in the intercropping programs was not uniform and they exhibited various levels of skill, while their income differed (Table 1). The average age of the farmers ranged from 36 to 53, and their farming experience was correlated with age. The average farmer income in the Purwakarta timber plantation was the highest among the study sites, i.e., 465,000 ± 298,200 rupiah/month, while that of the farmers in the Rajamandala cacao plantation was the lowest, i.e., 257,000 ± 166,500 rupiah/month. On the average, the farmers had been engaged in intercropping practices for more than 9 years in the Sumedang timber plantation, and for 3 to 4 years in the other plantations (Table 1). Farmers earned 57 to 72% of their income on the average through intercropping practices. Half of the respondents were unable to earn enough money to compensate for their expenses in the Cikumpay rubber plantation, but most farmers in the Purwakarta and Sumedang timber plantations were able to earn a sufficient amount of money to live on (Table 2).

Average farm size, including home gardens in the Purwakarta timber, the Sumedang timber, the Rajamandala cacao and the Cikumpay rubber plantations was 0.97 ha, 0.46 ha, 0.22 ha and 0.97 ha, respectively (Table 1). In the Rajamandala cacao plantation, 70 % of the respondents were landless farmers, whereas 40-50% were landless in the other plantations.

Several staple foods, root crops and fruit trees were cultivated on the farmers’ own land. Farmers in the Sumedang and Purwakarta timber
Table 1 Background of intercropping participants in the Purwakarta timber, the Sumedang timber, the Rajamandala cacao and the Cikumpay rubber plantations in West Java, Indonesia

<table>
<thead>
<tr>
<th></th>
<th>Purwakarta Timber</th>
<th>Sumedang Timber</th>
<th>Rajamandala Cacao</th>
<th>Cikumpay Rubber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>43.4 ± 7.7 ²</td>
<td>52.2 ± 9.6</td>
<td>53.0 ± 11.3</td>
<td>36.2 ± 8.0</td>
</tr>
<tr>
<td>Farming experience (years)</td>
<td>22.0 ± 9.1</td>
<td>29.8 ± 11.7</td>
<td>30.3 ± 15.4</td>
<td>14.3 ± 9.4</td>
</tr>
<tr>
<td>Farm size² (ha)</td>
<td>0.97 ± 0.94</td>
<td>0.46 ± 0.25</td>
<td>0.22 ± 0.25</td>
<td>0.97 ± 1.25</td>
</tr>
<tr>
<td>Landless farmers (%)</td>
<td>40</td>
<td>50</td>
<td>70</td>
<td>50</td>
</tr>
<tr>
<td>Monthly income (× 1,000 rupiah)</td>
<td>465.0 ± 298.2</td>
<td>275.0 ± 62.4</td>
<td>257.0 ± 166.5</td>
<td>280.0 ± 94.9</td>
</tr>
<tr>
<td>Involvement in intercropping (years)</td>
<td>3.9 ± 1.0</td>
<td>9.2 ± 8.2</td>
<td>3.8 ± 2.4</td>
<td>2.5 ± 1.4</td>
</tr>
<tr>
<td>Contribution of intercropping to total income (%)</td>
<td>71 ± 14</td>
<td>72 ± 21</td>
<td>57 ± 17</td>
<td>57 ± 15</td>
</tr>
</tbody>
</table>

² Average farm size was calculated by omitting landless farmers.

Table 2 Percentage of respondents whose income was less or exceeded monthly expenses in the Purwakarta timber, the Sumedang timber, Rajamandala cacao and the Cikumpay rubber plantations in West Java, Indonesia

<table>
<thead>
<tr>
<th>Expenses in relation to income</th>
<th>Purwakarta Timber</th>
<th>Sumedang Timber</th>
<th>Rajamandala Cacao</th>
<th>Cikumpay Rubber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than income</td>
<td>20</td>
<td>10</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>Equal to income</td>
<td>20</td>
<td>60</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>Exceeded income</td>
<td>60</td>
<td>30</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

plantsations cultivated both upland and lowland rice for daily consumption, while farmers in the Rajamandala cacao and the Cikumpay rubber plantations cultivated only lowland rice (data not shown). Cassava, taro (Colocasia esculenta), Xanthosoma and sweet potato were important root crops on farmers' own fields in the the Purwakarta timber plantation and the Cikumpay rubber plantation. In the Rajamandala cacao plantation, cassava and taro were grown, while only cassava was grown in the Sumedang timber plantation (data not shown). More than half of the respondents at each study site were aware of the existence of elephant foot yam (Amorphophallus paeonifolius), but no farmers grew it because of low preference and marketability. Regarding fruit trees, banana was common at all the sites, especially in the Sumedang timber plantation and Rajamandala cacao plantation. Rambutan (Nephelium lappaceum) and durian (Durio zibethinus) were common in the Cikumpay rubber plantation and the Purwakarta timber plantation, respectively. Farmers selected these crops for daily consumption in the Purwakarta timber plantation, but for selling at markets in the case of the Rajamandala cacao plantation and the Sumedang timber plantation. Moreover, water requirement of plants and a low labor requirement were also important criteria for the selection of crops (Table 3).

Intercropping practice

Farmers participating in the intercropping programs managed 0.23 and 0.06 ha in the Cikumpay rubber and Rajamandala cacao plantations, respectively (Table 4). In the Sumedang and Purwakarta timber plantations, farmers managed larger areas than farmers in the Cikumpay rubber and Rajamandala cacao plantations, i.e., 0.44 ha and 0.65 ha per farmer, respectively. In the Rajamandala cacao plantation, no land was available because all the trees were already mature. Therefore, farmers cultivated scattered parcels of land (10 to 200 m²) where trees were damaged or already dead. From the farmers' point of view, land size was insufficient to support a comfortable life; they wanted to manage 0.48 to 0.50 ha on the average in the Rajamandala cacao and Cikumpay rubber plantations, and 0.73 to 0.85 ha in the timber plantations (Table 4). In the Purwakarta timber plantation, two respondents managed more than 3 ha in remote areas. Santosa et al. (2003) reported that rich farmers were able to manage larger land areas than poor farmers if there
Table 3 Criteria on the basis of which farmers decided to cultivate crops in their own lands in the Purwakarta timber, the Sumedang timber, the Rajamandala cacao and the Cikumpay rubber plantations in West Java, Indonesia

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Purwakarta Timber</th>
<th>Sumedang Timber</th>
<th>Rajamandala Cacao</th>
<th>Cikumpay Rubber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily consumption</td>
<td>100</td>
<td>40</td>
<td>10</td>
<td>60</td>
</tr>
<tr>
<td>Easy to sell</td>
<td>20</td>
<td>70</td>
<td>10</td>
<td>60</td>
</tr>
<tr>
<td>High profit/price</td>
<td>20</td>
<td>30</td>
<td>-</td>
<td>30</td>
</tr>
<tr>
<td>Climatic suitability</td>
<td>40</td>
<td>10</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>Farmer skill</td>
<td>10</td>
<td>10</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Low maintenance</td>
<td>40</td>
<td>30</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>Appetizer</td>
<td>10</td>
<td>20</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* Number indicates the percentage of respondents who addressed each criterion.

Table 4 Distance from villages to intercropping lands, and managed and desirable land areas for intercropping practices in the Purwakarta timber, the Sumedang timber, the Rajamandala cacao and the Cikumpay rubber plantations in West Java, Indonesia

<table>
<thead>
<tr>
<th></th>
<th>Purwakarta Timber</th>
<th>Sumedang Timber</th>
<th>Rajamandala Cacao</th>
<th>Cikumpay Rubber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance (km)</td>
<td>1.4 ± 1.0</td>
<td>3.0 ± 2.2</td>
<td>0.5 ± 0.6</td>
<td>2.2 ± 0.7</td>
</tr>
<tr>
<td>Managed lands (ha)</td>
<td>0.44 ± 0.26</td>
<td>0.65 ± 0.33</td>
<td>0.06 ± 0.03</td>
<td>0.23 ± 0.13</td>
</tr>
<tr>
<td>Desirable areas (ha)</td>
<td>0.73 ± 0.30</td>
<td>0.85 ± 0.24</td>
<td>0.50 ± 0.20</td>
<td>0.48 ± 0.22</td>
</tr>
</tbody>
</table>

* mean ± SE (n=10).

were no limits on land availability in the teak plantations of East Java.

**Land preparation**

Farmers prepared intercropping lands by slash and burn of brushwood, timber cut bases, and weeds during the dry season before the planting of tree seedlings by companies. Farmers believe that some soil organisms such as snakes, scorpions, rats, bees, pathogens and other dangerous organisms are eradicated by burning. Farmers recognized that crop growth and yield were higher in burned than in non-burned areas. Ketterings et al. (2002) recommended the removal of wood before the start of fire because intense fire increased phosphorus fixation on the surface soil and reduced phosphorus availability in the long term. In the Rajamandala cacao and Cikumpay rubber plantations, since slash and burn was not performed, weeds were buried as organic fertilizers.

After burning, the farmers plowed the land and built terraces to minimize soil erosion. In addition to terracing, furrows 20 to 30 cm in width and 100 to 300 cm in length were arranged along contour lines at a certain distance to increase water percolation and reduce soil erosion. Mulches made of plant residues also were spread to reduce water spill. Despite these efforts, the managers stated that soil erosion still occurred in the Sumedang and Purwakarta timber plantations where sloping lands accounted for more than 30% of the total area.

The companies usually plant timber tree seedlings either in the same year as cutting or one year after cutting. In both cases, soil preparation for crops was carried out at the end of the dry season (July to October), and planting in the early rainy season (November to January). After harvest of the first crops, second crops were grown until May.

**Crop selection**

Farmers replied that they performed intercropping under a canopy to increase their income level. Therefore, most farmers decided which crops they wanted to grow, based on profitability and marketability (Tables 5 and 6). In the Rajamandala cacao plantation, however, most farmers followed the regulations of the company or prioritized...
their preferences for daily consumption in selecting the crops they grew. Scherr (1995) reported that farmers in West Kenya perform intercropping to increase their income level and to meet the demand for daily consumption.

Each company recommended that farmers grow annual crops, such as maize, upland rice, groundnut, soybean, mung bean (*Vigna radiata*), tomato and chili. According to the farmers, groundnut, yard long bean (*Vigna unguiculata*), mung bean, and chili can be easily sold. Moreover, the farmers stated that Zingiberaceae plants, such as ginger and galanga (*Kaempferia galanga*), are profitable. Farmers carried out mixed cropping to reduce the risk of disease and drought problems. They also cultivated non-leguminous crops along with leguminous crops to maintain the soil fertility.

The timber companies authorized farmers to grow leaf and fruit banana (*Musa spp.*) and pineapple. The production areas for banana were located on slopes or in remote areas in the Purwakarta timber plantation, and in parcels of land under high-voltage transmission cables in the Sumedang timber plantation. A special *Musa* cultivar, ‘Nanggala’, was used for the production of banana leaves in the Purwakarta timber plantation, whereas fruit banana consisted of several local cultivars such as ‘Ambon’, ‘Emas’, ‘Muli’, ‘Pisang Sere’ and ‘Nangka’. Both fruit and leaf banana were intercropped with mahogany for six years until the tree canopies were fully closed. Pineapple was planted on steep slopes under the canopy of pine trees in the Purwakarta timber plantation. In Sri Lanka, intercropping of rubber trees with triple rows of banana provided...
sustainable income when the rubber trees were young (Rodrigo et al., 2001).

In the case of the Sumedang timber plantation, the company tried to introduce crops that fetched a high price such as vanilla, pepper and coffee under pine tree canopies. A demonstration plot of vanilla was established in a 35 year-old pine forest in 2000. The companies conducted regular surveys to determine whether intercropping of vanilla disturbed tree growth. Farmers replied that coffee and vanilla are suitable crops for intercropping because they were tolerant to severe shading. Other crops such as rattan (Siebert, 2000) and A. muelleri (Santosa et al., 2003) are also shade-tolerant. However, companies have not examined the effect of cultivation of these shade-tolerant crops on tree growth. Neither managers nor farmers were familiar with A. muelleri on any plantation, unlike in East Java (Santosa et al., 2003). Therefore, a market for A. muelleri should be developed to undertake the cultivation of A. muelleri under mature tree canopies.

**Maintenance**

The average distance from the villages to the intercropping lands in the Sumedang timber plantation was the longest among the four research sites, 3.0 ± 2.2 km, although the preferred distance was less than 1 km (Table 4). In the Sumedang timber plantation, therefore, farmers built temporary huts or shelter houses (5 × 5 m) in their intercropping lands where they stayed for 7 to 20 days per month. They also used these huts as storage houses. Some farmers stayed for more than 2 months during the harvest season for tobacco and chili. On the other hand, pineapple farmers in the Purwakarta timber plantation visited their farms only 1 to 4 times during the growing season until ethephon application. The first ethephon application was carried out 7 months after planting or after the leaf number exceeded 40. After ethephon application, they visited their farms 1 to 4 times per month until harvest. After harvest, they went to work in big cities during the dry season and came back at the end of the dry season. Therefore, it appeared that farmers grew pineapple in the Purwakarta timber plantation because of the low labor requirement. Santosa et al. (2003) reported that farmers want to grow A. muelleri in teak plantations in East Java because of the low labor requirement.

**Benefits for farmers**

Farmers in the Sumedang timber plantation replied that crop yield decreased by 10 to 30% per year, with the highest yield being recorded in the first year. They predicted that soil fertility and light intensity would decrease, and damage from pests and diseases would increase with time, as indicated by Rodrigo et al. (2001). In the Purwakarta timber plantation, farmers replied that they harvested 36-40 ton/ha of pineapple in the first year, then 20-30 ton/ha in the second year, and less than 20 ton/ha in the third year. The fruit size tended to decrease from the first to the third harvest.

According to farmers, the success of intercropping depended on marketing. Average production of upland rice was 1.6 ton/ha in the Sumedang timber plantation and sales totaled 1.6 million rupiah/harvest/ha. Since upland rice can be harvested once a year, the gross income amounted to 6.4 million rupiah over a 4-year period. Banana fruits were harvested every 10 to 15 days, starting from 11 to 13 months after planting. The yield amounted to 200 to 400 kg/month/ha, and the average banana price was about 800 to 1,000 rupiah/kg. Therefore, sales totaled about 160,000 to 400,000 rupiah/month/ha. Leaf banana was harvested every two weeks starting from 6 months after planting. The yield amounted to 500 to 1,000 kg/harvest/ha, and the average price was about 150 rupiah/kg. Therefore, sales totaled 150,000 to 300,000 rupiah/month/ha. Both banana types could be harvested all the year round until 4 to 6 years after planting. Gross income amounted to 4.7 to 11.7 million rupiah for fruit banana and 5.3 to 10.6 million rupiah for leaf banana over 4 years if the yield decreased by 20% per year. According to the farmers, pineapple yield ranged from 20 to 40 ton/ha, with an average price of about 160 rupiah/kg. Pineapple can be harvested starting from 16 to 24 months after planting and every 12 months thereafter. Thus, the gross income amounted to 12.8 to 16 million rupiah over a 4-year period. These results suggest that intercropping with banana or pineapple gave a larger return per ha per year than intercropping with upland rice. Farmers in the Purwakarta and Sumedang timber plantations derived a high income from intercropping because they grew banana and pineapple (Tables
Tomich et al. (1998) considered that regular income throughout the year leads to the success of intercropping practices. Companies assisted farmers in selling their products to food processing companies and remote markets, and the farmers' groups were responsible for grading their products based on standards.

Benefits for companies

Company managers stated that the plantations were slightly disturbed in the previous 3 years; illegal logging and fires occurred in the Sumedang and Purwakarta timber plantations (Table 7). However, fire occurred in small spots only in remote areas, less than 1.0 ha in total in each year on both plantations. In the timber plantations, land encroachment still occurred, but no land conflict between companies and farmers was observed in any study sites. Managers stated that the occurrence of land encroachment had declined by 50% in Sumedang and by 95% in Purwakarta timber plantations after the introduction of intercropping programs. Reduction in disturbances due to the introduction of intercropping programs is in agreement with the reports of Pratiwi (1997) and Adji (2000).

In our field investigations, no abnormalities were found in the growth of the main trees. Mahogany and pine seedlings intercropped with banana and pineapple showed normal growth in the Purwakarta timber plantation. In the Sumedang timber plantation, young teak trees intercropped with tobacco exhibited wider leaves than the teak trees intercropped with other crops, presumably because tobacco leaves provided a favorable microclimate for teak seedlings. The growth of rubber trees (2-years-old) did not show any difference in tree diameter (data not shown) whether annual crops were intercropped or not. Moreover, intercropping reduced the cost of weeding by 70% in the Cikumpay rubber plantation during the first three-year period, compared with covering of the plantation floor with legumes (*Calopogonium pubescens*, *Calopogonium mucunoides* and *Pueraria javanica*). Nissen et al. (2001) reported that intercropping reduced management costs for trees by 50%, compared with monoculture of trees. Siebert (2000) indicated that intercropping of cacao and coffee trees with rattan can stabilize the income, which is influenced by the fluctuations in the price of cocoa and coffee in international markets, compared with the monoculture of cacao trees.

The establishment of intercropping systems under mature tree canopies enabled farmers to cultivate the same lands for many years and to obtain a sustainable income. The prohibition of crop cultivation under mature tree canopies forced farmers to move from one area to another. Plantation companies may allow farmers to grow shade-tolerant tuberous crops under mature tree canopies unless the cultivation of such crops is found to exert a detrimental effect on the growth of adult trees.

Acknowledgements

We would like to express our gratitude to the managers and staff members of the Cikumpay and Rajamandala estate of PTP Nusantara VIII, KPH Sumedang and KPH Purwakarta of PT Perhutani III West Java and the farmers who participated in this study. This research was supported in part by a Grant-in-Aid from the Japan Society for the Promotion of Science.

### Table 7 Occurrence of disturbances in the Purwakarta timber, the Sumedang timber, the Rajamandala cacao and the Cikumpay rubber plantations from 2000 to 2003

<table>
<thead>
<tr>
<th>Disturbance</th>
<th>Purwakarta Timber</th>
<th>Sumedang Timber</th>
<th>Rajamandala Cacao</th>
<th>Cikumpay Rubber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encroachment</td>
<td>+x</td>
<td>++</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Illegal logging²/ theft³</td>
<td>++</td>
<td>+++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Grazing/cattle</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Fire</td>
<td>+++</td>
<td>+++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Drought damage</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Wind damage</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+++</td>
</tr>
</tbody>
</table>

² For personal use for daily purposes such as firewood, and for the construction of houses and cattle huts.
³ Stealing of cacao fruits and latex from rubber trees.

x = no occurrence, + = infrequent occurrence, ++ = occasional occurrence, +++ = frequent occurrence.
References


Pratiwi 1997 Several approaches for diminishing conflict in forest management in Indonesia. In: A state of the art report on some recent forest policies, initiative and achievements in Indonesia: Concept, strategies and action for sustainable forest management and forest development towards 21st century (Nasedi, B. D. ed.). Ministry of Forestry, Indonesia, Jakarta. 229-234.


(*: in Indonesian)