Chapter 16

Piper aduncum Fallows in the Lowlands of Papua New Guinea

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Primary forest covers about 75% of Papua New Guinea. Every year about 200,000 ha are cleared for commercial operations, including logging, plantations, and subsistence agriculture. The latter mainly takes the form of shifting cultivation. In many parts of the humid lowlands, secondary fallow vegetation is dominated by the shrub *Piper aduncum* L (see color plate 20). It is not known exactly when and how *P. aduncum* invaded Papua New Guinea from its native Central America, but it was first recorded in the mid 1930s (Hartemink 2001). The invasion has been aggressive and it has spread in a similar fashion to *Chromolaena odorata,* which was introduced to Asia in the late 19th century.

P. aduncum was first described by Linnaeus in 1753. It is common throughout Central America and is also found in Suriname, Cuba, Trinidad and Tobago, southern Florida, and Jamaica. It was introduced in 1860 to the botanical garden of Bogor, in Indonesia, and has naturalized in many parts of Malaysia (Chew 1972). In the Pacific, *P. aduncum* can be found in Fiji, but not in Hawaii. Australia has listed it as an unwanted weed species (Waterhouse and Mitchell 1998).

P. aduncum is a monoecious shrub or slender tree that grows up to eight meters tall. It has ovate and petioled leaves up to 16 cm long, and its flowers are arranged in a dense spiral (see Figure 16-1). It is commonly found along roadsides and in cleared forest areas on well-drained soils, but is never found in mature vegetation. *P. aduncum* has very small seeds that are dispersed by the wind, birds, and fruit bats. It withstands coppicing, but burning seems to be detrimental. It can be effectively controlled by hand cutting (Henty and Pritchard 1988). Throughout the neotropics, *P. aduncum* extracts are used as folk medicine; and it is mentioned in several ethnopharmalogical databases. It is avoided by livestock (Waterhouse and Mitchell 1998).

It is possible that seeds of *P. aduncum* were deliberately imported to Papua New Guinea, or that it hopped across the border from West Papua (Irian Jaya) (Rogers and Hartemink 2000). Whatever its means of arrival, *P. aduncum* can now be found in many parts of the humid lowlands of Papua New Guinea, whereas 20 or 30 years ago, it was absent (Bourke 1997). It is widespread in the Morobe and Madang provinces at altitudes up to 600 m above sea level (asl), and it is also found in the highlands up to altitudes of 1,800 m asl. It often grows in monospecific stands on steep hill slopes (Kidd 1997).

The stems of *P. aduncum* are used for firewood, fence posts, or supporting sticks for yams (*Dioscorea* sp.). In some areas it is even used for building material, but the wood rots quickly. In some coastal villages of Papua New Guinea, the bark or leaves

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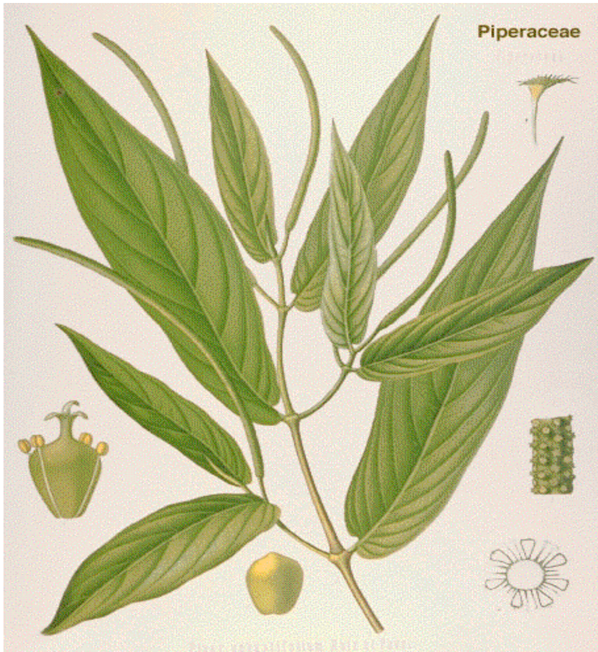

Figure 16-1. *Piper aduncum* **L.**
Source: H.A. Köhler's *Medizinal Pflanzen* 1887.

are used to dress fresh knife, axe, or spear wounds, and new leaves are also used as bandages (Woodley 1991). Farmers' perceptions of *P. aduncum* are mixed. Some value its rapid growth and the firewood it provides, while others are convinced that it is not a good fallow species. Many farmers in the lowlands stress that *P. aduncum* makes the soil dry and loose.

Despite its being widespread in Papua New Guinea, there is no information available on *P. aduncum's* basic growth characteristics nor on its effect on soil. In this chapter I present some results of my research on this rapidly invading fallow species in Papua New Guinea.

The Study Site and Methodology

In October 1996, a trial was set up to investigate *P. aduncum's* biomass and nutrient accumulation compared with that of *Imperata cylindrica* and *Gliricidia sepium.* The location was Hobu (6°34' S, 147°02' E), about 20 km northeast of Lae, at the foothills of the Saruwaged Range. Hobu is an area where much of the secondary fallow vegetation is dominated by *P. aduncum*. The altitude is 405 m asl, and the annual rainfall is about 3,000 mm, distributed throughout the year. The mean annual temperature is about 26.7 °C. The soils are derived from a mixture of colluvial and alluvial deposits of mostly igneous rocks. They have a high base status and are classified as Typic Eutropepts.

Three plots, each measuring six square meters, were planted with *P. aduncum*, *Gliricidia sepium,* and *Imperata cylindrica* (n = 4 each). Planting distances for the *Piper* and *Gliricidia* were 0.75 m by 0.75 m. One year later, the plots were harvested. The plants were slashed at ground level and separated into main stems, branches, leaves, and litter. Each plant part was weighed, oven dried at 65 °C for 72 hours, and analyzed for nutrient content at the laboratories of the University of Queensland.

Results

Biomass Accumulation

After one year the *P. aduncum* had produced about 13.7 metric tons(t)/ha of biomass. Of this, 43% was stems (Table 16-1). About 15% of the total dry matter production, excluding the roots, was found in the litter layer. The *G. sepium* had produced nearly three times more wood and slightly more leaves and litter than the *P. aduncum*. The *I. cylindrica* had also produced slightly more biomass than the *P. aduncum*. After removal of the woody parts, the total biomass returned to the soil was 7.8 t/ha for *P. aduncum* and 8.1 t/ha for *G. sepium*.

In another experiment, *P. aduncum* accumulated about 9 metric tons of dry biomass/ha after 11 months. When the trees were nearly two years old, the biomass had increased to 48 t/ha, and the height of the trees was 4.5 m. Growth rates increased with the age of the trees and were mostly linearly related to the amount of rainfall. The highest biomass accumulation rate observed in a two-year period was 134 kg of dry matter /ha/day.

Nutrient Accumulation

The total nutrient content of the fallow vegetation is shown in Table 16-2. *G. sepium* returned the largest amount of N to the soil. *P. aduncum* and *I. cylindrica* returned less than half of this amount of N. The amount of P was similar for all three fallows. The leaves and small branches of *P. aduncum* returned considerable amounts of K to the soil, whereas *G. sepium* returned more than 200 kg Ca/ha. *I. cylindrica* returned relatively few nutrients to the soil.

Table 16-1. Biomass of One-Year-Old *Piper, Gliricidia, and Imperata Fallows* (metric tons/ha ± 1 SD, dry matter)

Plant Part	Piper aduncum		Gliricidia sepium		Imperata cylindrica	
Stems	5.9	± 1.0	15.2	± 0.6		
Branches	1.6	± 0.2				
Leaves	4.2	± 0.4	5.2	± 0.3	14.9	± 2.0
Litter	2.0	± 0.4	2.9	± 0.9		
Total	13.7		23.3		14.9	

Note: Modified after Hartemink (2003a).

Table 16-2. Nutrients in One-Year-Old Fallow Aboveground Biomass at Hobu (kg/ha)

Fallow Species	*Plant Parts*	*N*	*P*	*K*	*Ca*	*Mg*
Piper aduncum	Total	120	22	299	157	46
	returned to the soil[a]	97	14	206	147	40
Gliricidia sepium	Total	356	36	248	312	64
	returned to the soil[a]	192	12	89	222	41
Imperata cylindrica	Total [b]	76	12	89	56	29

Note: Modified afer Hartemink (2003a). [a] *Piper and Gliricidia* main stems were removed from the plots. Totals exclude roots. [b] All biomass returned to the soil.

Table 16-3. Volumetric Soil Moisture Content of Sweet Potato Plots after Different Fallow Vegetation (%)

			Soil Moisture under Sweet Potato after One Year of Fallow with:			
DEP[a]	*Soil Depth (m)*	*Continuous Sweet Potato*	Piper aduncum	Gliricidia sepium	Imperata cylindrica	*SED*[b]
0	0–0.05	34.6	27.4	33.4	31.2	1.43
	0.10–0.15	37.3	29.8	38.8	33.3	3.35
93	0–0.05	41.7	43.4	44.1	46.8	1.04
	0.10–0.15	41.9	42.2	45.8	46.4	2.19
168	0–0.05	39.2	40.2	42.4	42.4	2.61
	0.10–0.15	41.2	39.7	38.3	41.4	3.05

Note: Modified after Hartemink (2004). [a]Days after fallow vegetation was slashed and sweet potato was planted (DEP). [b] Standard error of the difference (SED) in means (9 df).

Fallow Effects on Soil Moisture

Many farmers reported that *P. aduncum* depleted soil water. When the one-year-old fallow vegetation was slashed, volumetric soil moisture was measured (gravimetric content X BD). Soils under *P. aduncum* had significantly lower moisture levels than those under *Gliricidia* and *Imperata* (Table 16-3). Three months after the planting of sweet potato, the plots previously under *P. aduncum* still had significantly lower levels of soil moisture in the 0 to 0.05 m horizon than those previously under *I. cylindrica*. The differences in soil moisture levels, created by the fallow species, disappeared after five months.

Conclusions

P. aduncum's rapid invasion of the humid lowlands of Papua New Guinea can be explained by its dominance in the seedbank and its fast growth (Rogers and Hartemink 2000.). In trials at Hobu, *P. aduncum's* total biomass accumulation after one year was lower than that for *Gliricidia sepium* but similar to *Imperata cylindrica*. It returned less than half of the N returned to the soil by *G. sepium* but more than twice the amount of K. It was also confirmed that soils under *P. aduncum* fallows were significantly drier than the other fallows.

Whether the invasion of *P. aduncum* in the Papua New Guinea lowlands is a favorable development from an agricultural point of view remains to be seen. Current research focuses on the effect of different fallows on sweet potato, the main staple crop in Papua New Guinea (Hartemink, 2003b). However, from an ecological point of view the invasion is catastrophic because *P. aduncum* prevents the growth of rainforest seedlings. It can therefore be assumed that its dominance will mean a loss of biodiversity, which is frequently regarded as a measure of ecosystem quality (van Groenendael et al. 1998). On the other hand, if *P. aduncum* continues to invade areas currently dominated by *I. Cylindrica,* this would have to be regarded as a favorable development (Cairns 1997; Hartemink 2001).

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