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The fallow period as a weed-break in shifting cultivation (tropical wet forests)

Anneke de Rouw [1]

Department of Plant Ecology and Weed Science, Agricultural University Wageningen, Netherlands

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Abstract

In the wet tropics weeds can grow all year round. In shifting cultivation systems the fallow period is used to restrain the development of weeds because they threaten the re-use of the land. Overhead shade suppresses the heliophytic weeds growing on the site and interrupts the continuous re-seeding of the field. This is the first phase of weed suppression. During the second phase, shade cover is maintained to allow the reduction of viable weed seeds in the soil.

In the Taï farm system, Côte d'Ivoire, little weeding is carried out because optimum use is made of the natural fallow vegetation as a weed-break. The first phase took 6–12 months, the second 10 years. The shading out of weeds is cheap and effective yet demands much land. Those farm systems under the pressure of land shortage are likely to be infested by weeds. They suffer from weeds because shade-producing plants are eliminated from the system. Intensive use of the land is sometimes possible when shade plants are preserved (as stumps, tubers) during the period the field is covered by heliophytic crops, and are allowed to grow out afterwards.

Keywords: Tropical weeds; Seed bank; Rainfed rice; Shade; Taï rain forest

1. Introduction

Weeds pose a serious problem in a tropical ever-humid environment where they can grow and produce seeds continuously. Elimination of weeds in the field by pulling them out and cutting them back is only one aspect of weed control. Other practices, concerning both cropped and fallowed land, attempt to restrain the spread of weeds because this threatens the re-use of the land. Slashing and burning followed by fallow are strategies for fertility and the control of weeds and diseases, though increasing weed infestation is thought be the primary factor leading to shift fields (Nye and Greenland, 1960; Moody, 1975; Arnason et al., 1982).

A study of weeds in shifting cultivation must consider both the cropping phase when arable weeds grow and produce seeds on the site, and the fallow phase when weeds diminish or even disappear. The fallow period functions as a weed break because overhead shade is formed that suppresses the arable weeds, the latter being strongly heliophytic. Two phases can be distinguished in the process of weed suppression. After the harvest of the main crop many weeds persist into, and contribute to, the initial stage of forest regrowth. Progressively, shrubs, lianas, trees and coppice shoots suppress the weeds. In many tropical situations, this first phase takes 4–6 years (Ahn, 1978; Ramakrishnan and Mishra, 1981), though this period can be longer,

[1] Present address: ORSTOM, BP 11416, Niamey, Niger. Fax: (227) 75 28 04 / 75 20 54

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10–15 years (Adedeji, 1984), or shorter, 2–5 years (Staver, 1991). The second phase is the period the land is allowed to remain under continuous canopy cover in order to reduce the number of viable weed seeds in the soil. This may take at least 10 years (Staver, 1991). Most authors have studied only the first phase: the period during which the forest chokes the weeds. The second phase: the period to reduce weed seed banks to tolerable levels, has received less attention (Garwood, 1989).

Shifting cultivators use shade as a tool against the general build up of infestation: creating shade at the appropriate moment and maintaining it as long as necessary. However, overhead shade can only be employed at the end of the cropping cycle because almost all food crops are strongly light-demanding. Though shade can be produced by cover crops that develop after the main crop, or by the growth of planted fallow trees in agroforestry systems, most often however, it is the regrowth of the natural vegetation that checks the weeds (Spencer, 1966; Ahn, 1978; Alexandre, 1989). The shading out of weeds is cheap and effective, yet demands much land. (Moody, 1975). Though the role of shade as a weed-break is at least as important as soil restoration, the conservation and restoration of soil under fallowed land has received much more attention. Yet the worldwide trend of shortening fallow periods and the degradation of forest-structured fallow vegetation into thickets and grassy shrub lands, usually under the pressure of land shortage, brings on an explosive development of weeds. Where the weed-break no longer functions effectively farmers are often forced to change the farm system rather radically. Rainfed rice cultivation for example, being very sensitive to weeds, is abandoned in many parts of Africa, maize and cassava became the staple crop instead (Fresco, 1986; Garrity et al., 1992; Sankaran and De Datta, 1985).

This paper concentrates on natural fallow vegetation being used by farmers to eliminate the weeds of cultivation. As was pointed out by Staver (1991) woody plants and herbaceous plants are to be considered separately. During cultivation, woody plants, trees, lianas and shrubs, reduce crop yield as do the herbaceous plants in a field. However, during fallowing, woody plants are essential to land restoration. Obviously, both the cropping phase and the fallow phase must be studied. The fallow period prevents weeds being carried over from the previous cropping period through the fallow period to the next cropping phase, either as seeds or as vegetative sprouts. (1) During the cropping period we studied how rapidly the population of herbaceous weeds build up. We analyzed how farmer's practices slow down or accelerate this process. (2) During the fallow period we examined how quickly weeds are suppressed, both in the fallow vegetation and as viable seeds in the soil depending on length and quality of the fallow vegetation.

A farm system was studied where optimum use is made of the fallow as a weed break, both during the first and the second phase of weed suppression. This was possible because in the study area the necessary observations and experiments were conducted during a period when the forest was still in good supply. Shifting cultivators retained freedom of choice by site selection (1979–1984). Later, for reasons described below, good forest became increasingly scarce. The effectiveness of the fallow period to limit weed growth was reduced. We analyzed the changes in cultural practices as fallow periods were shortened and fallow vegetation of poor quality appeared (1985–1989). Finally, we examined how the fallow vegetation was used in other farm systems under similar climatic conditions, and why they suffered in different degrees from weeds.

2. Study area

The Taï forest in the southwestern region of Côte d'Ivoire represents the largest tract of rainforest in West Africa. Outside the National Park, fields, patches of primary forest, secondary forest of different ages, and degraded vegetation form a mosaic. The Taï rainforest forms part of the UNESCO network of Biosphere Reserves as well as being inscribed on the World Heritage List. The natural ecosystem with damaged and transformed areas has been the object of many studies and therefore is relatively well known.

The study area, 5°57′–5°20′ N and 7°30′–7°14′ W, covers the agricultural zone between the Cavally River and the Taï National Park. It receives a mean annual rainfall of 1900 mm, the greater part falling in two rainy seasons. Most food cultivation is performed in the heaviest rainy season from March through August.

The indigenous population, Oubi, Guéré, and Krou, slash and burn mature forest with the aim of cropping it with rainfed rice for one season and then letting it return to forest. Very short cropping periods (6 months) alternate with long forest fallow periods (14–30 years). A new field is required each year. Owing to the population increase, widespread cocoa farming and the extension of the nearby Taï National Park, the cropping period is sometimes extended to 2 years and fallow periods are shortened to 6–10 years (De Rouw, 1991; Slaats, 1992).

The land is undulating to sloping. The soils are severely leached and acid with kaolinite as the main clay mineral, low CEC, low organic matter content and much sesquioxides (Collinet et al., 1984; Van Reuler and Janssen, 1989). In the revised FAO-system most cultivated upland soils are Ferralsols. Regosols are found in alluvial plains and some of the lower slopes (FAO, 1988).

Primary and secondary forest has been studied by Alexandre et al. (1978) and Guillaumet (1967). More recently, successional stages of secondary forest, degraded vegetation, and weed vegetation were described, classified and mapped (De Rouw et al., 1990). The same publication relates the history of land use and the extension of cultivated and fallowed land (1956–1989).

3. Methods

During the first phase of weed suppression the fallow chokes out the weeds of cultivation. To follow the degeneration and gradual disappearance of weeds, 26 abandoned rice fields under natural fallow were sampled. The abandoned rice fields differed in the time they had been left fallow and the level of drainage. Fallow vegetation on well-drained soil was sampled 3, 5, 11, 15, 18, 24, 28, 54, 66, and 78 months after the rice harvest, each period was represented by two sites. Fallow vegetation on poorly drained soil was sampled 6, 11, and 78 months after the rice harvest, each period was represented by one site. During the period of study the forb *Chromolaena odorata* (L.) King and Robinson (ex-Eupatorium odoratum) invaded and spread in the area. From 1984 onwards, the weed started to invade fields and subsequently young secondary forest (Gautier, 1992; De Rouw, 1991). Five sites infested with the forb were sampled 6 months (two sites), 8 months (two sites), and 42 months (one site) after the rice harvest. Drainage was studied separately because primary forest as well as seral stages on well-drained soil differs structurally and floristically from those on poorly drained soils. Fallow vegetation infested with *C. odorata* was singled out because the forb alters the course of succession dramatically.

Fallow sites were chosen after having checked the agricultural history through interviews with farmers, and the structure and floristic composition of the vegetation. As many vegetation studies were conducted in the region some experienced scientists were able to estimate the age of a regrowth quite closely. The sites were selected to be similar in aspect to soil, meaning that the obvious characteristics such as slope, texture and the occurrence of gravely layers were comparable (all were common soils of the migmatite series, Guillaumet, 1967; De Rouw et al., 1990).

During the second phase of weed suppression weed seeds die off in the soil. In order to observe whether a fallow period of a given length had resulted in a reduction of the weed seed bank in the soil, sites were sampled indirectly. Only once was the seed bank in a forest soil sampled directly and the results of this experiment have been published separately (De Rouw and Van Oers, 1988). We selected seven sites under natural fallow. Again the main differences between sites were related to type of forest cleared: primary forest (three sites), mature secondary forest (two sites, 19 and 30 years old), or young regrowth (two sites, 6 years old and 6 months old), and to drainage: six sites were on well drained soil, and one, a primary forest, on poorly drained soil. All sites were cultivated with rice following local practice. The vegetation was felled followed by one overall burn. The seeds of local land races of rice were dibbled in with a planting stick. Planting densities were between five and eight hills per square metre. One weeding round was carried out 2–3 months after sowing in the fields prepared in secondary forest, in fields prepared in primary forest, weeding was not necessary.

Prior to clearing, the vegetation and the soil were checked. All sites belonged to the common migmatite soil series. The structure and floristic composition of the forest were investigated to make sure that no further disturbance had interfered with forest development since the previous cultivation period.

The rice fields were sampled three times 2, 3 and 5 months after land clearing. At each period four plots were taken (4 m × 9 m) in non-weeded areas that were delineated at the onset of the cropping period. In rice-field plots, all non-crop plants were pulled out, identified and counted by species. A distinction was made between seedlings and vegetative regrowth, and between reproductive and non-reproductive plants.

In fallow vegetation, the same surface (36 m^2) was sampled using two plots of 18 m^2. All terrestrial plants were identified and counted by species and the flowering or fruiting status of plants was recorded.

The species of the sample plots were grouped into two broad ecological groups either they belonged to the category of arable weeds or forest plants. The group indicated as arable weeds are herbaceous or sub-woody, mostly annual or bi-annual plants of open spaces. They may be erect or climbing, prostrate or creeping dicotyledons, and tufted, creeping, climbing or stoloniferous grasses and sedges. In this group we find some of the widely distributed common weeds of the wet tropics. These plants (66 species) are strongly heliophytic during all of their life cycles and cannot persist in shade, except for five species that could vegetate in light shade during some years. The group of forest plants (643 species), all perennials, consists of trees, shrubs, lianas and some shade-tolerant herbs. These plants start to produce seed after a juvenile stage of one to several years depending on species. Though pioneer trees and lianas may be light-demanding during some stage of their life cycle, all these plants have in common that they can live, grow and fruit, at least finish their life cycle, in a forest environment.

4. Results

4.1. Arable weeds in rice fields and in fallow vegetations

To investigate the level of weed infestation in rice fields and the persistence of arable weeds in fallowed land, we selected farms that practised a normal shifting cultivation cycle: fallow periods over 14 years and short cultivation periods of 6 months. In Fig. 1 the densities of arable weeds and total densities of plants are plotted against time since last slashing and burning. Just after burning the soil is bare, the following 5–6 months rice predominates, afterwards the secondary forest takes over. All through the cropping period and the months of subsequent fallowing, forest plants outnumbered arable weeds. On well-drained soil the weed densities decreased from approximately 30 to 10 plants m^{-2} during the cropping period (Fig. 1a). As the plots had not been weeded, this was due to natural thinning and to competition with the rice. The local rice varieties are tall (180 cm) landraces with long droopy leaves forming a good cover. Most arable weeds flowered, set seed and finished their life cycle together with the rice crop, or shortly after (Fig. 2a). In the following months (up to 18 months after clearing), the sub-woody *Desmodium velutinum* (Willd.) DC. and *Solanum* spp fruited and died. In the period up to 72 months after land clearing, only those weeds that could vegetate in the light shade of small gaps created by the falling down of short-lived pioneer trees persisted (mainly *Trema guineensis* (Schum. and Thonn.) Ficalho, the ground herbs *Piper umbellatum* L., *Phaulopsis falcisepala* C.B.Cl., *Elytraria maritima* J.K. Morton, *Desmodium adscendens* (Sn.) D.C., and the climbing sedge *Scleria boivinii* Steud). No arable weeds were encountered in the 84 month old forest, or in still older forest, 8, 10 and 14 years old. Reproductive plants were not recorded 34 months after clearing (Fig. 2a).

On poorly drained soil fewer plants appeared during rice cropping (Fig. 1b) and the suppression of weeds by forest plants took longer. Obviously, both weeds and secondary forest plants had difficulty getting established in seasonally waterlogged soil. A maximum of flowering and fruiting weed species was recorded 12 months after clearing (Fig. 2b). The usual vigor of the pioneer trees was reduced by the waterlogged soil, canopy closure was retarded, and some weeds, especially sedges that are typical for swampy soil (*Scleria depressa* (C.B.Cl.) Nelmes, *S. naumanniana* Boeck.) could continue to grow.

The forb *C. odorata* did not cause much trouble in rice fields because it occurred in very low numbers in the seed bank prior to felling (De Rouw and Van Oers, 1988). It did however persist in 1 and 2 year old fallow vegetation where some individuals reached the canopy (2–4 m high). The secondary forest infested by *C. odorata* had more arable weeds remaining in the vegetation for a longer period after the field was abandoned (Fig. 1c).

The sudden clearing of the forest permits almost the entire seed population to germinate. The brief cultivation period allows weeds to produce just one crop of

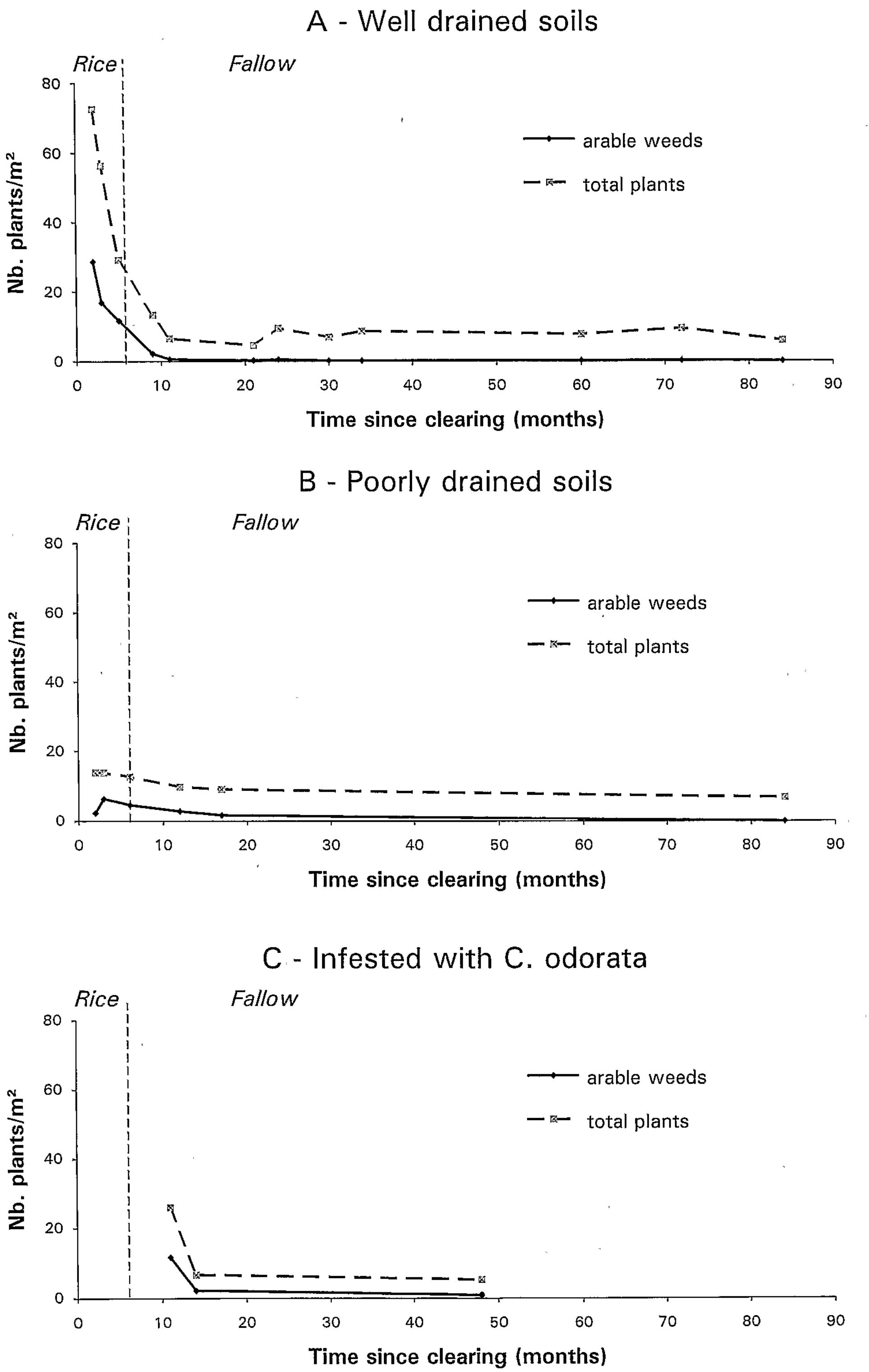

Fig. 1. The relation between number of arable weeds, number of total plants and time since slashing and burning, during the cultivation phase (0–6 months) and during fallowing (7–180 months). Ricefields: mean of four plots of 9 m^2 per field; Fallow: mean of two plots of 18 m^2. (a) Well-drained soil. (b) Poorly drained soil. (c) Sites were infested by the forb *Chromolaena odorata*.

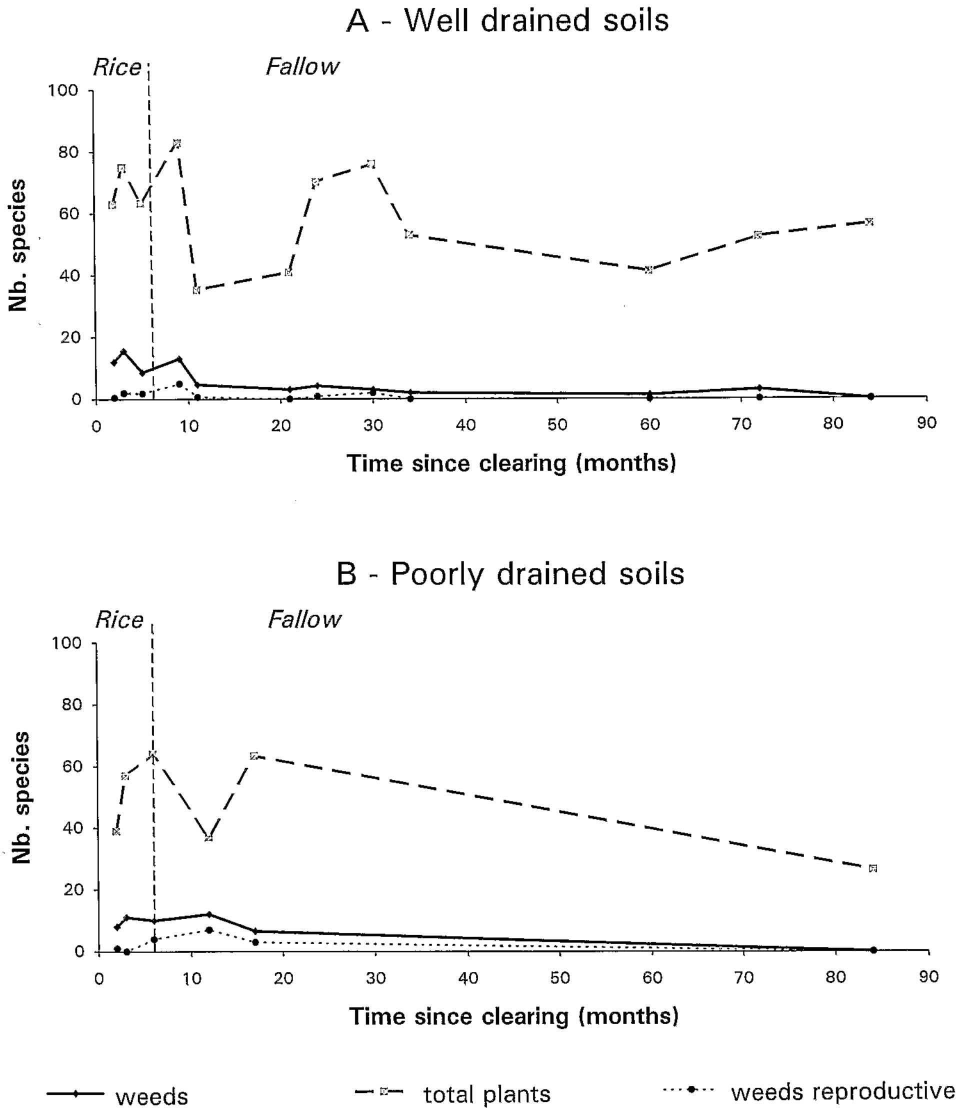

Fig. 2. Number of weed species and total number of species in relation to time since slashing and burning, during the cultivation phase (0–6 months) and during fallowing (7–180 months). Ricefields and fallow: mean of two plots of 18 m^2. (a) Well-drained soil. (b) Poorly drained soil.

seeds before being choked in the forest regrowth. The weeds have a short life cycle which is either genetically controlled, because they are annuals, or environmentally controlled, because they are suppressed if overtopped. The first phase of weed suppression, the elimination of arable weeds by shading them out, occurs in three steps. Within 1 year after clearing, 66% of the weed species (46 species) have disappeared while weed densities have fallen to less than 1 plant m^{-2}. During the following 6 months, sub-woody bi-annuals (six species) are suppressed. Finally, after some years, the species that support light shade (five species) are eliminated. The whole phase takes about

5 years, however, most weeds are suppressed within 6–12 months.

5. Weed infestation and length of the previous fallow period

Four fallow vegetations and three primary forests were cut, burned and cropped with rice following local practice. Five months after burning, arable weeds, secondary and primary forest plants were counted in non-weeded areas. Fig. 3 shows the relation between the densities of non-crop plants in fields and the length of the previous fallow period. The clearing of the regrowth only 6 months after the last harvest, gave an average of 150 plants m^{-2} during the cropping season, almost all of them weeds. Few forest plants appeared because the first felling and burning had permitted the seed stock to germinate and now, 1 year later, the stock had not been replenished. The stock of arable weeds however, had been filled up with seeds produced in the 1 year period between clearings. So it was merely the second generation of weeds that was able to exploit the new clearing. The farmer deemed the field too weedy, not worth the trouble of hand weeding.

After slashing and burning the 6 year old secondary forest, non-crop plant densities in the ricefield were about 60 plants m^{-2}, 80% belonged to arable weed species, 20% were forest plants. Apparently the stock of weed seeds deposited in the forest soil 6 years before had been reduced considerably. The number of forest plants was relatively low, considering the huge quantities of seeds of pioneer trees that had been produced and stocked in the soil during the previous years of fallowing. Not a single seedling of *Macaranga hurifolia* Beille was recorded in the field though this short-lived pioneer tree constituted the general crown layer of secondary forest. The peculiarities of pioneer stands of *M. hurifolia* have been noticed by Kahn and De Namur (1978): if a quasi-monospecific stand is cut, no seeds of *M. hurifolia* will germinate in the field. If secondary forest is cut from which *M. hurifolia* has gone, that is forest older than about 10 years, *Macaranga* germinates massively. It is possible that the trees produce toxic substances (leached out of fallen leaves, or exudated by roots, or other) which inhibit seeds of the tree to germinate as long as a dense stand of the pioneers exists. Hand weeding started 2 months after sowing the rice but stopped 1 month later because of weediness. The farmer had cleared less than 1 ha during this period and this frustrated further weeding attempts.

After slashing and burning a 19 year old secondary forest containing no surviving *M. hurifolia* trees, 50% of the forest plants germinating in the field belonged to this species. Arable weed densities had been reduced to 20–25 seedlings m^{-2}. Weeds were controlled by one hand weeding, starting 3 months after burning and requiring 18 days work for 1 ha.

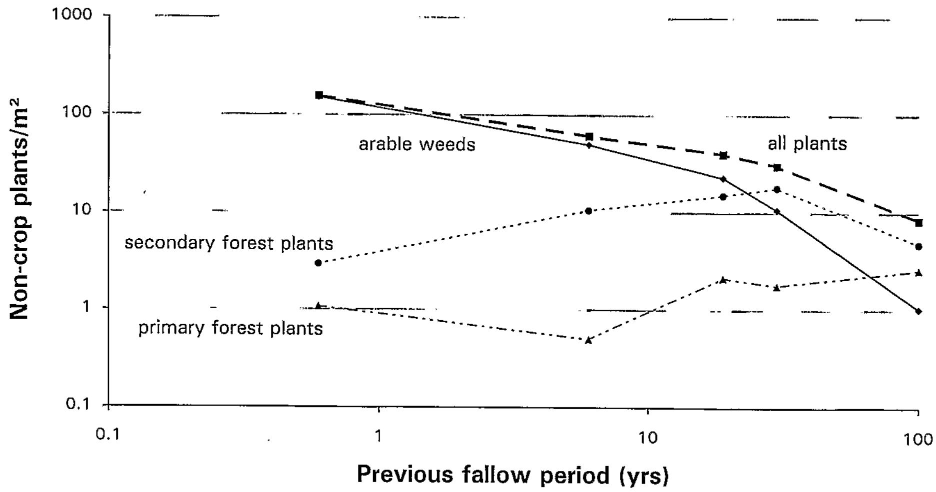

Fig. 3. Densities of non-crop plants in unweeded ricefields, 5 months after slashing and burning in relation to the length of the previous fallow period: 0.6 years, 6 years, 19 years, 30 years and primary forest (100 years). Ricefields: mean of four plots of 9 m^2 per field.

In the field prepared in 30 year old secondary forest, forest plants outnumbered the arable weeds, the latter were reduced to about 10 plants m^{-2}. The seedling stand of forest plants was no longer dominated by *M. hurifolia* but many trees with longer life spans appeared. Apparently, long-cycle secondary forest trees with a longer juvenile stage, have had the opportunity to produce seed. About 10 days were spent on weeding 1 ha.

Secondary forest trees produce continuously and copiously small, long-lived seeds, whereas primary forest species produce fewer seeds, being larger and generally short-lived (Swaine and Whitmore, 1988). Thus, the soil under primary forest contains few seeds and fields in primary forest have the lowest densities of weeds and forest plants. No weeding was carried out in fields prepared in primary forest.

The second phase of weed suppression begins at the moment that weed plants stop producing seeds. For most arable weeds this is 6 months after the harvest, 1 year after the opening up of the forest. It ends when weed seed numbers have declined down to manageable numbers for Oubi and Guéré farmers this is about 40 arable weeds m^{-2}. This density corresponds to approximately 1 months work for 1 ha. To decrease to these densities, continuous shady conditions should be maintained for at least 10 years.

6. Discussion and conclusion

6.1. The weed-break under long fallow periods

The success of the fallow as a weed break in the Taï shifting cultivation system depends on the extremely rapid development of overhead shade after the harvest (Fig. 4). Rapid shade in its turn, develops only under three necessary conditions: (1) tree seedlings have to be present on the site at the end of the cultivation period; (2) resprouting forest plants have to survive the cultivation period; (3) the number of arable weeds should be less than the number of forest plants. How are seedlings of forest plants secured over the cropping phase keeping in mind that the first weedings after clearing are catastrophic for the tree and shrub seedlings (Staver, 1991; De Rouw, 1991)? First, a long

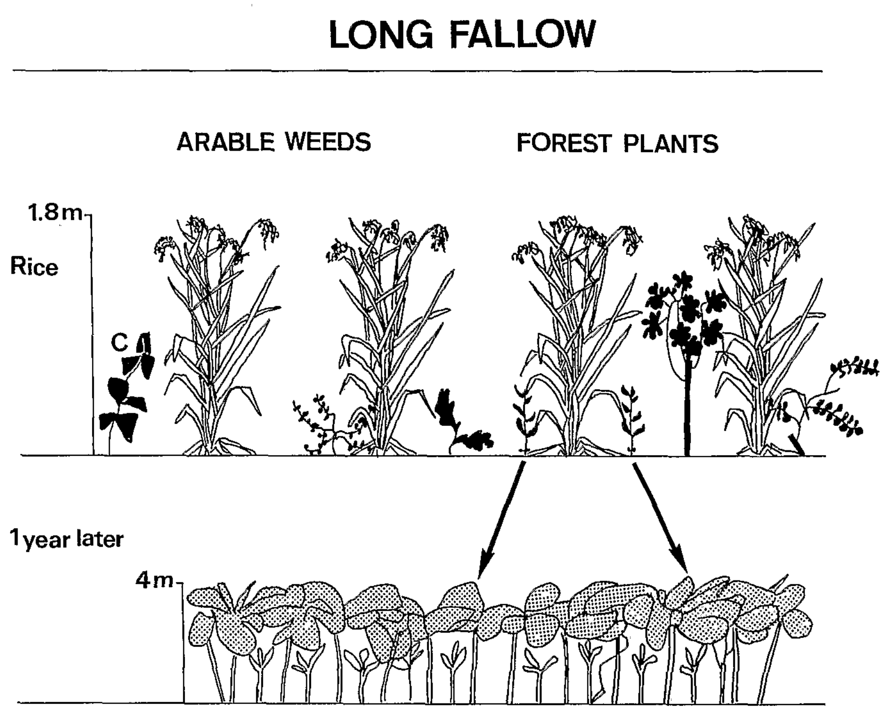

Fig. 4. Rotation: rainfed rice crop, more than 16 years of fallow. Spontaneous plants in a ricefield and the development of the natural vegetation 1 year later. Secondary forest trees constitute the canopy. C, *Chromolaena odorata*.

preceding fallow is needed for the replenishment of the tree and shrub seed bank. Second, weeding is rather poor. In most shifting cultivation systems, poor weeding is so widespread that it seems to be part of the land-use system (Ruthenberg, 1976). In fact, poor weeding also called residual weeding (Swamy and Ramakrishnan, 1988), or selective weeding (Chacon and Gliessman, 1982), enforces the preservation of forest plants in the shifting cultivation cycle and thus stimulates the rapid post-harvest shade. A population of resprouting forest plants is obtained at the end of the cropping phase by one single burning at the onset of the cultivation period and by slashing back the coppice only once. Low densities of arable weeds are acquired by a long period of forest cover during which weed seeds perish in the soil, and by a brief cropping period during which only one generation of weeds develops before canopy closure. This is how in Taï, when there is plenty of rotation land, weeds are controlled with very little effort.

The same process of immediate forest cover has been reported from other rainforest areas where upland rice is grown in shifting cultivation (French Guyana (Gely, 1984); Malaysia (Kochummen and Ng, 1966); Liberia (Kunkel, 1966); Western Côte d'Ivoire (Mouton, 1959)) In all these cases forested land was, or is, in good supply. These farm systems have become rare nowadays because rainforest and mature secondary forest are disappearing rapidly in many areas.

Unlike shifting cultivators who grow cereals, farmers planting tubers or root crops are obliged to clean the forest soil more thoroughly which means extra burning, some tillage to bury the plant material and extra weeding because of the longer growing season. Inevitably, they destroy much of the forest seed stock, eliminate part of the seedling population and weaken coppicing plants. Farm systems with root and tuber crops are therefore more open to weed infestation, even in areas with forest reserves. These farmers spend more time on weeding and regeneration of forest takes longer (Amazonia (Carneiro, 1983; Hames, 1983; Johnson, 1983; Uhl and Murphy, 1981); Congo (De Foresta and Schwartz, 1991); New Guinea (Rappaport, 1971)). The weed build up during the longer cultivation period results in the need for a longer fallow period to eliminate the weeds from the vegetation and to reduce weed seeds numbers in the soil.

6.2. *The weed-break under short fallow periods*

Where a 6 year old fallow was cleared for renewed cultivation (Fig. 3), weed infestation was not the only problem. A second disadvantage was the weeds:forest plants ratio. During the months following the harvest the few forest plants present compared with the large number of arable weeds, formed a broken canopy (Fig. 5). Though post-harvest shade can be sufficiently dense to avert a massive germination of a second generation of weeds, still it is sparse enough to permit the invasion of *C. odorata*. The forb chokes the fallow so that succession to forest is generally arrested for 2–5 years. In Taï, much secondary forest has degenerated to *C. odorata* thickets (Slaats, 1992).

A succession of short fallow periods eliminates the seed and seedling bank of forest plants, leaving little overhead shade after the harvest. This provides the opportunity for annual weeds to produce several crops of seeds and the persistence of a weedy seed and seedling bank. Both trends enforce a serious delay in reforestation.

In many tropical regions short fallows have become inevitable with increasing population. Farmers may concentrate on soils that stay relatively fertile even under short fallow periods and work very hard: one weeding round before planting the rice, and two weedings during the cropping season (Thailand (Lyman, 1969)). A combination of hard work and selective weeding is reported from dry rice farmers (Thailand (Hubert-Schouwmann, 1974; Hinton, 1978)), and root crop farmers (New Guinea (Rappaport, 1971)). Selective weeding implies leaving most, or all woody plant seedlings in the field during the cultivation period. It also condemns a farmer to continuous weeding of herbaceous plants. Staver (1991) proved, experimentally, the beneficial effect of selective weeding on forest regrowth, whereas clean-weeding seriously impaired tree and shrub regeneration. In these areas with pressure on land there is a minimum length of the fallow period that usually corresponds with the first phase of weed suppression. The forest vegetation is kept growing long enough to reach the stage at which woody species have eliminated the weed biomass.

In many areas in the wet tropics shifting cultivation is a continuing practice despite short fallow periods. In some cases the obvious choice for the farmers is not allowing weeds to develop by using the fallow as a

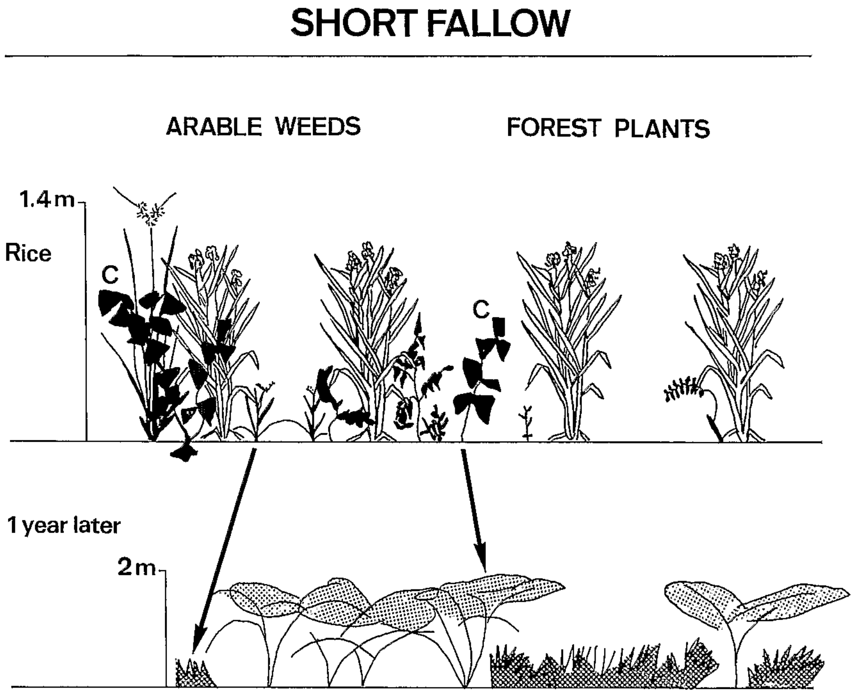

Fig. 5. Rotation: rainfed rice crop, 6 years of fallow. Spontaneous plants in a ricefield and the development of the natural vegetation 1 year later. *Chromolaena odorata* constitutes a broken canopy. C, *Chromolaena odorata.*

weed-break. How is this done? More than two clean-weeding rounds in one season or a succession of short fallow periods eliminates most of the forest seed and seedling stock. The group of resprouting plants however, proves to be less vulnerable. Though shade can be formed rapidly by vigorous shoots, the cover remains patchy because the distribution of resprouting plants over a field is far from uniform. Subsequently, the open spaces between stumps are filled by new generations of weeds. Efficient and relatively rapid establishment of cover depends on their being ample coppice stumps and suckers left at the end of the period of cultivation. The abilities of sprouting plants to exclude and suppress weeds have been used in some shifting cultivation systems suffering from land shortage (Belize (Kellman, 1980; Lambert and Arnason, 1986); Nigeria (Clayton, 1958); Guatemala and Panama (Snedaker and Gamble, 1969); North eastern India (Kushwaha et al., 1981)). Deliberate preservation of stumps was mentioned by Aweto (1981; Nigeria), Delvaux (1985; Zaire), and Sabhasri (1978; Thailand). In the Taï area we found two small areas comprising 640 ha where rainfed rice is cropped for one season while fallow periods are surprisingly short, not exceeding 6 years. Both areas are almost flat and the soils, a combination of valley bottoms and alluvial flood plains, are somewhat better than average (De Rouw et al., 1990). The natural vegetation of these wet places includes many *Marantaceae* and *Zingiberaceae*, stout, herbaceous often climbing plants. They are cut back during the cropping period but at the end of the season they resprout from underground tubers. Their large leaves and vigorous growth assure a rapid ground cover, thus preventing the spread of heliophytic weeds, such as grasses, sedges and annual dicots (Fig. 6). However, neither the growth of pioneer trees, nor the development of *C. odorata* is suppressed. One condition for rice cropping is the removal of *C. odorata* seedlings early in the season because it constitutes the only severe threat to the installation of a fallow vegetation comprising both pioneer trees and *Marantaceae* climbers. It is the resprouting ability of established *C. odorata* plants that would drive out the *Marantaceae* and make rice cropping impossible. In a similar way, sprouts of *Marantaceae* preserve young banana plantations from being choked by weeds (Congo (De

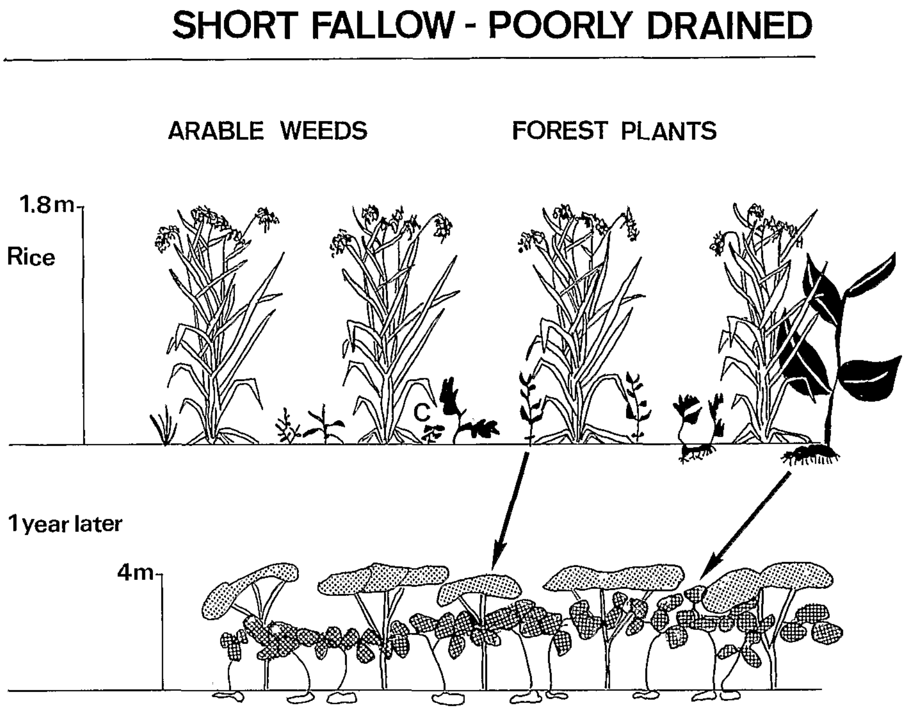

Fig. 6. Rotation: rainfed rice crop, 6 years of fallow in valley bottoms and alluvial floodplains. Spontaneous plants in a ricefield and the development of the natural vegetation 1 year later. Secondary forest trees and *Marantaceae* climbers constitutes the canopy. C, *Chromolaena odorata*.

Foresta and Schwartz, 1991)). An example of planted shade trees comes from Vine (1954; Ibo country). The fallow growth consists mainly of the small tree *Acioa barteri* (Hook.f. ex Oliv.) Engl. The fallow vegetation is cut and burnt and yams are planted. The many stems of *A. barteri* serve as yam stakes while maize, melon and cassava are interplanted. The stumps of *Acioa* begin to produce new shoots before the last cassava is removed. Heavy weed infestation is avoided while fallow periods are reduced to 4 years. The system succeeds only on loamy clay and not on sand.

Where repeated cutting and burning destroyed the seed bank of forest plants while no effort had been made to preserve resprouting forest plants, the forest fallow is replaced by a closed or open thicket. Degradation of the land forces the farmers to modify the system as recent examples report from Sierra Leone and Côte d'Ivoire. Where upland rice cultivation was cultivated in cycles of less than 10 years of fallow, rice cropping became uneconomic because of weeds (Nyoka, 1982). Food crop cultivation has switched to cassava and groundnuts (Davies and Richards, 1991) or cassava and maize (Slaats, 1992), alternated with short thicket-covered fallow periods.

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The fallow period as a weed-break in shifting cultivation (tropical wet forests)

Anneke de Rouw [1]

Department of Plant Ecology and Weed Science, Agricultural University Wageningen, Netherlands

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